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DAVID BREWSTER, LL.D.

F. R. S. LOND. AND EDIN. AND M. R. I. A.

CORRESPONDING MEMBER OF THE ROYAL ACADEMY OF SCIENCES OF PARIS, AND OF THE ROYAL ACADEMY OF SCIENCES OF PRUSSIA; MEMBER OF THE ROYAL SWEDISH ACADEMY OF SCIENCES; OF THE ROYAL SOCIETY OF SCIENCES OF DENMARK; OF THE ROYAL SOCIETY OF GOTTINGEN, AND OF THE ROYAL ACADEMY OF SCIENCES OF MODENA; HONORARY ASSOCIATE OF THE ROYAL ACADEMY OF SCIENCES OF LYONS; ASSOCIATE OF THE SOCIETY OF CIVIL ENGINEERS; MEMBER OF THE SOCIETY OF THE ANTIQUARIES OF SCOTLAND; OF THE GEOLOGICAL SOCIETY OF LONDON, AND OF THE ASTRONOMICAL SOCIETY OF LONDON; OF THE AMERICAN ANTIQUARIAN SOCIETY; HONORARY MEMBER OF THE LITERARY AND PHILOSOPHICAL SOCIETY OF NEW YORK, OF THE HISTORICAL SOCIETY OF NEW YORK; OF THE LITERARY AND PHILOSOPHICAL SOCIETY OF UTRECHT; OF THE PHILOSOPHICAL SOCIETY OF CAMBRIDGE; OF THE LITERARY AND ANTIQUARIAN SOCIETY OF PERTH; OF THE NORTHERN INSTITUTION, AND OF THE ROYAL MEDICAL AND PHYSICAL SOCIETIES OF EDINBURGH; OF THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA; OF THE SOCIETY OF THE FRIENDS OF NATURAL HISTORY OF BERLIN; OF THE NATURAL HISTORY SOCIETY OF FRANKFORT; OF THE PHILOSOPHICAL AND LITERARY SOCIETY OF LEEDS, OF THE ROYAL GEOLOGICAL SOCIETY OF CORNWALL, AND OF THE PHILOSOPHICAL SOCIETY OF YORK.

WITH THE ASSISTANCE OF

GENTLEMEN EMINENT IN SCIENCE AND LITERATURE.

IN EIGHTEEN VOLUMES.

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THE

EDINBURGH ENCYCLOPÆDIA.

FUCI.

The Fuci constitute a tribe of plants commonly included, along with Ulvæ and Marine Confervæ, under the more general title of Submersed Algæ, or *Thalassiophyta*, (from θαλασσιος *marine*, and φυτον *a plant*), and well known in this country by the popular name of Sea Weeds, (a familiar appellation which we shall not scruple to employ). In Scotland, the name *wrack* (probably from the French *varec*) is often applied to those fuci which are cut on the shores for the manufacture of kelp. In the Sexual System, the fuci form part of the third order, Algæ, of the last class Cryptogamia; an order in which Linnæus included Jungermannia, and the other genera now denominated Hepaticæ. In the system of Tournefort, they form part of the second section, *Plantæ marinæ*, &c. of the 17th class, *Aspermæ vulgo habitæ*. The word *fucus*, (φυκος), which means a paint, may be supposed to allude to the quality possessed by some of the small reddish species, of affording a sort of rouge.

Alliances.

It is not easy to class the thalassiophytes with any of the families of land plants. In the most recent systematic works, they are placed after the Tremellæ, with which they are connected by the Ulvæ. To the Lichenes, which follow them, they are more closely allied: So great is the affinity of one little species, Fucus pygmæus,* that in the *Flora Danica* it is described by the name of Lichen confinis, and in the *Methodus Lichenum* of Dr Acharius, as a Stereocaulon. The general resemblance between the rein-deer lichen and two plants figured by Mr Turner, in his *History of Fuci*, F. viscidus, t. 119, and F. amphibius, t. 109, is striking; and the ramuli of F. Chemnitzia, (t. 200), greatly resemble the shields of Parmelia perforata elevated on peduncles. If more illustration be wanting, it may be noticed, that four different species of sea-weed have, at different times, on account of their similarity to lichens, received the trivial name of *lichenoides*.

In some of the fuci, other striking resemblances to certain land plants may be traced; but these are of no importance towards their classification. To creeping land plants, they are allied by a curious family, known by the title of Caulerpæ, to be afterwards described. In general appearance, some fuci resemble filices, and others musci: F. membranaceus, (*Turn.* t. 158), and F. Woodwardia, (*Ner. Brit.* p. 13, t. 6), are very like ferns of the genus Woodwardia; and the frond of F. scalpelliformis, (*Turn.* t. 174), has a great similarity to some mosses of the genus Fissidens.

With the animal kingdom, sea-weeds are connected by F. tomentosus, and F. bursa, (*Turn.* t. 135, 6,) both of which resemble sponges in imbibing water, and giving it out on being pressed; and also in emitting a peculiar disagreeable odour a few hours after being taken from the sea. F. bursa, indeed, is classed, both by Linnæus and Pallas, as a zoophyte. F. simpliciusculus of Turner, (t. 175), and F. lycopodium, (t. 199), approach very near to that class of beings; but, of all others, a small caulerpa, found by Mr Brown in King George's Sound, attached to mytili, and lately figured by Turner, under the title of F. peniculus, (t. 228), forms a link that most closely unites sea-weeds to the animal kingdom.

If it is a difficult task to distinguish and arrange the vegetable productions of the surface of the earth, which can be examined at all seasons, the difficulty is evidently greatly increased in regard to marine plants. In these last the organization is more simple, and consequently they exhibit fewer distinctive characters; and their place of growth almost precludes the possibility of watching their progress and reproduction. Those best able to delineate their characters are often situated at a distance, and must decribe from the examination of specimens not always judiciously selected by others; frequently from such as are torn from the rocks, and thrown ashore in storms, when the root or means of attachment is generally wanting.

History.

The older botanists, such as Clusius, the Bauhins, Barrelier, and Morison, contented themselves with giving very short descriptions, or a few figures of sea plants. About the year 1711, Reaumur first examined the parts of fructification in some fuci. He fell into a mistake similar to that which long prevailed concerning the seeds of ferns and mosses; in considering as seeds what are truly capsules, or tubercles, containing seeds. The opinions of Reaumur seem to have been

Reaumur.

* Excellently figured in Lightfoot's *Flora Scotica*, p. 964, t. 32. (The first time that any species of fucus is mentioned, a good figure of it is, in general, referred to.)

Fuci. History. Linnæus. almost implicitly adopted by botanists down to the close of the 18th century. The celebrated Linnæus had too much to do in reforming the arrangement of phænogamous plants, to pay very great attention to the cryptogamia. His situation at Upsala was certainly not favourable for the investigation of the submersed algæ, and his herbarium contained but comparatively a few species; yet he described near 60 species of fuci. In 1768, Gmelin published, in 4to, his *Historia generalis et specialis Fucorum*, a work in which he not only collected whatever was previously known, but added very considerably to the stock of knowledge. Indeed, considering it as the first general work on this branch of natural history, the author deserves great praise. He divided the plants of which he treated into nine orders: Vesiculosi, Globuliferi, Penicilliferi, Corallini, Membranacei, Radicati, Agara, Tremellæ, and Ulvæ. He described 101 species; of which number he considered 37 as new, for he gives no synonimes with them. Linnæus's name is given to 27 species only. His notions, in general, concerning the fructification of fuci, and particularly the supposition of *unisexual* and *asexual* plants, were rather crude, and have not been adopted.

Gmelin.

Ray. The numerous fuci which inhabit our own shores, have been gradually illustrated by a series of writers since the days of Ray, who enumerated a good many in his *Synopsis*. Those kinds of algæ which Dillenius considered as entitled to a place in his *Historia Muscorum*, which were chiefly Confervæ, he arranged according to general habit and structure. But in the minute kinds, the want of a microscope has often led him into error; for instance, to describe as jointless, plants in which the dissepiments are obvious under an ordinary lens. Withering, in his Arrangement of British Plants, gives descriptions of a number of species. He subdivides the genus into several sections: those with bladders; with pod-like leaves; necklace-like, or jointed; flat; cylindrical; and capillary: the flat he farther distinguishes as either mid-ribbed or ribless; and these he still further separates, as either opake or pellucid: both the cylindrical and capillary he likewise subdivides by the same character of opake and pellucid. Hudson, in his *Flora Anglica*, is remarkable for care and accuracy; in evidence of which it may be mentioned, that his nomenclature is seldom altered by that most scrupulously exact naturalist Mr Turner of Yarmouth, in his writings on this branch of natural history. The descriptions of Lightfoot, in his *Flora Scotica*, when made from specimens picked up by himself, and examined on the spot, are highly characteristic and luminous. The *Nereis Britannica* of Stackhouse, which appeared, in fasciculi, between 1795 and 1802, has very considerable merit. The author had good opportunities of examining the English sea-weeds, as he resided on the shores of Cornwall. He divided the genus Fucus into several genera, chiefly according to the fructification; and although he was but imperfectly acquainted with this, his arrangement deserves attention, and shall be afterwards detailed. Major Velley's figures, which are highly finished, and his dissertation on the propagation of fuci, do him great credit. In the third volume of the Transactions of the Linnean Society, the Bishop of Carlisle and Mr Woodward not only gave a most accurate summary of the state of knowledge with regard to British fuci; but added several new species, and amended the specific characters of others. In the course of editing the extensive periodical work *English Botany*, Sir James Edward Smith likewise added several new species to the list. In 1802, Mr Dawson Turner, of Yarmouth, produced his *Synopsis of British Fuci*, a valuable little work, which gave the most encouraging earnest of what might be expected from this writer, in his great work on fuci, then only projected, but the publication of which is now considerably advanced.

Dillenius. Withering. Hudson. Lightfoot. Stackhouse. Velley. Goodenough and Woodward. Sir J. E. Smith. Turner.

Corréa da Serra. In the Philosophical Transactions for 1796, M. Corréa da Serra, a Portuguese naturalist of merit, published his remarks on the fructification of those fuci which are furnished with distinct receptacles. In the following year, Dr Albert William Roth of Bremen published his *Bemerkungen über das Studium der cryptogamischen Wassergewächse*, in which he divided cryptogamic water plants into new genera, to be afterwards mentioned. In the *Catalecta Botanica* of the same writer, considerable additional light has been thrown on marine plants, particularly by the communications of Professor Mertens of Bremen, characterised by Mr Turner as one of the most able algologists of the present day. Professor Esper's *Icones Fucorum cum characteribus systematicis, &c.* in 4to. appeared in 1799. It is a useful work, though, as the author described and figured from dried specimens only, both his descriptions and representations are occasionally imperfect and unsatisfactory. Professor Weber and the late Dr Mohr, in their *Beiträge zur Naturkunde*, have endeavoured to subdivide the genus Fucus by the character and disposition of the seeds; and in the course of this attempt, have made many excellent observations on this tribe of plants. In 1803, Baron Xavier du Wulfen published a little work, entitled *Cryptogamia Aquatica*, containing some useful information concerning fuci. In the *Flora Danica*, published in folio, at the expence of the Danish government, (a lesson to governments that are more rich and powerful,) a number of fuci, from the shores of the Baltic, and likewise from the distant settlements of that industrious nation, have been figured and described by the successive editors, Oeder, Vahl, and Hornemann. Several other foreign writers have, at various times, contributed to a general knowledge of fuci; particularly the Count Ginanni Ravennate, Bishop Gunner in his *Flora Norvegica*, Rumphius in his *History of Amboyna*, Seba in his *Thesaurus*, and Forskael in the *Flora Ægyptiaco-Arabica*.

Roth. Esper. Weber and Mohr. Wulfen.

French writers. The French have of late distinguished themselves in this branch of natural history. The labours of Decandolle deserve much praise. There is a very good general account of fuci given by M. Poiret, in the botanical part of the *Encyclopedie Methodique*. The *Flora Atlantica* of Desfontaines is a work of great merit. But above all, M. Lamouroux of Agen, now Professor of Natural History at Caen, has studied the fuci with uncommon diligence and success. He published, in 1804, dissertations on several new or rare species; and in 1813 he gave a new arrangement of the family, in the twentieth volume of the *Annales du Museum d'Histoire Naturelle*. Of this arrangement we think it right to give a pretty full account, because at present it is the best. We must however confess, that in our opinion there has been some precipitancy in bringing it before the public. It would certainly have been far better, first to have published descriptions and figures of the many *species ineditæ* referred to by the author, and to have left the classification to the last. This is the plan wisely adopted by Mr Turner; and circumstances seem to intimate, that the French naturalist has not been entirely free of a wish to anticipate our countryman. But, in any case, it may be deemed fortunate for Mr Turner, that M. Lamouroux has actually given his views to the world; for while the can-

Lamouroux.

Fuci. History.

dour of the former will induce him to bestow all due honour on any rival arrangement, we confidently trust that he will not suffer his own sound judgment to be shackled, but will proceed, unembarrassed, on the foundation which he has so well laid, to rear a system worthy of his name; and we are therefore not displeased to find it announced as his opinion, that previously to any permanent classification being established, it will be proper to reduce the present genera, Fucus, Ulva, and Conferva, into one mass, and to proceed in arranging *de novo*.

Turner and Hooker.

The first fasciculus of the *Historia Fucorum*, or General History of Fuci, by Mr Turner, was published in 1807. Above forty fasciculi have now (1815) come out; in which about 240 species have been described and illustrated. We speak the opinion of very competent judges on the Continent when we say, that both the descriptions and the coloured engravings are admirable, and do honour to the country. The latter are chiefly from drawings from the masterly pencil of Mr William Jackson Hooker, well known for his Tour in Iceland, and his beautiful monograph of the Jungermanniæ. Never, as remarked by Sir James Edward Smith, was there a more perfect combination of the skill of the painter and the botanist than in this work. It is meant to include figures of all those plants which have, by Linnæus and subsequent botanists, been arranged under the genus Fucus. Many new species have already been added, communicated by distinguished botanists and travellers, particularly Mr Robert Brown, (the associate of the unfortunate Flinders), who remained for more than a year about Van Diemen's Land and Kent's Islands, and had thus a precious opportunity of collecting the marine plants of those distant countries, which he did not fail to improve. The fuci collected by Lord Valentia and Mr Salt, in the Red Sea, also enrich the work; and Professor Mertens has communicated the Asiatic fuci collected in the first Russian voyage round the world, in the ships Newa and Nadeshda. The distinguished Dr William Wright, of Edinburgh, freely communicated those he had gathered on the shores of Jamaica, during his residence in that island. The illustrious Presidents of the Royal and the Linnean Society (Sir Joseph Banks and Sir J. E. Smith) are likewise contributors. The descriptions by Mr Turner are ample and luminous, and are given both in Latin and English. Particular care is bestowed in illustrating the physiology and fructification, and on this account the work is doubly interesting. In no botanical production was there ever greater attention paid to minute accuracy; and some very general allegations of occasional incorrectness, thrown out by Lamouroux in the *Annales du Museum*, are perhaps sufficiently confuted by this fact—that not one instance of real error is specified by the critic. The names at present attached to the plants by Mr Turner, may, in some measure, be considered as temporary; at least new generic names must be adopted. It is probable, however, that, in the *arrangement* with which he is to conclude his work, few of the specific or trivial names will need to be changed. Every classification of fuci must, in the present state of our knowledge of them, be to a certain extent artificial; but from this author, as near an approach to a natural arrangement as possible, may confidently be expected.

Explanation of Terms.

Before going farther, it seems proper to explain, in a general way, a very few terms, chiefly connected with the fructification of the fuci, as these terms must frequently recur in the subsequent part of this article, and are scarcely to be found explained in elementary books, as applicable to this class of plants.

Receptacle. Plate CCLXI. Figs. 3, 4, 5.

By a *receptacle* is meant a process, often resembling a pod, and generally containing many tubercles, which again contain the seeds, as in Claudea elegans, (Plate CCLXI. Fig. 3.); F. vesiculosus, Fig. 4.; and F. nodosus, Fig. 5. at *a a a*.

Tubercle.

Tubercles are nearly solid, generally roundish, often composed of minute fibres, among which the seeds lie; they frequently resemble pimples or warts, and are often perforated, or marked with a pore; frequently clustered together; sometimes half immersed in the frond; sometimes on short peduncles. See Plate CCLXI. Figs. 3, 4, 5, above referred to; and also Fig. 7.

Fig. 7. Capsule. Figs. 10, 11.

Capsules are seed-vessels, often partly hollow; frequently placed singly; smooth on the surface; sometimes spherical, but often of a lanceolate shape, like minute siliquæ. See Plate CCLXI. Fig. 10. spherical capsules; Fig. 11. lanceolate capsules. In some cases, it may be observed, the terms *tubercle* and *capsule* become nearly synonymous: they seem to be used almost promiscuously by Mr Turner, in speaking of particular species, as F. bracteatus, gigartinus, and kaliformis, (*Turn.* t. 25, 28, 29.)

Vesicle.

Vesicles are the air-bladders, well known in F. vesiculosus, Plate CCLXI. Fig. 4. *b*; and nodosus, Fig. 5. *b*, and others; but these *vesiculæ* have no connection with the fructification.

Previous to the account of Lamouroux's system, it may be right to notice very shortly some of the methods suggested since the time of Linnæus and Gmelin, particularly those of Walker, Stackhouse, Roth, Decandolle, and Wahlenberg.

Dr Walker's Method.

Method of Dr Walker.

The method of Dr John Walker, late professor of natural history in the University of Edinburgh, was never published; but it has been kindly communicated by his friend Mr Charles Stewart (author of Elements of Natural History, in 2 vols. 8vo. 1801, and editor of the new edition of Dillenius's *Historia Muscorum*), as contained in vol. 6th of the Doctor's Adversaria, dated 1771. We trust that we do an acceptable service to botanists in here preserving it. Not that it is preferable to some later methods, but that it constitutes matter of some curiosity, and enables us to trace the progress of the science. It has besides been indirectly alluded to by Mr Turner, in his *Historia Fucorum*, vol. i. p. 96.

Dr Walker divides the submersed algæ into fourteen genera: Cervina, Flabellaria, Bombycina, Annularia, Nodularia, Catenaria, Fucus, Platyceros, Phasganon, Ulva, Chartacea, Plumarium, Neurophyllum, and Spongia. Of these we shall give a very brief account, stating only the essential character, and the description of the fructification; and we think that fairness requires that the characters and descriptions be given in his own words.

The 1st genus *Cervina* or Hornweed, has the following character: "Coriacea, dichotoma, inarticulata. *Fr.* Vesiculæ terminales vel superficiales, sessiles." It is divided into two sections; compressed, as Fucus nodosus, and round, as F. fastigiatus, Lin. (rotundus, *Turn.* t. 5.) By *vesiculæ*, it is scarcely necessary to remark, the author means receptacles: He uses *bullæ* to express air-vesicles.

2d genus, *Flabellaria* or Fanweed: "Coriacea, pen-

Method of Walker.

nata, inarticulata. *Fr.* Vesiculæ rotundatæ solidæ terminales." It is likewise divided into two sections; with air-bladders as F. siliquosus (*Turn.* t. 159); and without air-bladders, as F. pinnatifidus, (t. 20.)

3d, *Bombycina* or Silkweed: "Cartilaginea abulla, inarticulata, ramis filamentosis. *Fr.* Vesiculæ globosæ, solidæ, ramis solidis." This includes Conferva scoparia, C. tomentosa, and similar plants.

4th, *Annularia* or Ringweed: "Cartilaginea annulata, ramis filamentosis. *Fr.* Tuberculæ globosæ solidæ terminales." This is subdivided into several sections, and embraces a number of Confervæ, as C. fucoides and pennata of Hudson.

5th, *Nodularia* or Knob-weed: "Herbacea, viridia, ramis alternis, capillaceis, nodosis. *Fr.* Tubercula ramos per intervalla occupantia." This is divided into sections, with simple filiform fronds, as Conferva plicata of Hudson, and with filiform fronds much branched, as C. glomerata.

6th, *Catenaria* or Chain-weed: "Gelatinosa, ramosa, articulata; articulis tumidis." The fructification was unknown to the author. The genus was divided into several sections, with verticillate, opposite, dichotomous, and alternate branches, and included Ulva articulata of Hudson, Conferva corallinoides of Linnæus, and similar plants.

7th, *Fucus* or Wrack: "Coriaceus, dichotomus, costatus. *Fr.* Vesiculæ terminales, intus gelatinosæ, tuberculis seminalibus rotundis." This is divided into sections; with air-bladders, as F. vesiculosus; without air-bladders, as F. serratus, (*Turn.* t. 90.); and with inflated fronds, as F. inflatus of Linnæus, now ascertained to be a variety only of F. vesiculosus.

8th, *Platyceros*: "Palmatus, dichotomus, enervius. *Fr.* Vesiculæ superficiales, sessiles, sparsæ, subglobosæ." This is subdivided into leathery, membranaceous, and gelatinous, and, according to Dr Walker, embraces F. ceranoides and lacerus of Linnæus.

9th, *Phasganon* or Tangle: "Stipitatum, monophyllum, coriaceum. *Fr.* Vesiculæ superficiales globosæ, gelatinosæ, inter corticem et epidermidem folii tumidæ." This is subdivided into two sections; those which are nerveless or destitute of a midrib, and those which have a midrib. The former section includes Ph. balteiforme, or Sea-belt of Dr Walker, (F. saccharinus, Lin.); Ph. Mariæ or St Mary's thistle, Walk. (F. polyschides, Lightf.); and Ph. esculentum, or Common tang, Walk. (F. digitatus, Lin.) The latter section includes Ph. Scoticum, Walk. or F. esculentus, Lin.

10th, *Ulva*, or Laver: "Sessilis, monophylla, membranacea, enervia. *Fr.* Tubercula intra membranas, Lin." There are three sections, by means of which plants very widely different are brought together: (1.) Frondescent, including U. umbilicalis, or slake; (2.) completely tubular, such as the common U. compressa; and (3.) tubular, divided by septæ, embracing F. filum of Linnæus, afterwards described (*Turn.* t. 86).

11th, *Chartacea*, or Dilse: "Sessilis, monophylla, enervia, palmata, laciniata." The fructification was unknown to Dr Walker. There are two sections; membranaceous and gelatinous. The first includes the common dilse, F. palmatus (*Turn.* t. 115.), with F. prolifer, (*Lightf.* t. 30.) and others: the second, F. gelatinosus of Hudson, the Sea ragged staff of Pallas, 353. It may be observed, that Fucus Sarniensis of Roth, (*Turn.* t. 44.) was known to Dr Walker by the name of Chartacea dichotoma.

12th, *Plumarium*, or Feather-weed: "Stipitatum, cartilagineum, inarticulatum, ramosum, pennatum; fronde composita. *Fr.* Globuli laterales sessiles." This genus is divided into several sections, being cartilaginous or membranaceous, and possessing or wanting a midrib; and includes F. plumosus, (*Turn.* t. 60.) dentatus, (t. 13.) and others.

13th, *Neurophyllum*, or Nerve-weed: "Stipitatum, ramosum; foliis membranaceis distinctis. *Fr.* Tubercula globosa pedunculata, superficie foliorum." F. sanguineus is a good example of this genus, (*Turn.* t. 36.)

Spongia is the last genus of Dr Walker; and he divides sponges into sessile and branched; but it is now generally admitted that they belong to the animal, and not to the vegetable kingdom.

Mr Stackhouse's Method.

Method of Stackhouse.

Mr Stackhouse published his arrangement, in his *Nereis Britannica*, about the year 1797. He formed six genera: Fucus, Palmaria, Chondrus, Sphærococcus, Corda, and Codium; the characters of which are taken chiefly from the fructification, but partly from structure.

1. *Fucus* has this generic character: "Fructification a jelly-like mass, with imbedded seed-bearing granules, and external conical papillæ, terminating." This genus is divided into two sections; with the fruit exserted, as F. serratus and vesiculosus; or innate, as F. loreus, (*Turn.* t. 196.)

2. *Palmaria.* "Skin smooth, glossy, polished on each side, with a colourless mucus within; forming together a thick consistent substance, with the seeds very minute, naked, orbicular, of the colour of the skin of the plant, disposed in patches or in lines, just within the surface of the cuticle." This includes F. digitatus, (*Turn.* t. 162.) and edulis, (t. 114.)

3. *Chondrus.* "Fructification an ovate rigid imbedded pericarp, containing seeds in a clear mucus, and prominent on either surface." This embraces only one species, F. crispus, and its numerous varieties. (*Turn.* t. 216, 217.)

4. *Sphærococcus.* "Fructification, external globular pericarps, adnate or immersed; sessile or pedunculate; containing seeds as in the others." This genus is subdivided into several sections; with distinct leaves, as F. sanguineus; with a midrib, as F. alatus, (*Turn.* t. 160.); with a compressed frond, as F. coccineus; or a round frond, as F. rotundus.

5. *Chorda.* "Fructification a mucous fluid in the hollow part of a cylindrical frond, with naked seeds affixed inwardly." The principal example of this genus is F. filum.

6. *Codium.* "Fructification invisible to the naked eye; frond roundish; soft and spongy when wet; velvety when dry." This embraces only the sponge-like fuci, particularly F. tomentosus, a fine downy or spongy sea-weed found on the south-west shores of England, (*Turn.* t. 135.)

Mr Stackhouse expresses his conviction, that his genera Fucus and Sphærococcus will soon fall to be further divided into several new genera; and he mentions some species having anomalous fructification, particularly F. ligulatus, (*Fl. Scot.* t. 29.) and lycopodiodes, (*Turn.* t. 12.) to which he had not been able to give a place in his arrangement.

Dr Roth's Method.

Method of Roth.

Dr Roth, in his *Catalecta Botanica*, and in his *Re-*

Fuci. Method of Roth.

marks on the Study of Cryptogamic Water Plants, proposes the following genera: Fucus, Ceramium, Batrachospermum, Conferva, Mertensia, Hydrodictyon, Ulva, Rivularia, Linckia, and Tremella. The plants usually denominated sea-weeds, are contained in four of these genera, viz. Fucus, Ceramium, Conferva, and Ulva.

Fucus is characterised thus: "Vesicles (receptacles) aggregate, imbedded in the substance of the frond, and furnished with mucifluous pores."

Ceramium thus: "Plant filiform, substance membranaceo-cartilaginous, with adnate granuliferous capsules." Of this genus there are two divisions: 1st, With uniform capillary fronds, containing some of the more slender fuci, and of the unjointed capsuliferous confervæ; 2d, With the fronds irregularly jointed, comprehending the jointed fuci, and the remainder of the capsuliferous confervæ. It may here be noticed, that Mr Stackhouse at one time, while the French revolutionary wars prevented the naturalists of this country from knowing what was done by their brethren on the Continent, proposed to constitute a very different genus, embracing the broad smooth-fronded fuci, under the title of Ceramium; but that he afterwards dropt that name, and substituted the appropriate one of Palmaria.

The *Confervæ* of Roth, are defined as consisting of small tubes, or herbaceous filaments, with granules of fructification scattered on the inside coats of the tubes; and the *Ulvæ*, as presenting expanded diaphanous membranes, with granules of imbedded fructification principally towards the margins, which the Doctor considered as liable first to decay, and thus to liberate the seeds.

M. Decandolle's Method.

Method of Decandolle.

M. Decandolle, in the *Flora Gallica*, and *Flore Française* (1805), has given an arrangement of the submersed algæ, chiefly founded on the writings of Dr Roth, and M. Vaucher of Geneva. Eleven genera are enumerated: Nostoch, Rivularia, Ulva, Fucus, Ceramium, Diatoma, Chantransia, Conferva, Batrachospermum, Hydrodictyon, and Vaucheria. Of these, Ulva, Fucus, and Ceramium, comprize the sea-weeds.

Ulva includes all those with membranaceous fronds, in which the seeds or capsules are placed under the epidermis, without any means of being discharged but by the destruction of the frond itself. The genus seems rather heterogeneous, and is divided into no fewer than six sections: (1.) Those that are gelatinous within, as F. tomentosus; (2.) Those that are tubular, as the well-known Ulva compressa; (3.) Flat, without peduncle, and without mid-rib, as U. umbilicalis, or laver; (4.) Flat, with a longitudinal mid-rib, as F. membranaceus; (5.) Flat, with a peduncle, as the well-known tangle F. digitatus; (6.) Flat, marked with transverse zones, as U. pavonia.

Fucus is characterized as flat or filiform, with the seeds or capsules united in groups or tubercles, sometimes lateral, sometimes terminal; the seeds being discharged by a distinct external pore. This description takes in a part only of the plants usually considered as fuci, particularly F. vesiculosus, serratus, siliquosus; some having, as already noticed, passed to the genus Ulva, and others, as F. filum, going to the following genus.

Ceramium is distinguished by having filiform fronds, which are either simple or branched, and with or without articulations, bearing tubercles full of globules, which globules appear to be capsules. This includes the species of Dr Roth's second division of Ceramium, with articulations, those of the first being sent back to the genus Fucus: it likewise embraces the marine Confervæ. The genus Conferva of the Flore Française is confined to those fresh-water species which were huddled together by Linnæus, under the name of *Conferva bullata*.

Dr Wahlenberg's Method.

Method of Wahlenberg.

Dr Wahlenberg* proposes the division of the Linnean genus Fucus into three genera, or rather tribes: *Fucus*, properly so called; *Sphærococcon*; and *Palmaria*.

1. *Fucus*: "Semina in capsulis poro dehiscentibus, aggregatis, frondi immersis; simulque adsunt vesiculæ simplices seu articulatæ." This includes F. serratus, vesiculosus, siliquosus, nodosus, loreus.

2. *Sphærococcon*: "Semina in capsulis imperforatis, solitariis, superficialibus; simulque adsunt granula immersa in appendicibus foliorum, fere ut in confervis." This takes in F. sanguineus, alatus, plumosus.

3. *Palmaria*: "Semina solitaria nuda, in frondium superficie." This includes the large fuci, as F. digitatus, and saccharinus, (*Turn.* t. 163.)

He adopts the following subdivisions:

(1.) Frondescent, with a simple mid-rib or nerve in the centre of the frond; as F. serratus and vesiculosus.

(2.) Frondescent, with branched veins or nerves; as F. sanguineus, and sinuosus, (*Turn.* t. 35.)

(3.) Stipitate, with a simple stem, proceeding from a fingered root, and spreading out into a broad frond; as F. digitatus and saccharinus.

(4.) Foliaceous and stemless, membranaceous, without nerves or veins; as F. palmatus, and canaliculatus (*Turn.* t. 3.)

(5.) Caulescent, with distinct fruit-bearing processes, (i. e. receptacles), which are deciduous; as F. siliquosus and nodosus.

(6.) Caulescent, naked and compressed; as F. loreus and plumosus.

(7.) Filiform, with spherical fronds; as F. filum and lycopodiodes.

M. Lamouroux's Method.

Method of Lamouroux.

Lamouroux, far from confining himself to the fructification as the basis of his divisions, derives his characters from every part of the plant, or even from any remarkable accessary circumstance. He divides all the thalassiophytes, into six Orders, viz. Fucaceæ, Florideæ, Dictyoteæ, Ulvaceæ, Alcyonideæ, and Spongodeæ.

1. Fucaceæ.

The *first order*, Fucaceæ, is the most numerous. They are distinguished by their "woody structure, and their colour being somewhat olive, drying to blackish."

Most of the species of this family have distinct stems and leaves. In the stems of the larger kinds, particularly in F. digitatus, may be observed parts analogous to the epidermis, bark, wood and pith of land plants. The Fucaceæ are readily torn in a longitudinal direction, and a well characterized fibrous organization is then displayed. In general the fibres are divided by septa; the partitions being more distant and of a looser texture than in herbaceous plants. In most of the Fucaceæ the organs of fructification are complicated: According to Lamouroux, the *seeds* are inclosed in *capsules*; these

* Georgii Wahlenberg *Flora Lapponica*, Berlin, 1812, 8vo.

Fuci. Method of Lamouroux. FUCACEÆ.

capsules are themselves enveloped by a particular membrane, and form *tubercles*; and these tubercles are grouped into polymorphous *masses*. These masses are attached to the branches or to the extremities of fronds; they contain a mucilaginous matter, the quantity and viscidity of which increase as the seeds ripen; and when they are dispersed, it disappears with them. The fronds of the Fucaceæ vary in composition, situation, general or particular shape, with or without nerves; exhibiting a variety almost as great as the leaves of dicotyledonous plants.

Fucus.

The 1st genus is *Fucus*, which is thus defined: "Tubercles numerous, collected in cylindrical receptacles, which are flat or compressed, solitary or in pairs; the root an expanding callous disk." This character has no doubt the effect greatly to reduce the numbers of the old genus Fucus; but it is still very extensive, and the author has judged it necessary to divide it into no fewer than eleven sections. Plants which materially differ in general aspect and habit are still brought together: thus F. natans, siliquosus, vesiculosus, loreus, and canaliculatus, are arranged under this one genus; while we might expect them to form as many distinct genera. In specifying the different sections, some of the best known or most remarkable species shall be mentioned as examples.

Sect. (1.) With petiolated air-vesicles; leaves distinct, either sessile or petiolated. This includes F. natans and F. bacciferus of Turner, (t. 46, 47.) both of them found floating in the ocean, and forming much of the Mar do Sargasso of the Portuguese. But not one British species falls under this section, unless, perhaps, F. salicifolius of Poiret.

(2.) With petiolated air-vesicles, furnished with a terminal foliaceous membrane; as F. turbinatus, (*Turn.* t. 24.) found in the East and West Indies.

(3.) With oblong vesicles, winged with a triple membrane, producing a three-sided or angular appearance. A single species only belongs to this section, viz. F. triqueter, (*Turn.* t. 34.) from the sea near the Cape.

(4.) With petiolated vesicles lengthening in the form of a pod. Highly characteristic of this section, a well known British species occurs, F. siliquosus; but the *vesicles* or air-bladders may be readily overlooked by a careless observer, on account of their resemblance to the *receptacles* generally to be found on the same plant.

(5.) The vesicles forming a part of the branches; leaves distinct. For example, F. tamariscifolius of Hudson, (F. ericoides, *Turn.* t. 191.)

(6.) Fructification at the ends of the fronds, which are flat, branched, generally provided with a single nerve, and with vesicles. This includes the two very abundant and well known species, F. vesiculosus and serratus.

(7.) Vesicles innate in the branches; the fructification on peduncles. This likewise includes a very general species, F. nodosus.

(8.) Without leaves; vesicles like a string of beads, and covered with the fructification. This section is created solely for the very remarkable sea-weed named by Labillardiere F. moniliformis, and by Mr Turner F. Banksii, (*Hist. Fuc.* t. 1.) The former name is so expressive of the character of the plant, that any change is to be deprecated, particularly as the illustrious President of the Royal Society is already loaded with well merited botanical honours.

(9.) Without vesicles, and with a single round umbilicated frond at the base of the branches.—This section embraces only the remarkable species F. loreus, common on many of our shores, and which attracts attention chiefly on account of the round umbilicated frond above mentioned, which, in the early stage of growth, resembles a large peziza, and gives the rocks the appearance of being covered with a crop of mushrooms.

(10.) Without leaves and without vesicles; fructification at the ends of the branches, which are channelled. —This takes in F. canaliculatus (*Turn.* t. 3.), common on our shores; and F. Mackaii (t. 52.), a species found on the west coast of Scotland, and named in honour of the discoverer Mr James Townsend Mackay, of the College Botanic Garden, Dublin, an excellent and most deserving botanist.

(11.) Without leaves or vesicles; branches cylindrical, with the fructification at the tips; as F. tuberculatus, (*Turn.* t. 7.)

Laminaria.

2. *Laminaria*: "With the root fibrous and branched." This generic character is perhaps objectionable, on the ground that the root is frequently wanting in specimens of sea-weeds which are cast ashore; but, on the other hand, the fructification, from which generic characters are commonly taken, is also frequently wanting, and at any rate it is very little known. Most of the laminariæ are large plants, with broad fronds, inhabiting deep places of the shores, where they are much exposed to the action of waves, and requiring therefore the strong mode of attachment with which they are furnished, and from which the generic character is derived. Some have air-vesicles, as F. pyriferus (*Turn.* t. 110.), and F. buccinalis (t. 139.); and in others, vesicles seem entirely wanting. Not only the gigantic sea-weeds of the Southern Seas, some of them described as more than 1000 feet in length, belong to this genus; the largest of the British fuci also fall under it, the well known great *tangles*, F. polyschides or bulbosus, F. digitatus and saccharinus.

Osmundaria.

3. *Osmundaria*: "Fructifications minute, oblong, on footstalks, situated at the points of the leaves; the leaves entirely covered with small spiny mamillæ."—This genus, named from its resemblance to some ferns of the genus Osmunda, is formed for the sake of one species of trifling size, brought from the shores of New Holland. Till, however, it be examined by some botanist in a recent state, its characters cannot be accurately known.

Desmarestia.

4. *Desmarestia*: "Fructification unknown; branches and leaves broad, contracted at their origin, so as to appear supported on petioles; the edges garnished with small spines."—This includes F. aculeatus (*Turn.* t. 187.), which is very common on our shores, and F. ligulatus (t. 98.), which is rare. Lamouroux, as well as Stackhouse, is inclined to consider the marginal spinules as containing the seeds of the plants; but Mr Turner has doubts on the subject.

Furcellaria.

5. *Furcellaria*: "Fructification pod-shaped, subulated, simple or branched, smooth, stem and branches cylindrical, and without leaves."—This includes only F. lumbricalis (*Turn.* t. 6.) and its varieties.

Chorda.

6. *Chorda*: "Fructification unknown; stem simple, cylindrical, divided by internal dissepiments,"—the *genicula intergerina* of Roth. The name Chorda was first applied by Stackhouse to a small group of fuci, consisting chiefly of F. filum and F. thrix. The latter is now known to be nothing but the filum in a young state; so that at present F. filum is the only species of this genus.

2. FLORIDEÆ.

The *second order*, FLORIDEÆ, are distinguished by their "organization being coralloidal; their colour be-

Fuci. Method of Lamouroux. Floridеæ.

ing purple or reddish, and acquiring lustre on exposure to the air." While fresh and living, the Florideæ are of a purplish red colour, but have nothing of the lustre which they acquire when dead, and when they have been exposed for some time, in a moist state, to the action of light and air, so as that a degree of fermentation may be excited. It is in this order that the double mode of fructification (afterwards described) is chiefly to be observed. The leaves of the Florideæ are flat expansions, divided rather than branched, proceeding from a cylindrical stem, fixed by a disc more convex and less extensive than that of the Fucaceæ. The leaf is just an expansion or continuation of the stem, and it is sometimes difficult to assign the respective limits of these parts. All the flat portions are reckoned leaf, and all the round or compressed parts, branch or stem. Some of the leaves have nerves, of a deeper colour than the rest of the leaf: in these, the fructification is situated on the nerves, or at their extremities. In leaves destitute of nerves, the fructification is spread over the surface of the leaf. The size of the Florideæ is not considerable, none of them much exceeding two feet in length. Lamouroux considers them all as annual or biennial productions.

He makes two divisions: 1st, With flat leaves, Claudea, Delesseria, Chondrus: 2d, With cylindrical leaves, and wanting leaves, Gelidium, Laurencia, Hypnea, Acanthophora, Dumontia, Gigartina, Plocamium, and Champia.

Claudea. 1. *Claudea.* "Tubercles in a pod-shaped receptacle, which is attached to the nerve by its two extremities."—There is only one species, Claudea elegans, which, according to Lamouroux, is the most beautiful of all sea-weeds, for variety of colour, elegance of shape, and delicacy of organization. It is certainly the most curious of all the tribe. (See Plate CCLXI. Fig. 1, 2, 3.) It was found on the coast of New Holland by the unfortunate Peron. The frond consists of a very fine membrane, which when dried is almost invisible to the naked eye, crossed by nerves forming a net-work. The fructification, as stated in the generic character, consists of rows of siliques, suspended by the two extremities between parallel nerves. Dried specimens exhibit fine tints of red, green, yellow, and violet, passing into each other in the most pleasing manner. It is figured in *Annales du Muséum*, tom. 20. pl. 8. fig. 2. from whence our figure in Plate CCLXI. is copied. It is always desirable that a generic name should, if possible, suggest some idea of the kind of plant intended; but although this could easily have been accomplished in the present case, the unmeaning title of Claudea has been imposed;—borrowed, we are told, from the Christian name of Lamouroux's father, *Claude*, and a better proof, surely, of filial attachment than of judicious nomenclature.

Plate CCLXI. Figs. 1, 2, 3.

Delesseria. 2. *Delesseria.* "Tubercles spherical, generally compressed, somewhat like grape-stones (subgigartina), innate, sessile, or pedunculated, situated on the nerves, the branches, the margin of the leaves, or scattered on their surface."—The colours are varied and brilliant. From rose-colour, or even bright scarlet, they descend to dark brown, passing through yellow, green, violet, and purple. Many of them are parasitical on the larger sea-weeds. The genus is subdivided into three sections.

a. With a single longitudinal nerve, simple or branched.—This includes several beautiful species, common on all our shores, F. sanguineus, sinuosus, alatus, and dentatus; with F. ruscifolius, (*Turn.* t. 15.) found on the south coast of England. Speaking of the first of these, F. sanguineus, Mr Turner remarks, that "in the elegance of its appearance, and the exquisite colour of its most delicately veined leaves, this plant so much excels all its congeners, that it carries away the palm with no less justice from the vegetables of the ocean, than the rose, the flower of the poets, from its rivals in the garden."

b. With the longitudinal nerves buried in the substance of the leaves. This takes in F. rubens and laceratus, found on our shores. The former is admirably described and figured by Lightfoot, in the *Flora Scotica*, vol. ii. p. 919. t. 30. under the title of F. prolifer. The latter is one of the variable fuci, Mr Turner (*Hist. Fuc.* t. 68.) describing no fewer than eight varieties. It is F. endiviæfolius of the *Flora Scotica*, t. 32. and it is to be observed that the longitudinal veins not being readily perceived, have been overlooked by Lightfoot and others.

c. Without any nerve or midrib. This includes the well-known F. palmatus, or *dilse* of Scotland, with the remarkably variable F. ciliatus, (*Turn.* t. 70.) which is also eaten; as well as F. edulis, (t. 114.) which, as implied in the trivial name, is considered as fit for food. F. Brodiæi of Turner, t. 72. likewise falls under this section: this species was found on the shores of Nairnshire, by Mr Brodie of Brodie, who likewise detected its fructification, and ascertained the specific differences of the plant.

Chondrus. 3. *Chondrus.* "Tubercles hemispherical or oval, situated on the surface of the leaves, never on the edges nor the extremities; leaves flat, branched, sometimes mamillary."—The generic name, it will be observed, is adopted from Stackhouse; but the character is changed. The small black lichen-like fucus, F. pygmæus, which covers many of our sandstone and greenstone rocks at high-water mark, belongs to this genus.

Gelidium. 4. *Gelidium:* "Tubercles nearly opake, oblong, situated on the branches or at their extremities." The generic name is derived from the quality which the plants possess, of being almost entirely reduced to a gelatinous substance, by boiling or maceration. The foreign species of which the swallows in India construct the edible nests, Lamouroux considers as belonging to this genus. F. corneus (*Stackh.* p. 61. t. 12.) and F. coronopifolius (*Turn.* t. 122.) rarely found on the English coast, are likewise gelidia.

Laurencia. 5. *Laurencia:* "Tubercles globular, somewhat like grape-stones, situated at the extremities of the branches and their divisions." F. pinnatifidus, the pepper-dilse of Scotland, may be mentioned as an example.

Hypnea. 6. *Hypnea:* "Tubercles subulated, almost opake." This is named from its general resemblance to the branched mosses or hypnums; but the fructification is not readily seen without a lens. F. Wigghii, (*Turn.* t. 102.) belongs to this genus. All the species are annuals.

Acanthophora. 7. *Acanthophora:* "Tubercles roundish, and spiny." The species of this genus are equatorial plants, in general appearance resembling Hypneæ.

Dumontia. 8. *Dumontia:* "Capsules solitary, scattered, innate in the substance of the plant; stem and branches fistular." The species are all of very delicate structure, and annuals.

Gigartina. 9. *Gigartina:* "Tubercles spherical or hemispherical, sessile, like grape-stones, filled with a semitransparent mucilaginous substance; stem uniformly cylindrical."—This includes most of the genus Ceramium of Roth. It is divided into three sections.

a. With distinct leaves; as F. subfuscus (*Turn.* t. 10.) and tenuissimus, (t. 100.) not uncommon on our shores.

Fuci. Method of Lamouroux. Florideæ.

b. Without leaves; stem and branches without contractions; as F. confervoides, (*Turn.* t. 84.) purpurascens (t. 9.) and plicatus (t. 180.) of our shores.

c. With evident contractions, as F. kaliformis, (*Turn.* t. 29.), articulatus (t. 106.), and opuntia (t. 107.) of the British shores.

Plocamium. 10. *Plocamium:* "Tubercles somewhat like grapestones; stems and branches compressed, the extremities partitioned, or divided by septa."—The plants of this genus approach nearest to the truly articulated sea-weeds or marine confervæ. They are all annual; and many of them parasitical on the perennial species. The elegant F. plumosus of our shores belongs to this genus; and the dissepiments in the extreme branches, or pinnæ, are beautifully delineated by Mr Turner, (*Hist. Fuc.* t. 60.) It must, however, be remarked, that though this new genus is evidently named from F. plocamium of Gmelin (F. coccineus of Hudson and others); yet this species, instead of affording a characteristic example of the genus, exhibits no traces of dissepiments in its branchlets.

Champia. 11. *Champia:* "Capsules numerous, somewhat egg-shaped; situated in papillæ rising from the stem and branches."—This consists only of one species, a native of the shores of the Cape of Good Hope.

3. Dictyoteæ. The *third order*, Dictyoteæ, is distinguished by the "organization being reticulated and foliaceous; the colour greenish, and not liable to become black on exposure to the air." This family consists of four genera, Amansia, Dictyopteris, Dictyota, and Flabellaria, all of them well characterized by the reticulated organization, which is visible with a common lens, or even by the naked eye. The fructifications are numerous, covering the surface of the leaves, on which they occur in groups of various shapes. The root consists of a fibrous callosity, furnished with very fine long whitish hairs, which become yellowish or brown in drying. In some species these hairs extend up the stem, or are continued on one side of the frond. They increase in number with the age of the plant. They seem analogous to the tufts observable on F. serratus, vesiculosus, and natans, and are probably secreting and absorbing organs. The dictyoteæ, which have nerves or midribs, are perennial, and are found chiefly in equatorial latitudes: those destitute of nerves are annual, and found chiefly in the northern seas.

Amansia. 1. *Amansia:* "Reticulations hexagonal, regular and elongated, with the points acute."—The species are foreign.

Dictyopteris. 2. *Dictyopteris:* "Capsules forming masses slightly elevated; scattered over the leaves, which are divided by a single nerve."—All the species are natives of warm climates.

Dictyota. 3. *Dictyota:* "Capsules collected in masses, forming lines having various directions."—This is divided into two sections: a. *Padina*, with the fructification in transverse, incurvated, and concentric lines: b. *Dictyota* proper, with the fructification in longitudinal lines, rarely transverse and never concentric, often entirely or partially scattered. The padina are analogous to the *fuci corallini* of Gmelin, and include those species which the late M. Draparnaud proposed to associate as a genus, under the title of *Zonaria.*

Flabellaria. 4. *Flabellaria:* "Fructification unknown; reticulations very fine and intermixed, so as to produce an appearance of felt."—This includes only one species, found in the Mediterranean.

4. Ulvaceæ. The *fourth order*, Ulvaceæ, is distinguished by the "organization being herbaceous and uniform, the colour green, becoming yellowish or whitish in drying."—This order comprises four genera, Asperococcus, Ulva, Bryopsis, and Caulerpa. It includes most of the species of the genus Ulva of Linnæus and others. The organization resembles that of the seminal leaves of many land plants, a herbaceous tissue destitute of fibres and vessels. The plants of this order abound with a mucilaginous matter, in which the colouring principle resides. The nature of the fructification is not yet accurately known. It is apparently very simple, seeming to consist of naked seeds imbedded in the frond at its surface. The bodies which have been taken for seeds, however, may in reality prove to be capsules, containing granules or seeds.

Fuci. Method of Lamouroux. Ulvaceæ.

1. *Asperococcus:* "Seeds solitary, scattered, at first innate, but afterwards prominent; stems fistular."—Of this genus, Ulva rugosa, Lin. may be considered as an example. Asperococcus.

2. *Ulva:* "Seeds solitary, innate in the substance of the plant, scattered, never prominent."—This genus is divided into two sections: Ulva.

a. With flat leaves; as U. lactuca, latissima, umbilicalis, all very common on our shores.

b. With fistular leaves; as U. compressa, which covers with its fine green colour almost all rocks where brackish water occurs.

3. *Bryopsis:* "Seeds globular, green, contained in the stem, or the branches, which are always fistular."—All the species are foreign. Bryopsis.

4. *Caulerpa:* "Fructification unknown; stem cylindrical, horizontal, creeping, and branched."—This is a curious genus, first described and figured in the French *Annals of Botany* for 1811, by M. Lamouroux. It is not clearly ascertained whether some, or perhaps even all the species, should not rather be considered as belonging to the animal than to the vegetable kingdom. The organization certainly differs from that of marine plants in general, and is more analogous to that of some zoophytes. Weber and Mohr rightly remark, that the stiff straw-coloured stem of a caulerpa exhibits few traces of vegetable organization. Even with the aid of a microscope, neither fibres nor reticulations can be detected; an epidermis is observable, and a cellular tissue, the cells of which are so extremely minute, that it is impossible to determine their form. The caulerpæ are destitute of any gelatinous or viscid property. Their membranaceous substance, and their uniformly green colour, have induced Lamouroux to place them among the Ulvaceæ. Sometimes the leaves of a particular species, Caulerpa prolifera, are partly covered with small opake points; such leaves have not the brilliancy nor half the transparency of the others; they are of a dull earthy green colour. If these points prove to be seed-vessels, then is Caulerpa properly placed among the Ulvaceæ; but the fructification is at present completely unknown. The roots are entirely fibrous, like those of many of the flexible zoophytes. The Caulerpæ grow, not on rocks, but on sandy shores, generally near high water mark, creeping in the loose sand and soil; and no other sea-weeds possess a similar mode of attachment. Viewed as plants, they may be considered (as formerly stated) as connecting sea-weeds with the vegetables of the earth. All the species are foreign, most of them tropical. When fresh, they are of a fine grass-green colour, which is liable to pass to a transparent horny white. Several of them are figured by Turner, under the names of F. pinnatus, taxifolius, clavifer, (*Hist. Fuc.* t. 53, 54, 57); and he has added some, entirely unknown to Lamouroux. Among these may be mentioned. Caulerpa.

F. cactoides, (t. 171.) brought by Mr Brown from the south coast of New Holland; and F. hypnoides, (t. 173.) brought from Kent's Islands by the same naturalist. This last is not only singular for its beauty, but is very remarkable for the exterior of the stem being closely beset with small scales, like some of the fern tribe: to this there is nothing analogous among the rest of the fuci; the appearance of scales in F. squamulosus (*Turn.* t. 128.) being occasioned merely by the remains of old ramuli. The other new species of Caulerpa published by Turner, were brought from the Red Sea by Mr Salt, and are likewise very curious. The Caulerpæ appear to be perennials, or at least to endure for more than one year. We may remark, that the sea-weed of a fine green colour, described by Humboldt as found growing in the sea at the great depth of 192 feet, and by him named Fucus vitifolius, belongs to this genus.

5. ALCYONIDEÆ. The *fifth order*, ALCYONIDEÆ, is characterised by the "organization being gelatinous, or like that of a tremella, of a dirty olive red colour, becoming darker on exposure to the air." The Alcyonideæ evidently approach very near to the zoophytes of the genus Alcyonium; but neither polypi, nor the habitations of polypi, are to be observed in them. A transverse section of these plants, exhibits large hexagonal or irregular reticulations, which diminish in size towards the sides of the stem. In a longitudinal section, these reticulations appear lengthened, and form at the exterior a very fine epidermis. The fructification of this order is conspicuous enough. It consists of yellowish capsules, situated in the epidermis, and full of small black seeds. The Alcyonideæ have considerable affinity to the genus Dumontia of the Florideæ, above described. They decompose rapidly when left by the tide on the shore. Their texture is so loose, that when once dried and compressed, they never resume their original form.

Alcyonidium. The only genus is *Alcyonidium*: "Capsules containing seeds, innate in the fleshy or gelatinous substance of the plant." The principal species is the Ulva diaphana of former writers, (*Eng. Bot.* t. 263), and which is not uncommon on our shores. It is remarked by M. Lafoy, that, at certain times of the year, the Ulva diaphana is phosphorescent; but this fact has not been accurately ascertained, and it is possible that the phosphorescence alluded to, may depend merely on numbers of a minute shining nereis adhering to the plant, when newly cast ashore, or drawn from the sea. We have frequently observed a brilliant phosphorescent appearance produced by this cause, in specimens of Fucus dentatus, and in various species of Sertulariæ, recently taken from the sea, the phosphorescence being renewed upon moving the specimens, or disturbing the minute animals.

SPONGODEÆ. The *sixth order*, SPONGODEÆ, has this character: "Organization spongy, colour green, tarnishing on exposure to the air." This order, as published by Lamouroux, consists only of a single genus, which Olivi, a distinguished Italian naturalist, proposed in his *Zoology of the Adriatic Sea*, under the name of Lamarckia. This name, however, having been pre-occupied by a genus of phænogamous plants, Stackhouse suggested Codium. Lamouroux has preferred *Spongodium*, on account of the general resemblance of the plants which constitute the genus, to some kinds of sponges, and because, like them, they imbibe water. It has this character: "Seeds scattered through the substance of the plant, but most abundant at the extremities of the filaments which clothe its surface." One of the principal species is Spongodium dichotomum, the Fucus tomentosus of former authors, figured in *English Botany*, t. 712, and in the *History of the Fuci*, t. 135. The substance of the plant consists of a collection of interwoven fistular tubes, full of a transparent fluid. The surface, as noticed in the character, is covered with small capillary filaments, which seem to serve for the absorption of water, and among which vesicles and capsules are to be looked for. These filaments are best observed while the plant remains in the sea: when it has been withdrawn for some time from that element, they nearly disappear. The colour is a dark grass green, which becomes paler by drying. It may be proper to add, that the Fucus fungosus, found on the coast of Barbary by Desfontaines, and described in the *Flora Atlantica*, is to be considered as only a variety of F. tomentosus. Another species of Spongodium is Fucus bursa of our shores, (*Turn.* t. 136.) the Alcyonium bursa of Linnæus. It may here be mentioned, that since the publication of Lamouroux's system, Turner has described and figured (*Hist. Fuc.* t. 175) a new spongodium, by the title of *Fucus simpliciusculus*, a name which is to be understood as applicable only in a relative sense, being meant to distinguish it from either the dichotomous ramification of F. tomentosus, or the spherical shape of F. bursa. Instead of having a soft velvety exterior like these, it is papillose; but its internal structure is quite similar. Turner remarks, that F. simpliciusculus, in external appearance, closely resembles the caulerpæ, having the same colour, the same glossy surface, and the same kind of substance, intermediate between the submersed algæ and the zoophytes, or even approaching more to the nature of the latter than of the former. The spongodeæ appear to last more than one year. They inhabit places never completely uncovered by the tide. They are nearly allied to the Ulvaceæ, and might perhaps commodiously follow them.

In Lamouroux's arrangement of sea-plants which has now been detailed, no fewer than 273 ascertained species are referred to by the author. There are, besides, near 200 unpublished species alluded to by him: of 20 of these, figures are given in the *Annales*, but no descriptions; and when, or in what form, the remainder are to be brought before the public, does not appear. There are nearly 100 *varieties* of different species mentioned; but in no tribe of plants is there greater difficulty in determining the limits between species and varieties; it will be nowise surprizing, therefore, if several of these varieties be hereafter established as species; and, on the other hand, a few of the species degraded to the rank of varieties. Marine plants are not only liable to very considerable diversity of form, but, as already noticed, it is nearly impossible to cultivate them with a view to observe their germination, and extremely difficult even to watch their progress, on their native submarine rocks, from infancy to maturity. Of the ascertained species, 148 are found on the shores of France.

In the course of our ample account of Lamouroux's arrangement, a number of particulars connected with the general history and physiology of these plants have been incidentally stated. There remain, however, several points deserving of further and separate consideration, particularly their germination and growth, their general structure, and the nature of their fructification.

Notwithstanding the many observations of late inquirers, in no department of natural history does there

Fuci.

remain greater room for discovery, than in tracing the progress of living fuci. The *habitat* of the plants presents many difficulties. It is only in a few favourable situations, in calm weather, and at low ebb tides, that observations can be made either as to the earliest appearance of the plants when germinating, or as to the progress of the fructification, and shedding of the seeds in the mature plant. To afford any satisfactory information, individual plants must be watched, visited at every season of the year, and the observations must be continued for a series of years.

Germination and Fructification of Fuci.

Germination.

Mr Stackhouse, we believe, is the only person who has succeeded in vegetating the seeds of fuci, or in convincing himself that he has done so; for doubts have been started as to the accuracy of his experiments. So extremely minute are the real seeds, and so great is the liability to error from other seeds floating unperceived in the waters of the ocean, that to prosecute discovery in this way, would probably be a hopeless task. It may be right, however, to state his mode of proceeding. He selected three species for his experiments, Fucus serratus, canaliculatus, and bifurcatus, (by which last, F. tuberculatus is to be understood.) He detached some specimens of these very carefully from the rocks, preserving their bases or roots uninjured. He placed them in wide-mouthed jars, and changed the water every twelve hours, drawing it off by means of a syphon, to prevent agitation. In the course of a week he succeeded in procuring what he considered to be the seeds. These, when ripe, he says, burst asunder transversely in the middle, with a kind of explosion. They appear therefore to have been, in reality, capsules containing seeds. They were inclosed in a bright mucus, immiscible with sea water, and likewise specifically heavier than it; so that this mucus was calculated to serve the double purpose of carrying the seeds to the bottom, and fixing them to the rocks. He thus ascertained that some marine plants scatter their seeds when ripe, without awaiting the decay of the frond. The next point was to cause the seeds to germinate. He took some pebbles and small fragments of rock from the beach, the surfaces of which he considered as having been thoroughly purified by friction; and after having drained off the greater part of the water in the jars, he poured the remaining drops on the stones. He left them to dry for some time, that the seeds might fix themselves. He then placed the stones in wide-mouthed jars, and alternately sunk them for some hours in sea-water, and exposed them to the air and rain, in order to imitate their peculiar situation between high and low water mark. In less than a week, a thin membrane was discoverable on the stones, precisely on the spots where the drops of water containing the seeds had been poured, and where of course the seeds had lodged. This membrane gradually extended itself and became of a blackish olive colour. There at last appeared mucous papillæ or buds coming up from the membrane. These buds were somewhat hollow in the centre, from whence a shoot pushed forth: in some instances they seemed to rise on a short thick footstalk, and in this case resembled minute pezizæ, favouring the supposition that other fuci besides F. loreus present at their base the mushroom appearance, though on a very reduced scale.

Fructification.

Till within these few years, the fructification of the fuci was little known; and even yet it is not by any means well understood. To the minute and accurate investigations of Mr Turner, Mr Hooker, Sir J. E. Smith, the late Miss Hutchins, and Mr Sowerby, jun. we are much indebted. But the fructification of the largest species in the world, F. pyriferus and buccinalis, and even of some of the largest and most common British species, such as F. digitatus, filum, and aculeatus, still remains to be discovered. Of the nature of the fructification of the caulerpæ, no conjecture has hitherto been formed.

By attending to the characters in Lamouroux's arrangement, a general idea may be gathered of the families of fuci in which the different kinds of fructification occur, whether consisting of receptacles, tubercles, capsules, or patches. It seems unnecessary, therefore, to enlarge much on this subject. A few farther remarks on the *double mode of fructification*, may however be proper. This double mode, it will be remembered, occurs either on the same plant, or on separate individuals of the same species; and it is of various kinds, some of which may be mentioned.

Double mode of fructification.

a. On different individuals of the same species, globular capsules and lanceolate capsules are observed, as in F. subfuscus, alatus, pinastroides (*Turn*. t. 11.), and coccineus: (see Plate CCLXI. Fig. 10, 11.) and both these kinds of capsules sometimes occur on the same frond of the last named species. This fact did not escape Mr Stackhouse; for in his *Nereis Britannica*, he makes it part of the specific character of F. coccineus, that it bears polymorphous fructification; and Mr Turner, in his *Synopsis*, afterwards divided it into two varieties, one with spherical capsules, the other with lanceolate or elliptical capsules.

Plate CCLXI. Figs. 10, 11.

b. On the same individual, lineari-lanceolate capsules, and also pedunculate capsules of an urceolate form, as in F. dentatus. (Plate CCXLI. Fig. 8, 9.) Figs. 8, 9.

c. Lanceolate capsules and small patches of naked seeds are found on the same plant; as in F. hypoglossum, (*Turn*. t. 14.)

d. Ovate capsules and spherical immersed seeds, on the same individual; as in F. dasyphyllus, (*Turn*. t. 22.)

e. Ovate and oblong capsules, on the same plant; as in F. acanthophorus of Lamouroux, (*Turn*. t. 32.)

f. Cilia containing seeds, on the margins and midrib of the plant; and spherical tubercles immersed in obovate processes on different parts of the plant; as in F. sinuosus. (Plate CCLXI. Fig. 6, 7.) Figs. 6, 7.

g. Urceolate sessile capsules on one plant, and naked seeds immersed in the frond on another plant of the same species; as in F. articulatus. It is a remark of M. Lamouroux, that the double fructification is never found on the truly articulated sea-weeds, that is, the marine confervæ: but in this he seems mistaken, as the double mode occurs in the plant named Fucus fruticulosus, (*Turn*. t. 227), which, as Mr Turner properly remarks, belongs to the confervæ.

In a few capsuliferous species, as F. plumosus and flaccidus, (*Turn*. t. 61), the seeds, or what are reckoned the seeds, are not inclosed in proper capsules, but merely surrounded by setæ, producing the appearance of an involucrum. In the large species, F. saccharinus and bulbosus, the fructification is in irregular patches on the frond, and consists of a profusion of seeds imbedded among whitish fibres, but without any covering or epidermis. Mr Brodie of Brodie, in a communication to Mr Turner, (*Hist. Fuc*. vol. iii. p. 62.) very aptly compares a section of the last-named species when in fruit, and placed under the microscope, to a section of a syngenesious flower, with the seeds protruding from the receptacle among the bristly pappus.

It has already been stated, that in some species there are found both seeds in tubercles, and seeds scattered in the substance of the frond. Mr Turner was at one time of opinion, that the seeds in the tubercles might become subsequently disseminated through the frond; but more careful examination with the microscope, enabled him to satisfy himself that the capsular granules differ as to shape from those which lie naked in the frond.

He is inclined to believe, that those plants on which the two modes of fructification occur on different individuals, are truly diœcious, though a plant, possessing each mode of fructification, may frequently arise from the same basis, and thus occasion ambiguity. Dr Solander, it may be remarked, first suggested that these might be male and female. It would evidently be almost a hopeless attempt, to endeavour to observe the mode of impregnation in their native element; and it is not improbable that this may for ever remain among the arcana of nature.

A few species have a proliferous tendency, putting forth peltate leaves, ready to lengthen into branches, if the plant have sufficient vigour. Mr Turner seems to think it probable, that, like the bulbs of allia, these new productions may fall off when the frond decays, and shoot up into independent individuals. Some species, that have broad terminal receptacles, have been observed occasionally to become viviparous, particularly F. vesiculosus and serratus; the seeds vegetating while in the receptacles, and thus producing the viviparous character.

Seeds of Fuci.

We have already seen, that what Stackhouse considered as seeds, were probably capsules, as they burst asunder and discharged smaller bodies. Turner makes the remark, that the seeds of different species have been observed to discharge very minute granular globules; and with that candour and diffidence which distinguish the accurate observer, he confesses his doubts whether the small bodies, generally accounted seeds, may not themselves be seed-vessels. It may be remarked, indeed, that his representation of the bursting of a *capsule*, (*Hist. Fuc.* t. 181.), and his figure of a *seed* pouring out its contents, (t. 61.), bear the greatest resemblance to each other. The seeds of fuci, in general, must be very minute: they seem to abound imperceptibly in the sea, as the impalpable seeds of fungi, musci, and lichens, do in the air.

In most of the tuberculiferous fuci there are visible, besides the seeds, and intermixed with them, numerous elliptical *pellucid granules*, much more minute than the seeds; together also with many small *jointed fibres*, among which the seeds and pellucid granules lie imbedded.

Duration of Fuci, and their Rapidity of Growth.

Duration.

The fuci, like land plants, reach maturity in different spaces of time, and endure for different periods. Many of the smaller and more delicate are annual; others of the herbaceous kind seem to be biennial, or at least frequently perish at the end of the second season; and many continue for several seasons. Those with stems of woody texture endure for a considerable number of years, in situations where they are protected from the violence of the waves during storms. Old stems of Fucus digitatus are frequently to be observed, not only completely invested with parasitic fuci, confervæ, and flustræ, like old trees with lichens and mosses, but with the epidermis and bark become split and rough, and loosened from the woody part of the stem.

The well known Fucus saccharinus has been observed to renew its frond in a very curious way, the new growth proceeding from the base, and pushing before it the old frond after it has discharged its office, in the same way as the human nails are renewed. "The plant," observes Mr Turner, "thus acquires a perennial growth, and as Tibullus beautifully says of the serpent, *novus exuit annos.*" It is the opinion of Mr Turner, that Fucus agarum (t. 75.) renews its frond in the same way.

In judging whether a fucus belongs to the class of annuals or perennials, besides attending to the general structure and habit, Lamouroux has pointed out another mark: he has very commonly found, that those fuci, which bear their fructification on the branches, are perennial, while those which have it on the tips of the fronds are annual.

Rapidity of growth.

It is remarked by Mr Turner, that the smaller and more delicate sea-weeds produce their fruit in the beginning of autumn; while the larger and coarser species prefer for this purpose the "stormy months of winter." But the rapidity of growth of some of the large coriaceous kinds throughout the winter, is wonderful, and it is believed has only of late been fully ascertained. The facts shall therefore be stated with some minuteness of detail. They were observed in the course of the very arduous undertaking of erecting a stone-beacon on a low rock called the Carr, situated near the entrance of the Frith of Forth: and when we mention as the observer the distinguished civil engineer Mr Stevenson, a man accustomed to habits of accurate observation, it is perhaps superfluous to add, that particular attention was bestowed at the request of the writer of this article, and specimens of the fuci transmitted to him. The Carr Rock is about 20 feet broad, and 60 feet long: it is only uncovered at the lowest ebb of spring tides. It was completely clothed with the larger fuci, particularly Fucus esculentus and F. digitatus. In the course of autumn 1813, the workmen had succeeded in clearing out and levelling with the pick and axe a considerable part of the foundation of the intended beacon, when, in the beginning of November, the operations were necessarily abandoned for the winter. At this time the rock was reduced to a bare state. The coating of sea-weed had at first been cut away by the workmen; the roots or bases were afterwards trampled by their feet; and much of the surface of the rock had been chiselled. Upon returning to the Carr in May 1814, in order to recommence operations, it was matter of no slight surprise to find the surface again as completely invested with large sea-weeds as ever it was, although little more than six months had elapsed since the work had been left off, when, as already said, the rock was cleared of weed. In particular it was observed, that many newly produced specimens of Fucus esculentus measured six feet in length, and were already furnished with the small appendages near the base, or pinnæ, which at maturity contain the seeds of the plant. Lightfoot mentions four feet as the ordinary length of this fucus, but adds that it sometimes reaches nine feet. Those at the Carr Rock, therefore, were nearly full sized. The common tangle, F. digitatus, was generally only about two feet long; but this species when fully grown seldom exceeds three or four feet. It is to be observed, that the specimens here alluded to were taken from that part of the surface of the rock which had been dressed off with the pick and chisel the preceding autumn, they had therefore grown from the seed; and indeed it was remarked, in general, that the sea-weeds had grown more luxuriantly on the newly-dressed rock, which is sandstone, than from the old stools, which had been merely cut over, or trodden

Fuci.

down by the workmen's feet. It appears, therefore, that the seeds of these fuci, floating about abundantly in the waters of the Frith of Forth, must have attached themselves to the dressed surface of the sandstone after the middle of November, and must have vegetated and increased with great rapidity during a winter remarkable for severity: for this, it will be remembered, was the winter of the *great frost* as it was styled, which continued nearly the whole of the month of January 1814, and of which a very full account will be found in the *Scots Magazine* for February of that year. Other circumstances, it may be observed, were here favourable to their growth. During the winter and spring months, the Carr Rock must have been almost constantly under water. The incessant struggle of the tides at Fifeness is calculated to produce that degree of agitation which has long been considered favourable to the growth of the stronger sea-weeds; and this does not seem to have been interrupted by the rolling of heavy waves for many weeks during winter.

If, however, still further proof of the rapid growth were wanted, the experience of the following season afforded ample evidence. In autumn 1814, a course of large hewn freestone was completed, and the operations were again suspended till the following summer. It was as late as the beginning of July 1815 before the weather permitted boats to approach the rock at low water; when, on the new course of the beacon, a crop of Fucus esculentus was found, the fronds of which measured on an average six feet long, and were, as before, furnished with pinnæ. This must of necessity have been the growth of not more than eight months from the time of the very minute seeds having attached themselves to the hewn stone.

The opinion of Lamouroux, therefore, that during winter the vegetation of sea plants is suspended like that of land plants, is proved to be erroneous.

It may here be mentioned, that Dr Walker states, * on the authority of the kelp-makers, that "sea-weeds do not grow so much in seven years upon freestone as they do in two years on whinstone." The facts above detailed shew that this remark is not universally applicable, although it may be true of the loose masses of stone on the shores, which, if soft, must be liable to be worn by the striking of smaller boulder stones.

It is not improbable, that the growth of the large pelagic fuci may even be much more rapid than that now described. The Fucus giganteus of the Pacific Ocean attains several hundred feet in length: Forster mentions specimens even 800 feet long. In the bays of this country, F. filum frequently reaches 30 or 40 feet, and in some places, as Scalpa Flow in Orkney, this is considered as the growth of the summer and autumn months, from May to October.

General Structure, &c. of Fuci.

General structure.

From the characters of the orders in Lamouroux's arrangement, some notion of the general structure of the different tribes of marine plants must already have been acquired. In treating farther of the same subject, brevity shall therefore be studied.

In general it may be observed, that some species are coriaceous, often branched and shrub-like; some are membranaceous, and traversed by a longitudinal nerve or midrib; others are filiform, generally not jointed: they produce receptacles, tubercles, or capsules; and most of them are furnished with air-vesicles.

Decandolle considers marine plants as composed entirely of cellular tissue; attributing the difference of structure observable in the stems, the mid-ribs or nerves, and the fronds, to modifications in the form of this cellular tissue. Mirbel is of the same opinion. It is certain that all the parts of sea plants are much more nearly of uniform texture than in land plants in general; most of them seeming to be capable of changing into others; the peduncle becoming a branch, the air-vesicle a frond, and so on. Lamouroux, however, has remarked, that the stem of Fucus digitatus is formed of four distinct parts, analogous in situation, relative size, and even organization, to the epidermis, bark, wood and pith of dicotyledonous plants. It perhaps requires some aid from the imagination to enable the observer to see all this. But it is certain that a section of the stem of Fucus digitatus forms a curious microscopic object, and that it is distinctly perceived to be composed of longitudinal parallel jointed colourless fibres, disposed in concentric circles, and constituting altogether a pretty solid mass. Lamouroux has likewise discovered, or imagined he has discovered, in certain sea-weeds belonging to different tribes, most of the characters which distinguish the brilliant corollas of phænogamous plants, the stems and leaves of trees, and the herbaceous structure in general.

That marine algæ are not furnished with continuous vessels of the same nature as those of land plants, is obvious, from the well known remark, that if one portion of a sea plant be plunged in water, and the other left exposed to the air, only the immersed portion remains in vigour; no fluid seems to rise speedily enough through the frond to nourish or refresh the other part of the plant. The result of microscopic observation, and attempts at injection, support the same view. On the other hand, the fructification of some families, as the Fucaceæ and Florideæ of Lamouroux, is observed to be placed almost always on the stems or branches, near to the masses of fibres, or at their extremities. In the Dictyodeæ of the same writer, the more regular and visible the structure of the reticulations, or cellular tissue, appears, the situation of the fructification is found to be more uniform; and the less regular and distinct, the fructification is more scattered. The production of capsules regularly at the extremities of branches or fronds, which is observed in many species, proves the existence of some kind of vessels, and the elaboration of particular fluids. Upon the whole, therefore, as something analogous to circulation is indispensable, the masses of fibres, or cellular tissue with lengthened cells, may be considered as calculated to perform the functions of longitudinal vessels. Horizontal vessels are distinctly seen in some species, particularly F. vesiculosus and nodosus.

Some of the fuci are quite cartilaginous in texture; such as the stem and midrib of F. esculentus, and the whole plant of F. aculeatus. A few species dissolve into jelly on being placed in boiling hot water. Some are quite flexible when recent, and become stiff and apt to break when dry: others, on the contrary, as the genus Dictyopteris of Lamouroux, are stiff and frangible when living, and become flexible when dried.

Jointed structure.

The jointed structure of the frond was long considered as characteristic of *Confervæ;* but this, it is now admitted, does not effectually distinguish them from several fuci, such as F. fruticulosus and pinastroides, or even some lichens and fungi; and it has therefore been abandoned as a generic distinction. Lamouroux remarks, that it is easy to distinguish the truly ar-

* *Transactions of the Highland Society*, vol. i. p. 27.

Fuci. ticulated sea-weeds, or marine confervæ, from those fuci that are marked by contractions or partitions. If the stem of these last be cut longitudinally, the substance shews no mark of interruption, but appears quite homogeneous. In the former, the tissue appears at every joint to change its quality and form, and the colour varies. Some of the small cylindrical fuci seem to acquire the appearance of contractions or partitions just before the time of fructification; nature perhaps producing these partitions, to give firmness to the stems, or to delay the circulation of the juices, and make them undergo a more complete elaboration at this crisis. It was first observed by Mr Dillwyn, that the aculei of F. aculeatus are regularly jointed, and that the main filaments towards their extremities have a jointed internal tube: all of these jointed appearances vanish as the plant grows old. The tufted fibres of F. radiciformis (*Turn.* t. 189.) are also jointed; as are those likewise of F. pedunculatus (t. 188). F. dasyphyllus (t. 22), it may be noticed, is sometimes, but rarely jointed; generally it is without joints.

Vesicles. No part of the structure of fuci has more universally attracted notice than the inflated portions of the stem or frond resembling bladders, seen in many species, and particularly conspicuous in the well-known F. vesiculosus and nodosus. (See Plate CCLXI. Fig. 4, 5.) They are now generally denominated Air-vesicles, or simply Vesicles. Most of the sea-weeds having a texture approaching to ligneous, are provided with distinct air-vesicles; and those that are not so provided, have in their stems empty spaces, sometimes visible to the naked eye. These probably serve the purpose of air-vessels: they proceed from the root or base, rise with the stem, and disappear in the frond.

Plate CCLXI. Figs. 4, 5.

Formerly, the air-vesicles were generally supposed to be the male fructification. The generic character of Fucus, given by Linnæus, was the following: "*Male*, Vesicles smooth, hollow, with villose hairs within, interwoven. *Female*, Vesicles smooth, filled with jelly, sprinkled with immersed grains, prominent at the tip, seeds solitary." If the reader imagine to himself the application of this character to the common F. nodosus, he will perceive, that by *male vesicles* must be meant the air-bladders; and by *female vesicles*, the receptacles, the *immersed grains prominent at the tip*, being a sufficiently distinct description of the *tubercles*. They were afterwards for a long time considered as destined merely to give buoyancy to the plant. It is now, however, generally believed, that they serve some important purpose in the economy of sea-weeds. Lamouroux considers them as respiratory organs; and he observes, that where they are wanting, the organization is less complicated, and the vital functions are more simple. He affirms, that sea plants exert the same action on atmospheric air as land plants. The ligneous fucaceæ, he says, absorb oxygen during the night, and give it out during the day, though in very small quantity. Analogy would lead us to consider this statement as probably correct; but whether it is founded on direct experiment, is not explained by the author. The Florideæ, he adds, exhale less oxygen than the former. They retain it, in his opinion, in order to produce the brilliant tints which adorn them. The Ulvaceæ, like herbaceous land plants, give out by the action of light, a great quantity of oxygen gas, and a little carbonic acid. The decomposition of the atmospheric air must take place in the vesicles, or in the spaces or cells already alluded to; these perhaps at once serving as reservoirs, and as organs for decomposing the air. On some species, vesicles have never yet been found; but Turner is inclined to think, that none are entirely and at all times destitute of them; so that the division "absque vesiculis" might be given up.

Pencils of white hairs. Many fuci, such as the common F. vesiculosus and serratus, have small tufts of white filaments like hairs scattered over their surface. Reaumur conjectured, that these might be a sort of male flowers, and as such he described them. In this notion, he was followed by some distinguished botanists. But they are now known to be analogous merely to the hairs on land plants, and to be useful probably for the secretion or absorption of particular fluids. It has generally been said, that they occur on the plant in every stage of its growth, and at all seasons of the year. Lamouroux, however, asserts, that they are not permanent, but disappear at certain seasons, and at certain stages of the life of the plant. They are never seen on the stem or the nerve, but on the frond only.

Food of sea-weeds. It does not appear probable that the submersed algæ derive much of their nourishment from the processes by which they are attached to rocks or other substances, although these processes in many instances resemble roots, and usually receive that name. It appears likely, that the principal part of their food is imbibed by their general surface. They are attached to rocks of mica-slate, greenstone, basalt, sandstone, and limestone. Many of the smaller kinds grow on the stems of the larger plants. It is to be observed, however, that Mr Turner, in the introduction to his *Synopsis of British Fuci*, hints it as his opinion, that the root-like processes are not merely intended for fixing the plants, but are to a certain degree useful as organs of nutrition; and he mentions that some species seem peculiar to chalk, some to sandstone, and others to still harder rocks. On the other hand, at least one species, Fucus bacciferus of Turner, (t. 47), has never been found with a root or base: it evidently lives and increases while floating about. The extensive meadows of sea-weeds through which navigators to distant countries continue to sail for days in the unfathomable ocean, and which are found in a fresh and growing state, afford convincing evidence that certain kinds of fuci at least are not entirely, nor even chiefly, dependent on their roots for nourishment. M. Desvaux, editor of the *Journal de Botanique*, has lately made a direct experiment on this subject. Having detached some fuci above the roots, he fixed them to stones by means of cords or other artificial methods, and plunged them again in the sea. Having visited them some time after, he found that they had increased very sensibly.

Some authors have supposed that the fuci are nourished by their mucilage: but this is only removing the difficulty one step; and besides, particular species, as F. esculentus, possess little or no mucilage. It has been remarked, however, that the cups or discs of F. loreus become flaccid and destitute of juice, whenever the *thongs* of the plant have attained full size; and this has been ascribed to the exhaustion of the mucilage by their growth.

The Caulerpæ of Lamouroux creep in the sand, and seem to possess true roots; but these, though at present associated with the fuci, form not only a very distinct genus, but a separate family.

Colours of Fuci.

Colours of sea-weeds. The colours of sea-weeds have not yet been much attended to. A great proportion of the fuci are of an olive hue; olive brown, olive yellow, or olive green. A good many are red or brownish red. Some are verdigris green, particularly F. æruginosus, (*Turn.*

Fuci.

t. 147,) a species from the Red Sea, resembling Lichen prunastri, and F. Valentiæ, (t. 78), brought also from the Red Sea, by the nobleman whose name it bears; the latter rendered more remarkable by producing bright red spherical tubercles, which form a striking contrast with the glaucous frond.

Some phænomena not uninteresting to the physiological chemist are slightly mentioned by Professor Mertens in the *Allgemeine literatur Zeitung* for 1810, in his critique on Mr Turner's *History of Fuci.* He states that F. ligulatus and F. viridis (*Turn.* t. 97.) possess the property of suddenly altering the colour of other fuci along with which they happen to be steeped in a vessel full of fresh water; the red colour of Conferva rubra, or Fucus ovalis, being changed to purple, and these plants rendered at the same time much more prone to decomposition, while the ligulatus and viridis remain unhurt. F. viridis itself undergoes remarkable changes. While the plant is growing, it is of a deep rich orange; but, says Mr Turner, "no botanist can have gathered it without being struck by the circumstance, that before he had conveyed it home, it had changed its original golden hue to a bright verdigris green." At the same time, it undergoes a change in its substance; from being stiff and elastic, it becomes completely flaccid.

Humboldt and Bonpland describe,* under the name of *Fucus vitifolius,* (as already mentioned,) a species of a fine grass green colour, brought up, at l'Alegranza, from the great depth of 192 feet, at which depth it had vegetated. The light at that depth could only have been equal to half the light of an ordinary candle; yet, according to Humboldt's experiments, common garden-cresses, exposed during vegetation to the light of two Argand's lamps, acquire only a slight tint of green. That distinguished philosopher therefore concludes, that it is only under the influence of the solar rays, however weak, that the carburet of hydrogen is formed in the organs of plants, the presence of which makes the parenchyma appear of a lighter or darker green, according as the carbon preponderates in the mixture.

The colour of all the soft and annual fuci depends on a very fugacious extractive. Those that are horny in texture retain their colour with more force. Several of them become of a greenish hue when boiled; and every one who has seen dulse fried, must have remarked the change to green produced by the application of heat. The ultimate tendency to a green hue observable in several species, may probably be ascribed to the more complete developement of the alkali contained in the plant.

To the botanist it may be useful to know, that when there is reason to suspect that the appearance of the plant is changed by exposure to the air or rains, the original colour may often be detected by holding up the specimen against a strong light. For example, F. sinuosus, which is frequent on the stems of F. digitatus, and has fronds resembling in shape the leaves of Alnus incana, is, when fresh, of a rosy red colour; in decaying on the shore, this changes first to violet, and then to tile red: but on holding the specimen against the light, the original rosy hue may be detected. Wahlenberg notices concerning F. plumosus, that when repeatedly washed in fresh water, it becomes green; that, in dilute muriatic acid, it preserves its colour, and when removed from it becomes green, as if an alkali had been poured on it.

Another species, F. ericoides, (*Turn.* t. 191), possesses the more extraordinary property of reflecting bright glaucous tints when seen under water in a growing state. It is naturally of a yellowish green colour, but under water appears as if in a state of vivid phosphorescence. On withdrawing it from the sea, the brightness vanishes. The phenomenon has not been thoroughly examined. This fucus grows on the shores of Devonshire and Cornwall; but Mr Stackhouse, who spent his days in those districts, and had many opportunities of observing the appearance, only says that the colour resides in, or is occasioned by a slimy mucus which covers the frond. When dried, the plant becomes of a reddish brown colour.

Concerning F. ligulatus, a species which occurs, though not plentifully, on our shores, and is excellently figured by Lightfoot in his *Flora,* (t. 29,) Professor Mertens mentions a curious fact: in the sea it is of an olive green colour; but as soon as it is brought in contact with the air, it becomes of a deep orange, or rather the colour of decayed leaves. The only specimens we have seen, which were taken from the rubbish of a fishing-boat at Newhaven in the Frith of Forth, were of a pale dull green; but to this colour, Mertens observes, the orange tint soon declines.

It has been remarked of some of the smaller and more delicate fuci, that the same species seems to vary in appearance, size, and especially colour, according to the nature of the substance to which it happens to be attached, whether a stone or shell, or the stem of a larger sea-weed. But this observation is by no means of universal application. Variations are more generally occasioned by the climate in which the plant grows; the depth of water; the exposed or sheltered nature of the situation; or the proximity to the mouth of a river or body of fresh water.

General Distribution of Fuci.

General distribution over the globe.

A few remarks on the general distribution of the fuci may here be made. Some may be considered as properly pelagic, as F. pyriferus, (*Turn.* t. 110), the giganteus of Foster, or the *badreux* of the Falkland Islands. This sends out numerous fronds, and the upper and under fronds are frequently found soldered as it were together, at certain spots of the edges. This species occurs so abundantly in the South American seas as to resemble islands, and it is one of the chief of the gigantic fuci alluded to by circumnavigators. Linnæus merely says, that it is the longest and largest of the fuci. Solander measured some of the apices, and found them to be from ten to twelve feet; but he gives no guess as to the length of the entire plant, which is said to extend from 500 to 1000, or even 1500 feet. F. *potatorum* of Labillardiere, is another of the great pelagic fuci, of such ample dimensions, that particular parts of it furnish various household implements to the natives of New Holland.

Others, of a small size, which are never found but in the great ocean, may, it is thought, have originally been torn from the shores: this is the case with the numerous species which have long been confounded together under the convenient name of Fucus natans, and which constitute the well known fields of floating seaweeds met with in the great oceans.

New Holland.

The fuci of the northern seas are in general different in character and appearance from those of the tropics or of high southern latitudes. To take for example New Holland. It is well known that the land plants of this singular country have a peculiar character, arising chiefly from many of the trees and shrubs being aphyl-

* *Plantæ Æquinoctiales,* vol. ii. p 8. t. 69.

Fuci.

lous, and many others having leaves pointing upwards, or presenting both surfaces equally to the light. The shores afford a tribe of fuci equally different from those of other parts of the world. They belong to the *fuci proprii*, and are all composed of a stem repeatedly pinnated with different series of branches, the whole of which, as well as the stem itself, are flat, and formed, as it were, of a set of distinct joints, placed upon each other in a sort of zigzag direction; the branches almost always arising from the flat part of the stem, and not, as in Europe, from the angles. This tribe of fuci was brought to light by our justly celebrated countryman, Mr Brown, during his voyage with Captain Flinders and residence in Van Diemen's land already alluded to, M. Labillardiere having happened to observe only one species of the tribe: this one was the very remarkable F. Banksii, (*Turn.* t. 1.) which occupies on the Australasian shores the place of our vesiculosus. Instead of our serratus, these shores possess F. confluens, (*Turn.* t. 141.) a species which resembles it, but wants the midrib. The place of our large digitatus and bulbosus is there supplied by a distinct species considerably resembling them, described and figured by Mr Turner under the name of F. radiatus, t. 134.

The temperature of the ocean in different regions may be supposed to vary much less than that of the land: on account of the moveable nature of the element, the means of transportation of fuci must be more easy than in the case of land plants: and the waters of the sea appear almost every where to teem with the seeds of fuci. It is not surprising, therefore, that some tropical species should make their appearance in high latitudes, or that particular kinds should be found in places the most remote from each other, and climates the most opposite. Fucus agarum is found chiefly in the Indian Ocean; but it occurs also at Nova Scotia and in Hudson's Bay. F. cartilagineus of Linnæus, (*Turn.* t. 124.), which is abundant at the Cape of Good Hope, and often gathered there to form ornamental pictures, is found also on the shores of Finmark; and F. flagelliformis of Flora Danica, (t. 650.) is found both at the North Cape of Norway, and at the southern promontory of Africa. Some are most widely distributed over the globe, but are not abundant in any particular quarter. F. musciformis of Wulfen (*Jac. Coll.* iii. t. 14.) has been found on the coast of France in the Adriatic, off the coast of Egypt, at Ceylon, in the West Indies, at New Zealand, and in Nootka Sound. F. thyrsoides is marked by Mr Turner (vol. i. p. 38.) as found at New Zealand by Sir Joseph Banks, at Jamaica by Dr Wright, and in the Red Sea by Lord Valentia. F. turbinatus, Lin. (*Turn.* t. 24.) is a native equally of the seas of the East and West Indies. F. acanthophorus of Lamouroux, (*Turn.* t. 32.) is found on the coast of North America and in the Red Sea. F. Wrightii of Turner, (t. 148.) on the shores of Jamaica and the Red Sea. F. triangularis (*Turn.* t. 33.) has been picked up at Jamaica, New Holland, and New Zealand. Several species inhabit the shores on both sides of the Atlantic, as the common kelp weeds, F. vesiculosus and nodosus. F. dentatus, which is common in the Frith of Forth, grows also in the Chesapeak. Some other British species are very widely disseminated over the world. The elegant pinastroides of our shores was observed on the coast of New Zealand by Sir Joseph Banks, and has been found also at Ceylon. F. fibrosus (*Turn.* t. 209.) is common to England and the coast of Guiana; F. plicatus, to this country and New Holland. F. tomentosus, (*Turn.* t. 135.) which occurs on the southern shores of England and Ireland, has been found also in the Mediterranean, in Nootka Sound, and at the Cape of Good Hope. A very common British species, F. siliquosus, inhabits likewise the Mediterranean and Adriatic, and has been observed at Newfoundland, and in the Chinese seas.

A local disposition may be traced in some cases. In the East Indies, for example, the Straits of Sunda have afforded two curious species, with leaves resembling holly and dwarf-oak, F. aquifolius and ilicifolius of Turner (t. 50, 51.) The uncommon looking F. muricatus of the same author, (t. 112.) is a native of the same Straits. None of these have hitherto been found elsewhere. F. tenax, (*Turn.* t. 125.) one of the most useful of the tribe, is peculiar to the seas of China. The Caulerpæ may be considered as belonging to the Red Sea and New Holland. At the Cape of Good Hope, the place of our digitatus and bulbosus is occupied by F. buccinalis, (*Turn.* t. 139.) which is often observed floating about in great quantity, and, from its fistular and inflated stem, has received from navigators the name of *trumpet-weed*: by them its appearance is hailed as a sure prognostic of the vicinity of the Cape. F. flaccidus of Turner (t. 61.) is there parasitical on the larger fuci, like alatus and coccineus with us. Two Cape species are remarkable for being elegantly fringed along the margin, F. erinaceus (*Turn.* t. 26.) and F. vittatus, or ribbon-weed, (t. 64.) Some are peculiar to the north-west coasts of America. Among these may be mentioned F. Menziesii, (*Turn.* t. 27.) named in honour of Mr Menzies, who attended Captain Vancouver in his voyage of discovery, but whose valuable researches in the department of natural history are brought to light only in a tardy and almost accidental manner, he having received no encouragement from Government to publish his many botanical discoveries. To it may be added F. herbaceus, of Turner, (t. 99.) resembling a broad-fronded ligulatus; two others of Turner, F. osmundaceus (t. 105.), cordatus (t. 116.), and F. floccosus of Esper (*Icones*, t. 100.); with F. costatus of Turner, (t. 226.) curiously ribbed. Others of the north-west American species are found also in other countries: F. bracteatus (*Hist. Fuc.* t. 25.) occurs at the Cape, and F. ovalis (*Id.* t. 81.) is common to Nootka Sound and the shores of Britain. A few may be set down as peculiar to the Mediterranean, as F. nervosus of Decandolle (*Turn.* t. 43.), and linifolius of Turner, (t. 168.) F. purpurens, (*Hist. Fuc.* t. 224.) is very plentiful in the Mediterranean; but it is likewise found in the Red Sea. F. viridis, which is met with on the southern shores of England, but so sparingly as to be accounted a botanical discovery, occurs abundantly as a parasite on F. vesiculosus and serratus on the coast of France. These, as is well known, are two of our most common kelp fuci on the shores of Scotland; but in this country F. viridis never appears upon them. The very elegant small species F. asparagoides and Wigghii, (*Hist. Fuc.* t. 101, 102.) have not, it is believed, been found beyond the precincts of the British islands, and have more frequently occurred on the beach at Yarmouth than elsewhere. F. pusillus seems also to be local, and is described as creeping like a jungermannia, on the red sandstone rocks at Sidmouth in Devonshire. (*Ner. Brit.* t. 6.) A few may be ranked as arctic species; particularly F. distichus of Linnæus, (*Turn.* t. 4.) and ramentaceus, (t. 149.) F. lycopodioides grows plentifully on the most remote shores of Norway, and occurs sparingly on the coast of Scotland. F. soboliferus (*Flor. Dan.* t. 1066.) is common in Finmark, and has been detected on the shores of the Orkney Islands by Mr Fothergill. F. plumosus is one of the ornaments of the shores of the south of England; but it increases in

Fuci.

size and beauty as we proceed northwards, and is much finer in Orkney than in Cornwall: it has been observed even in Davis Straits.

Many species which grow most abundantly on all the shores of Europe which are exposed to the great ocean, are not to be found in the Baltic Sea, the waters of which are less salt, and are little affected by the influence of the tides. Hasselquist, in his Travels, expressess delight at meeting with our common F. saccharinus when he first cleared the Baltic. Some of those species, particularly F. vesiculosus, which grow very far up in the lochs or friths of the west of Scotland, do not appear in the Baltic. F. nodosus and serratus, it may be added, continue near to the heads of the Scottish arms of the sea; and F. canaliculatus is found in the most extreme corners to which the sea-beach can be said to extend; being exceeded only by F. amphibius, (*Turn.* t. 109,) which grows like a coralloidal lichen, parasitically on herbaceous plants, in salt marshes. On the banks of rivers too, where they enter the sea, F. caniculatus is found very high up, even among the brackish water.

Order in which fuci grow on the shore.

On our open sea-shores a certain order is observed in the habitat of the fuci, each species occupying pretty regularly its own zone or station. F. filum or sea-laces grows in water some fathoms deep. In places where the tide seldom entirely ebbs, but generally leaves from two to three feet of water, grow F. esculentus and bulbosus, and the larger specimens of digitatus and saccharinus, with some small kinds, as F. palmatus, siliquosus, and sanguineus. In places uncovered only at the lowest ebbs, smaller plants of digitatus and saccharinus abound, with F. loreus or sea-thongs. On the beaches uncovered by every tide, F. serratus occurs lowest down, along with crispus and mamillosus; next comes F. nodosus; and higher up, F. vesiculosus. Beyond this F. canaliculatus (already mentioned) still grows, thriving very well if only wet at flood tide, and though liable to become dry and shrivelled during a great part of the day. Lastly, F. pygmæus, figured by Lightfoot, (t. 32.) is satisfied if it be within reach of the spray.

Floating Sea-weeds.

Floating sea-weeds.

The great accumulations of sea-weed found floating in the Atlantic, Pacific, and Indian Oceans, on each side of the equator, nearly to the 40th degree of north and south latitude, have already been alluded to; but they are not undeserving of further attention.

Mar do Sargasso.

The *Mar do Sargasso* (or sea of sea-weeds) of the Portuguese, stretches between the 18th and 32d parallels of north latitude, and the 25th and 40th meridians of west longitude. It is often called the Grassy Sea, and is mentioned by many navigators. It is thus described by Barrow, in his *Voyage to Cochinchina:* "The surface of the sea for several days was literally covered with plants. Some of them were many feet in diameter; others only a few inches: all appeared in a growing state. The globose berries (by which Mr Barrow means the air-vesicles) were in some plants green; in others red. If taken out of the water, the plant became flaccid, and in the space of four and twenty hours turned brown or black. The naturalist in every plant may find a great variety of marine insects and worms, some naked and others with testaceous coverings." Those plants with green vesicles, it may be remarked, were probably specifically distinct from such as had red.

It is stated by Humboldt in his Personal Narrative, that in the great basin of the Atlantic Northern Ocean, there exist two banks of floating sea-weed. The most extensive is a little west of the meridian of Fayal, one of the Azores, between latitude 25° and 36°. Violent north winds sometimes prevail in this space, and drive the sea-weed to the low latitudes, as far as 24° or even 20°. Vessels returning to Europe either from Monte Video or the Cape of Good Hope, cross the bank nearly at an equal distance from the Antilles and Canaries. The other occupies a much smaller space between 22° and 26°, eighty leagues west of the meridian of the Bahama Islands. It is generally traversed by vessels on the passage from the Caiques to the Bermudas.

Columbus and Lerius encountered most extensive banks of floating fuci in their adventurous voyage: they compare them to extensive inundated meadows, and complain of their impeding the progress of the vessels. So novel a scene produced no little consternation and alarm in the crew of the Santa Maria.

Detached patches of floating sea-weeds of various extent, but not deserving the name of banks or meadows, are met with in different parts of the Atlantic. Bonpland observed such patches to the north of the Cape Verd Islands.

Linnæus, speaking of Fucus natans in the *Species Plantarum*, says, "Vegetabile, in fallor, inter omnia in orbe numerosissimum." But under this title he included a considerable number of species, indeed all that generally occur in the "sea of sea-weeds." Turner was the first who effectually distributed the Linnæan Fucus natans into various species. He remarks that they form a tribe by themselves, though very clearly allied to the *Fuci proprii* of Weber and Mohr. Their leaves never in any case lengthening into branches, and their vesicles being altogether empty, seem characteristic circumstances. It was formerly thought that these floating sea-weeds were natives of the Gulf of Mexico, and were carried across the Atlantic by the Great Stream: hence the common name of *Gulf-weed.* It is very evident, however, that the Gulf Stream would convey them rather to the Banks of Newfoundland than to the latitudes in which they usually occur; and it could not in any case accumulate them to the south of the Azores.

There is no doubt that it was the opinion of Linnæus that they vegetated in the ocean, and floated about without ever being attached. This notion is likewise now exploded. Several of the species and varieties have been found with roots or bases, and some have been gathered in their native place of growth, where they were fixed to the rocks. It appears likely that they grow on rocks, probably at very considerable depths, in the Atlantic, Pacific, and Indian Oceans, whence they are carried, among other rejectamenta of the seas, to the shores of almost every country, accumulating however on the surface of the ocean, in certain latitudes, owing to prevailing winds and currents. Some are inclined to think, that, being torn from their native rocks before they attain maturity, they perfect their seeds while in a floating state; and it seems not unlikely that this may sometimes be the case. M. Humboldt, however, is of a different opinion: he thinks that vegetation can scarcely continue for a longer time in a detached floating sea-weed, than it would do in the branch of a tree torn from its trunk; and he considers these floating fields as composed of plants which have passed maturity.

It is certainly very difficult to explain why great moving masses of marine plants should be found for ages nearly in the same local positions. When decaying, they may indeed be supposed to be carried away by the equinoctial currents; which may scatter them even towards the coasts of France and Norway. But how the fresh weed is supplied; by what causes it is detached from depths perhaps of forty or sixty fathoms, where it is generally thought the sea scarcely suffers agitation, are problems which remain to be solved. Lamouroux indeed states, that although fuci adhere firmly before the fructification appears, they separate very readily after this period; and Humboldt remarks, that fish and molluscous animals, by gnawing their stems, may also contribute to detach them.

The spherical vesicles, supported on flat stalks, and resembling juniper berries, interspersed on the stem and branches of the plants, were erroneously regarded by Linnæus as the fructification; but the true fructification, as ascertained by Turner, occurs in the form of cylindrical receptacles on the branches, inclosing globular tubercles, which again contain the seeds. It may be noticed, that Don Hippolyto Ruiz, in his *Flora of Peru*, and in his pamphlet, "*De vera Fuci natantis Fructificatione*," described the sexual organs of the floating sea-weeds in a manner that surprised botanists in general. Stamens and pistils were declared to be as obvious in this fucus as in most of the phænogamous vegetables! But the observations of M. Bonpland rectified the mistake of Ruiz. Certain appendages in the form of little cups and feathers, which he took for the parts of fructification, were found, on close examination, to be nothing else than parasitical zoophytes belonging to the family of ceratophyta. When dried, they effervesced with acids, as the calcareous substance of any common sertularia or flustra would do.

Very frequently the spherical vesicles, which have already been compared to juniper berries, are as large as small purple grapes, and have a striking resemblance to them. For this reason, the name of *Tropic Grape* is often applied to the floating sea-weed. As a proof that the vesicles are intended in the case of F. natans, chiefly to give buoyancy to the plant, Ruiz states that when the vesicles are all cut off, the plant sinks.

The great collections of floating sea-weed which have now been described, are not without their use in the economy of nature; for they afford both food and shelter to myriads of fishes and mollusca, and probably tend, by giving forth oxygen, to maintain the wholesome purity of the sea. To the mariner, the young or most succulent shoots of F. natans offer an acceptable salad, or they are prepared as a pickle like samphire.

Economical Uses of Sea-weeds.

Economical uses of sea-weeds in general.

It is observable on most coasts, that sea-weeds, or many species at least, very suddenly disappear from the rocks in the autumn. They do not decay, like land plants, on the spot where they grow; but, losing their hold, are washed away by the tides; and, in the narrow seas at least, generally wafted ashore to offer their services to man. Among the Romans, indeed, they were proverbially useless. When they wished to stigmatise any thing as utterly worthless, it was declared to be *algâ projectâ vilior;* and Horace, when he speaks of *alga* covering the shores as drift-ware, thrusts in the epithet *inutilis.* In modern times, the alga marina has become useful and valuable in various respects. To the agriculturist it furnishes a most important manure. To the glass-maker and soap-boiler it yields the fixed alkali; and the manufacture of kelp for this purpose, has become a valuable source of revenue to the proprietors of the rocky shores of Europe, particularly of Britain, and more especially to those of the Northern and Western Islands of Scotland. Of such importance has this manufacture appeared, that in some places attempts have even been made, and not without success, to *cultivate* the fuci. By merely covering sandy bays with large boulder stones, a crop of fuci has been procured in the course of two or three years, the sea appearing every where to abound with the necessary seeds. From the ashes of the fuci the chemist has of late years derived the very curious elementary substance named *iodine.* Several of them are so rich in saccharine matter, and vegetable mucilage, that on the shores of the northern countries of Europe, and in the Scottish islands, much of the winter provender of cattle is derived from them; and in the city of Edinburgh these plants are occasionally given as a useful stimulus to the stomach of milch-cows kept in confinement during the winter. A few of them even afford food to man. What might least of all be expected, two or three of them furnish fuel to the inhabitants of coasts where materials for firing are scarce. Some of the smaller sorts yield various condiments, or afford fresh salads; while others are employed as medicines. From a few of them, substances useful in the arts are procured; and with some of the more delicate and elegant species, ornamental pictures are constructed.

While considering the different purposes to which marine plants may thus be applied, it may be agreeable to the reader to see the descriptions of those chiefly employed, and more especially of such useful species as inhabit the British shores. The descriptions, however, must consist chiefly of the very accurate specific characters drawn up by Mr Turner, to which some explanations shall be added where they seem requisite.

As manure.

It is scarcely necessary to say, that every kind of seaweed may be employed as manure. In point of fact, what is used for this purpose is that which is cast ashore by storms in the winter months, consisting of all sorts, mixed with zoophytes, and all the other rejectamenta of the sea. In many places, the value of such manure is duly appreciated; while in others it is unaccountably neglected; not that it is any where entirely despised, but it frequently happens that on one day many tons of drift-ware are cast on a particular shore, and that on the next the whole is swept away. They who would avail themselves of this bounty of the deep, must snatch the moment of its being placed within their power, and muster all hands to drag it at least beyond the reach of the returning tide. It must not be left very long in the heap, nor suffered to run into the putrefactive fermentation; for in this case, sulphureted hydrogen, and other gases highly important in promoting vegetation, escape rapidly, and in great quantity; leaving a comparatively inert mass. But for details as to the mode of applying this manure to lands, so as best to secure its fertilizing effects, reference may be had to the article AGRICULTURE.

For making kelp.

The nature of kelp, and the mode of its manufacture, are now generally understood. It is a very impure carbonate of soda; containing sulphate and muriate of soda, and also sulphuret of soda, with a portion of charcoal. In Scotland the manufacture is carried on chiefly in the months of July and August. The kelp kiln is nothing but a round pit or basin dug in the sand or earth on the beach, and surrounded with a few loose stones. In the morning a fire is kindled in this pit, generally by means of peat or turf. This fire is gradually fed with sea-weed, in such a state of dryness that it will merely burn. In the course of eight or ten hours,

Fuci.

the furnace is found to be nearly full of melted matter. Iron rakes are then drawn rapidly backward and forward through the mass in the furnace, in order to *compact* it, or bring it into an equal state of fusion. It is then allowed to cool, when it is broken in pieces, and carried into a store-house, to remain till shipped.

The making of kelp from sea-weed was practised in France and England for more than half a century before the manufacture was introduced into Scotland. Mr James Fea of Whitehall in Stronsay was the first person in Orkney who (about 1722) exported a cargo of kelp; he sailed with it himself to Newcastle; and his success in the enterprize soon aroused the attention of the Orcadians. At present, in coasting these islands, as well as the Hebrides, in the summer months, great volumes of smoke are every where to be seen rolling from the kelp furnaces, and the peculiar odour, probably arising chiefly from muriatic acid gas, is felt to a considerable distance. From £40,000 to £50,000 sterling, are thus yearly brought into the country; but it must not be concealed, that in most of the islands agriculture has suffered, from the attention of the small tenants having been diverted from the land, and, by the influence of the landholders, turned almost exclusively to the manufacture of kelp.

The fuci which are chiefly cut on our shores for this manufacture, are Fucus vesiculosus, nodosus, and serratus. In some places, F. loreus and filum are employed, but not to a great extent. By means of a boat and long sharp hooks or bills, F. digitatus is cut in some places; and this species, together with F. saccharinus, bulbōsus, and esculentus, form much of the drift-ware employed in making of kelp. Some of these are no doubt richer in the alkaline salt than others; but of all of them it may be said, that when dry and fit for burning, they are capable of yielding about one-fifth of their weight in kelp.

Iodine.

Besides the alkali, kelp affords, as already hinted, a peculiar simple or hitherto undecomposed substance named *iodine*. It was discovered in the year 1812, by a manufacturer of saltpetre at Paris named Courtois, and has since been examined by the most eminent French and English chemists. It is readily procured by pouring concentrated sulphuric acid on the mother water of kelp from which soda has been extracted, or from spent soapers' leys. Heat is speedily produced, and the new substance appears as a violet-coloured gas, perfectly homogeneous and transparent. This, on being collected in the usual mode, soon condenses, and assumes the appearance of plumbago. It forms acids with hydrogen, chlorine and tin, called the hydrionic, chlorionic, and stannionic acids; and it combines readily with metals. The late Mr Tennant could detect no iodine in sea-water; so that it appears to be entirely a product of marine plants. French kelp, it is remarked by Sir Humphry Davy, yields more iodine than British; but for this, no reason is assigned. Iodine has a peculiar odour, and is decidedly poisonous. The name is derived from ιωδης, *violaceus*, in allusion to the very striking circumstance of the substance yielding a violet coloured gas on being exposed to an increase of temperature. The following is the mode of procuring iodine recommended by Dr Wollaston: "Dissolve the soluble part of kelp in water; concentrate the liquid by evaporation, and separate all the crystals that can be obtained; pour the remaining liquid into a clean vessel, and mix with it an excess of sulphuric acid; boil this liquid for some time; sulphur is precipitated, and muriatic acid driven off; decant off the clear liquid, and strain it through wool; put it into a small flask, and mix it with as much black oxide of manganese as you used before of sulphuric acid; apply to the top of the flask a glass tube shut at one end; then upon heating the mixture in the flask, the iodine will sublime into the glass tube." *

Kelp fuci.

The species reckoned kelp fuci shall now be more particularly described; and as most of them, besides yielding kelp, serve other useful purposes, these shall at the same time be noticed.

F. vesiculosus.

Fucus *vesiculosus*: "The frond is coriaceous, flat, mid-ribbed, linear, dichotomous, and quite entire; the vesicles are spherical, and innate in the membrane of the frond; the receptacles (containing tubercles and seeds) solitary, terminal, compressed, turgid, mostly elliptical."—In Scotland this is sometimes called *Black tang*; sometimes *Kelp ware*; and when the receptacles are large and swollen, *Strawberry-ware*. The Norwegians call it *Kue tang*, because their cows feed on it. It is the Quercus marina or *Sea oak* of the older writers. F. inflatus of Linnæus and Lightfoot, and F. spiralis of English Botany, are to be considered as varieties only of this species. The colour is a pale olive green, which becomes dull and almost black as the plant dries. It grows most plentifully on all our rocky shores, often not much below flood-mark. It is readily distinguished from F. nodosus by the air-vesicles very generally occurring in parallel pairs, while in F. nodosus they are single; and from F. serratus, by the edges of the frond being entire, or wanting the serratures which mark that species. It is generally from one to three feet long. It is the species most highly prized for the manufacture of kelp; being rich in alkaline salts. According to one account, 5 oz. of the ashes of the plant yielded about $2\frac{1}{2}$ oz. of alkali; and Dr Walker states that 1 lb. avoirdupois gave him 3 oz. of kelp. In the north and west of Scotland many hundred tons of this species are for this purpose yearly cut from the rocks, with old reaping hooks. To the Scottish islanders it is likewise valuable in another way; it constitutes a considerable part of the winter food of their horses, cattle and sheep, which seem instinctively to migrate from the hills to the sea-shore at the ebbing of the tide. Lightfoot mentions that during severe snow-storms, stags have been known to descend from the Scottish mountains to the shores, and to feed chiefly on this species. The same author states, that in some of the islands, the inhabitants cover their cheeses with its ashes, and thus supply the place of salt. Linnæus says, that the people in Gothland often boil the plant, and mixing it with some coarse flour, feed their pigs with it, and that it has hence received the name of *Swine-tang*. In the Channel islands it affords firing. In Jersey, in particular, it is collected and dried in July, and then housed for winter fuel. It is there also employed in smoke-drying pork, beef and fish. †

F. nodosus.

F. *nodosus*: "The frond is coriaceous, compressed, veinless, sub-dichotomous, branched in a pinnated manner; the receptacles are distichous, pedunculated, roundish, mostly solitary."—This is very common on the rocky shores of this country, growing about half way between flood-mark and the ebb; often on the intermediate space between F. vesiculosus and serratus, though it sometimes grows nearest to high-water mark. The fronds are from two to six feet in length, and at short distances swell into large oblong vesicles or air-bladders; by which, though not mentioned in the specific character, the plant is more familiarly distinguished, and from which it has derived its title *nodosus*. Boys

* Thomson's *Annals of Philosophy for April* 1814.

† *Communications to the Board of Agriculture*, vol. 1. p. 219.

Fuci.

amuse themselves by cutting them transversely near the end, and making whistles of them: hence the name *sea-whistles* sometimes bestowed on the plant. The seeds are contained in elliptico-spherical receptacles, which proceed, on short flat peduncles, from the sides of the branches. These receptacles acquire a yellow colour, and give occasion to the name of *yellow tang*, by which this species is known in Orkney. Like the last species, it is much used by the kelp-makers, and it often gets the name of *kelp wrack*. Zoophytes are seldom found attached to this fucus; but dense tufts of the dark-coloured Conferva polymorpha are frequently to be observed on it, and indeed this species of Conferva is scarcely ever to be detected in any other habitat.

F. serratus. F. *serratus*: "The frond coriaceous, flat, mid-ribbed, linear, dichotomous, serrated at the margins; receptacles solitary, terminal, flat, linear, serrated, sharpish." It is sometimes called *black wrack*, or *prickly tang*, sometimes simply *ware*. It is distinguished at first sight by the edges being serrated, and by the absence of air-vesicles. It is only uncovered at ebb tide, growing, as already remarked, in deeper water than F. vesiculosus, or nodosus. In its mode of growth, it forms a pulvillum or circular tuft, spreading out on every side from a central point of attachment. When fresh, the frond is of a dark olive green colour; when cast ashore and dried on the beach, it is almost black. It is very frequently overrun by the small coralline called Sertularia pumila, or sea-tamarisk. Serpula spirorbis, and spirillum, are also frequent on it. The black wrack is preferred for covering lobsters, or other shell-fish, that are to be kept alive during land carriage, being less apt to run into fermentation than some others which abound with mucus. According to Gmelin, 6 ounces only of lixivial salt are procured from 16 ounces of the ashes; and Turner mentions, that he was told that it is but little used for making kelp in the Western Islands, "because it shrinks so much in drying, and contains so little marine salt," meaning soda. In Norway, it is called *bred tang*; and Gunner states, that in some parts of that country, the inhabitants sprinkle it over with meal, and give it to their cattle.

F. loreus. F. *loreus*: "The substance of the frond is between cartilaginous and coriaceous, compressed, linear, nerveless, entire at the margins, dichotomous, expanded at its base into a bell-shaped cup; tubercles immersed in every part, and on both sides of the frond." This species is well known by the name of *sea-thongs*. In Orkney it is called *drew*,—a name which would seem to be etymologically related to the *badreux* of the Straits of Magellan. It is pretty common in the north of Scotland and its islands, particularly on shelving sandstone rocks. When in a young state, before the *thongs* have grown, it forms a concave disc or cup, and gives to the rocks the appearance of being covered with some sort of mushroom, or rather peziza, as mentioned in the specific character. From this circumstance, it is described by some old writers as *Fucus fungis affinis*; and it is perhaps the *Fungus phasganoides* of others. The extended strap-shaped fronds, generally two in number, arise from the centre of the cup. They are dichotomous, or divide into two at intervals. They are generally three, often six, or even ten feet in length. Borlase, indeed, in his *History of Cornwall*, mentions that on that coast, they are sometimes found twenty feet long. The colour is olive green, with a tinge of brown. The plant is pulpy and succulent, and a good deal of excellent kelp is made from it in Orkney; for instance in the island of Westray, on an estate belonging to Dr Traill of Liverpool. It is a perennial species, or at least the plants require two years to come to perfection. Wahlenberg therefore is in a mistake when he says that it is an annual; but it must be considered, that he describes from observations made on the most stormy shores of Norway, where, as he tells us, not a vestige of it survives the winter, where the discs appear only in May, and where the plant never attains a greater length than eight or twelve inches. The same author gives it as his opinion, that the cup-shaped disc is the only part analogous to a frond, the *thongs* being merely seminiferous spikes. To this notion he has been led, partly by the imperfect growth of the specimens he was acquainted with, and perhaps partly by the inaccurate description of the fructification given by Dr Roth. This was first correctly described and delineated by Mr Turner, (*Hist. Fuc.* t. 196.) Elliptical tubercles are everywhere immersed through the strap-shaped fronds, containing masses of minute dark brown seeds.

F. filum. F. *filum*: "The frond cartilaginous, slimy, cylindrical, filiform, attenuated at both ends, jointed internally, spirally twisted when old." This species is frequently called *sea-lace*. In Orkney, it gets the name of *cat-gut*, and in Shetland *lucky minny's lines*. The length to which it grows is amazing, not less than from twenty to forty feet. Lightfoot mentions, that the stalks, skinned when half dry and twisted, acquire such strength and toughness, as to be used for fishing line, like *Indian grass*, (which last, although it has got this vegetable name, is an animal substance, attached to the ovaries of some of the small foreign sharks.) The plant consists of a simple frond, without branches. It is of a deep olive colour. In the interior, the stem is divided by horizontal partitions, which Lamouroux says form a spiral when the plant becomes bent or twisted. The Bishop of Carlisle, and Mr Woodward, had previously remarked (in *Lin. Trans.* vol. iii.) that the whole frond is composed of two equal longitudinal threads, coiled spirally round each other; this structure becoming evident when the plant has received an injury. It floats about in the manner of Sparganium natans, following the course of the waves; but, as remarked by Linnæus, it lies immediately under the surface of the water, not on it. In Scalpa Bay, near Kirkwall in Orkney, we have sailed through meadows of it in a pinnace not without some difficulty, where the water was between three and four fathoms deep, and where of course the waving weeds must at least have been from twenty to thirty feet long. This, too, was the growth of one season; for the storms of winter completely sweep it from the bay every season. The plant, however, may not, strictly speaking, be an annual; and Lamouroux observes, that its duration depends very much on the nature of the place where it grows. In Orkney, a considerable quantity of kelp is occasionally made from this species; and the kelp-makers remark, that "it falls small in burning, and washes like soap." * It is common in all the friths of Norway, as far as the North Cape; and Bishop Gunner adds, that it furnishes a grateful and nutritious food to the Norwegian cattle. The fructification of this species has long been a problem to the naturalist. Roth considered it as placed in a glandular capsule at the extremity of the plant. Stackhouse thought he found it hid in the substance of the plant,

* *Tour in Orkney and Shetland*, 1806, p. 29.

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in the form of naked grains. Lamouroux is of opinion, that it is to be sought in certain tubercular excrescences sometimes to be observed near the base or root of the plant. Turner has lately ascertained, that the seeds, or perhaps capsules containing seeds, are situated in the substance of the frond; that they are of a pyriform shape, and crowded together; and that they escape as the epidermis melts away.

F. digitatus.

F. *digitatus:* "The root fibrous; stipes or stem woody, cylindrical, expanded at its apex into a single cartilaginous, flat, nerveless, roundish leaf, quite entire at its margins, deeply cleft into numerous ensiform, mostly simple segments."—This species has in England received the appellation of *sea girdles and hangers,* and in Scotland it is very generally known by the name of *tangle:* in Orkney it is called *red-ware.* It is the *Skalmetare* of the Norwegians, and the *slat-mhara* or sea-wand of the Scots Highlanders. It is one of the largest native species, having a stem often three feet in length, and a large divided frond; and was denominated *phycodendron* or *Fucus arboreus* by some of the older writers. It is very abundant on all our rocky shores, growing chiefly on rocks which are only partially uncovered at the lowest ebbs, so that in neap tides the fronds are scarcely perceptible. The root consists of a congeries of thick horny fibres, often covered with Balanus striatus, and the interstices inhabited by asterias sphærulata and other vermes. In deep water, exposed to a moderate current, but protected from the heavy action of the waves, it attains a great size, the stalk becoming as thick as one's wrist, from three to four feet long, and the fronds of corresponding length, perhaps from ten to twelve feet. Both Turner and Wahlenberg seem to doubt whether F. saccharinus (next described) and this, be specifically distinct. Wahlenberg observes, that, near the shore, the winds and waves prevent a large growth, or the copious production of mucilage, and that in this way the appearance of F. digitatus is so much changed, that a new name (saccharinus) is applied to it. We must be excused for remarking, however, that we have seen specimens of Fucus saccharinus cast ashore from the Frith of Forth, which measured fifteen feet in length; and for adding, that the Fucus digitatus which grows at the Black Rocks near Leith exposed to winds and waves, is uniformly possessed of the distinctive characters of F. digitatus as described by Turner. In Scotland, the very young stalks and leaves are eaten along with dulse, or F. palmatus. Old Gerrard indites, that being boiled tender, and eaten with butter, pepper and vinegar, it makes good food. But at present it is employed only in the raw state. On the shores of some of the Orkney islands, particularly Westray, it is cut by means of long knives or scythes, managed by men in boats at low water; it is tied in large bundles, and being floated ashore, is burned into kelp in reverberatory furnaces. Captain Richan of Rapness has considerable merit in forming a very pure kelp by these means. It may be stated, that Dr Traill of Liverpool, from a series of experiments made by him while resident in the northern islands, found that its fronds yielded more kelp than equal portions of F. vesiculosus, or any of the other species generally used in the manufacture.

In Scotland the stems are sometimes put to rather an unexpected use,—the making of knive-handles. A pretty thick stem is selected, and cut into pieces about four inches long. Into these, while fresh, are stuck blades of knives, such as gardeners use for pruning and grafting. As the stem dries it contracts and hardens, closely and firmly embracing the hilt of the blade. In the course of some months the handles become quite firm, and very hard and shrivelled, so that, when tipt with metal, they are hardly to be distinguished from hartshorn. In the north of Scotland, and especially in the Orkney and Shetland islands, the large stalks are dried and used as fuel. This is likewise done in Norway, and on some of the shores of France, where fuel is nearly equally scarce, but much less needed. The stems are generally invested with many parasitic fuci and confervæ, and not unfrequently with the shell-fish called anomia ephippium and scala.

A curious fact may be mentioned relative to this species. Dr Yule of Edinburgh being engaged in some experiments, in order to ascertain the state in which the saline matter exists naturally in the fuci, had some thick stems of F. digitatus hung up in his cellar. From different parts of one of these, young shoots of frondlets germinated,—of great delicacy and beauty, being nearly transparent. Do the fuci, then, produce buds from their stems, like most land plants; or did these germs originate from seeds accidentally attached to the stem, when in its native element? On being brought into a warm room, the young shoots speedily decayed.

F. bulbosus.

F. *bulbosus:* "The root hollow, swollen into a bulb, rough all over; stipes coriaceous, flat, twisted once at its origin, its margins undulated in the lower part; its apex expanded into a single, cartilaginous, flat, nerveless leaf, entire at its margins, deeply cleft into numerous ensiform, mostly simple segments. The fructification consists in oblong seeds immersed in the margins of the stipes."—This is the Fucus polyschides of the *Flora Scotica,* sometimes called *sea furbelows.* In size it far exceeds any other sea-weed found on our shores, and is certainly not undeserving the titles of *giganteus* and *arboreus,* sometimes bestowed on it by the earlier botanists. It is very curious that, notwithstanding its size, Linnæus seems to have been unacquainted with it. It sometimes occurs twelve feet long; and it is of such a specimen in its wet state, that Lightfoot speaks, when he says, that a single plant is a sufficient load for a man's shoulders. It is plentiful in the Pentland Frith, and numbers of large specimens are frequently cast ashore in the bay of Thurso, as well as on the Orkneys. It is likewise pretty common among the Western Islands. It is found more sparingly on the east coast of Scotland. On the shores of the south of England, of France, and in the Mediterranean, it is very abundant. It is always found in deep water, occupying very commonly, in the southern seas of Europe, those kinds of habitat which F. digitatus generally fills in the north. It very often forms a constituent of the drift-ware collected on the Scottish shores after storms, and either burnt into kelp, or laid on corn lands as a manure.

Esculent species.

In treating of the kelp fuci, it has already been mentioned, that most of them yield a substitute for winter provender to cattle on the bleak shores of northern countries. Some others, which are frequently employed as articles of human sustenance, and which have sometimes saved the inhabitants of those countries from the horrors of famine, are now to be enumerated; with the addition of two or three which are occasionally employed as ingredients in salads and condiments.

F. saccharinus.

F. *saccharinus:* "The root fibrous; fibres long and branching; stipes almost woody, cylindrical, undivided, expanding at its apex into a single cartilaginous flat simple linear oblong nerveless leaf, entire at its margins; the fructification consists in scattered seeds immersed in the leaf."—This species is often called *sea-belt*. It is very common, and one of the largest of our fuci. The colour is a deep olive brown, sometimes partly green. Wahlenberg mentions that he ascertained by experiment that the plant contains no mucilage. An extraordinary circumstance in the history of this plant (already alluded to) was first correctly observed by Mr Bingham of Uxbridge. A contraction is observed to take place in the frond every year: this is occasioned by a new or secondary frond proceeding from the stem, and pushing the old or primary frond before it. Mr Turner was the first who correctly described the fructification. It is observable in the centre of the leaf, in the form of irregular spots, the frond being at these places much thickened, and the surface found, on applying a microscope, to be covered with innumerable extremely minute oblong brown seeds. Lightfoot mentions, that the common people on the coast of England sometimes boil this species as a pot-herb. The Icelanders, we are told by Anderson, boil it in milk to the consistence of pottage, and eat it with a spoon. They are also said to soak it in fresh water, dry it in the sun, and then lay it up in wooden vessels; it soon becomes covered with a white efflorescence of salt, which has a sweetish taste, and in this state they eat it with butter. Lastly, it is mentioned that they feed their cattle with the plant, both in its recent and dry state. There is, however, every reason to think that all this is more properly applicable to Fucus palmatus or dulse, than to the true F. saccharinus; for Mr Hooker informs us that the *alga saccharifera Islandica* is the Fucus palmatus. We are positively certain that the Fucus saccharinus of the Frith of Forth, prepared according to the usual methods of cookery, makes a wretched pot-herb, and that, in its unprepared state, it is of so harsh a nature that cattle cannot relish it. The Norwegians, we may add, on the authority of Wahlenberg, prize it so little, that their name for it, *Toll-tare*, implies that it is fit only for the devil. Very different, however, is the estimate of its merits in some parts of the East Indies. It is there so extensively used as human food, that it is well entitled to be placed at the head of the list of edible fuci. Thunberg, in his *Flora Japonica*, states that it is much used in Japan, and is there prepared in such a way as to be quite esculent. Barrow, in his *Voyage to Cochinchina*, confirms this statement, and mentions, that, when valuable presents are made by the Japanese, they are laid on pieces of this fucus, in testimony, as he thinks, of their regard for it as the general emblem of those sources of subsistence which the sea affords. He is further of opinion, that the famous chinchou jelly of China is in part made from this species. If further proof be wanted, it is furnished by Broughton, who informs us,* that in Volcano Bay, in the island of Matsmai, he saw a junk laden with sea-weed, which he affirms, without hesitation, to have been Fucus saccharinus. He says that it grows plentifully on the shores of Volcano Bay, and that the people were constantly engaged in cutting it, drying it in the sun, and making it up into bundles for exportation. He repeats, in three different places of his work, that the plant alluded to is Fucus saccharinus; and although neither Barrow nor Broughton seem to have any pretensions as botanists, they are supported in this instance by Thunberg, who ranks high as a botanical authority. It may therefore seem extravagant to surmise the possibility of all these writers being in a mistake concerning the identity of the species; yet to those best acquainted with this tribe of plants, it would be no great surprise hereafter to learn, that the Fucus saccharinus of the East is in reality a non-descript species, resembling the British plant. In the mean time, however, we must receive them as the same, and conclude, that the Fucus saccharinus of our shores is neglected and despised, merely because we are ignorant of the mode of preparing it; and that, from the want of this knowledge, a plant, capable of affording a useful article of food or even a nutritious delicacy, is of no use to us, but to swell the heap of drift-ware for the kelp furnace or the dunghil. For the former purpose, indeed, it is not much esteemed, as it is found to become bleached and saltless from even slight exposure to rain."

F. esculentus.

F. *esculentus*: "The frond membranaceous, flat, mid-ribbed, simple, ensiform, entire at its margins, supported upon a short, cylindrical, pinnated stipes; pinnæ fleshy, distichous, oblong, flat, nerveless, containing numerous, pyriform, immersed seeds."—This is called *Badderlocks* or *Hen-ware*, on the east coast of Scotland; and in the Orkney islands, *Honey-ware*. In Norway it is, by way of eminence, styled *tare* or ware. It grows on rocks in pretty deep water, commonly in places where the tips of the fronds can reach the surface at ebb-tide. The stalk is generally from six inches to a foot in length; and near its base occurs a whorl of pinnæ. The frond varies from six to twenty feet in length, with a mid-rib extending the whole way. The mid-rib, stripped of its membrane, is the part chiefly eaten; but in some places, particularly in Orkney, the pinnæ are also eaten, under the name of *mirkles*. Mr Turner mentions that these are likewise called *keys*, and are only brought to market when thick and fleshy, which is generally in August and September. In Norway the pinnæ do not in general appear till the second year. Wahlenberg states, that during the first year the stem is naked, but next year, while the greater part of the frond is destroyed, the stem swells in the middle; from which swelling the pinnæ proceed. At the Carr Rock in the Frith of Forth, the pinnæ were visible not only the first year, but in plants only a very few months old; and the rudiments of them were discernible in some which were only three or four inches long, and apparently but a few weeks sprung.

F. palmatus.

F. *palmatus*: "The frond is membranaceous, flat, nerveless, palmated, quite entire at the margin; segments oblong, mostly simple; seeds naked, collected into wide, irregularly shaped spots, scattered all over the frond."—This is the well-known *dulse* of the low-land Scots, and the *duilliosg* of the Highlanders. In Ireland it is called *dillesk*; and it is there first washed in fresh water, and then dried in the sun, before being used. In this state it is often made up into rolls, and chewed like tobacco. The Icelanders call it *sol*. The Norwegians name it *sou-soell* or sheep's-weed, and Bishop Gunner has therefore adopted the name Fucus *ovinus*, observing that sheep and goats betake themselves in great numbers eagerly to the shore at ebb-tide to obtain this pleasant food. "Buy dulse and tangle," is one of the Edinburgh cries, *tangle* meaning the tender stalks and very young fronds of Fucus digitatus. Both are eaten recent from the sea, commonly without any preparation; they are sometimes considered as forming a salad, but more generally are used as a whet. Dulse is now very seldom fried and brought to table. It is said, that the inhabitants of the Greek

* *Voyage to the North Pacific Ocean, in* 1795, &c. by W. R. Broughton, p. 273.

Fuci.

islands are fond of this species, adding it to ragouts and olios, to which it communicates a red colour, and at the same time imparts some of its rich and gelatinous qualities. The dried leaves infused in water exhale an odour somewhat resembling that of sweet violets, and they communicate that flavour to vegetables with which they are mixed. Lightfoot mentions, that in the Isle of Skye in Scotland, it is sometimes used in fevers, to promote perspiration, being boiled in water, with the addition of a little butter. Fucus palmatus grows not uncommonly on rocks which are barely uncovered at the ebb of the tide; but it is more frequent as a parasite on Fucus nodosus; and it occurs also on the stems of Fucus digitatus, attaining in this situation a considerable size, perhaps twelve or fifteen inches long, while in general it is only about six or eight inches. It is soft and limber, and does not become rigid by drying, being of a more loose texture than many other sea-weeds.

F. edulis. F. *edulis.* "The frond fleshy, flat, nerveless, simple, cuneiform, quite entire, rounded at the apex, attenuated at the base into a very short cylindrical petiolus; solitary seeds scattered all over the frond."—This is not uncommon in Scotland, and being thick and succulent when young, is frequently preferred to F. palmatus, especially for roasting in the frying-pan. Like that species, it gives out a smell somewhat resembling that of sweet violets. When fresh, it is of a deep opake blood-red colour; on maceration, it gives out a purple dye. Old fronds of a large size, perhaps two feet in circumference, are sometimes cast ashore near Leith; these are of a dark colour, and very full of holes. These holes are supposed by the fishermen to be made by crabs, which, they assert, are very fond of this species.

F. ciliatus. F. *ciliatus.* "The frond between membranaceous and cartilaginous, flat, nerveless, generally lanceolate, branched in a pinnated manner, ciliated at its margins and surface; cilia mostly simple, patent, subulate, producing tubercles at their apices."—This is not very common on our shores: it is sometimes, however, mixed with F. palmatus, and sold and eaten as dulse along with that species. It is distinguished not only by its cilia or fringes, but its fine red colour, and almost pellucid substance. It was formerly known by the names of F. lanceolatus, and holosetaceus.

F. pinnatifidus. F. *pinnatifidus.* "The frond compressed, cartilaginous, branched; branches mostly alternate, doubly pinnatifid; ramuli blunt, callous; capsules ovate, sessile, and naked seeds on the ramuli."—In Scotland, this is sometimes called *Pepper-dulse*, from its hot biting taste in the mouth. On account of this quality, although its smell is not very prepossessing, it is sometimes eaten along with the common dulse. In Iceland, it is believed, it is still used in place of a spice. It appears to be an annual, and its pungency is considered as greatest in the early part of the summer. It is very common on all our shelving rocky shores, growing along with F. palmatus and crispus, and Corallina officinalis. It is subject to considerable variations, particularly in colour; being frequently olive yellow, but sometimes tinged with red, or dark red approaching to purple. It is somewhat curious that this species, which is common to Scotland and Iceland, should be found also in the Red Sea, and on the shores of Egypt.

F. natans. In treating of the oceanic fields of sea-weed, some of the uses of Fucus *natans* (including F. natans, bacciferus, and several others of Turner) have already been hinted at. The most succulent fronds are selected, and prepared as a pickle, like samphire, and the young and tender shoots are eaten as a salad, seasoned with juice of lemons, pepper and ginger. This sort of sea-weed is also in some repute as a medicine, being accounted aperient and antiscorbutic, and employed by the native Americans to cure fevers.

Many of the Asiatic nations bordering on the sea, use different species as food. The superior orders employ them chiefly to give consistence to sauces, or to moderate the pungency of the hot spices which they use in such profusion.

F. lichenoides. In the East Indies, and particularly in Ceylon, F. *lichenoides* (*Turn.* t. 118.) is in high estimation for the table. The following is its character: "Frond subgelatinous, cylindrical, filiform, much and irregularly branched; branches patent, nearly of equal height, acuminated, generally forked at their apices, with short divaricated segments; tubercles hemispherical, sessile, scattered all over the frond." From the circumstance of its being used as an article of food, Gmelin, in his *History of Fuci*, gave it the title of F. *edulis*, a name now appropriated to a very different one, allied to the *palmatus*, and above described. F. lichenoides is completely of a gelatinous nature: it is washed in fresh water, and squeezed, so as to remove a considerable part of its mucilage and saltness; after which it is served up with a sauce prepared with lemon-juice and ginger. This is supposed to be one of the principal ingredients employed by the East Indian swallows in constructing those edible nests which are so much in repute not only in China, but throughout India, and in request even at the luxurious tables of London. The most pure and transparent nests are now generally believed to be almost entirely composed of the gelatinous fuci.

F. tenax. F. *tenax* is employed in the Chinese empire to serve all the purposes of our gum Arabic and glue. It is a small cylindrical filiform species, allied to F. acicularis. It was first described by Turner in *Annals of Botany*, vol. ii. and is figured in the *History of Fuci*, t. 125. It is gathered on the shores of the provinces of Fo-kien and Tche-kiang; and although of small size, it is found so plentifully, that about 27,000lbs. are annually imported at Canton, and sold at 6d. or 8d. per lb. As soon as gathered, it is dried in the sun; and being then compressed, it will keep good for several years. When it is to be used, the saline particles and impurities are washed off; it is then steeped in warm water, in which it dissolves, stiffening as it cools into a vegetable gluten, which again liquefies on exposure to heat. It seems probable that this is the principal ingredient in the celebrated gummy matter called *chin-chou*, or *hai-tsai*, in China and Japan. Large sheets of paper or of coarse gauze are besmeared with it; they thus acquire additional transparency, and are used in windows or lanterns. Windows made merely of slips of bamboo crossed diagonally, have frequently their lozenge-shaped interstices wholly filled with the transparent gluten of the hai-tsai.

It is remarked by Mr Turner, (*Hist. Fuc.* t. 216—218), that the common and well-known though very variable species, F. *crispus* and *mamillosus* of our own shores, are readily melted by boiling, and that they afterwards form a gelatine. This has not yet, however, been applied to any use, either by the cook or the artist. Unfortunately they are not only of small size, but could not easily be gathered in sufficient quantity.

It may be mentioned, on the authority of Mr Barrow, that at the Cape a kind of gelatinous fucus, very useful as food, is gathered, particularly from the shores of Roben Island. The leaves are described as sword-

Fuci.

shaped, serrated, and about six inches long. These being first washed clean, and sufficiently dried to resist putrefaction, are steeped in fresh water for about a week, changing it every day. After this, being boiled for a few hours in a little water, they form a clear transparent jelly; which being mixed with sugar, and the juice of a lemon or orange, affords a pleasant and refreshing dish.

According to Dr Olaus Swartz, F. *spinosus*, (muricatus of Gmelin) is eaten by the inhabitants of Sumatra. This species occurs at the Cape, but is there neglected.

Some of the gigantic species, particularly F. *potatorum* of Labillardiere, furnish various instruments and household vessels, as well as food, to the native inhabitants of New Holland.

A few of the smaller and more delicate kinds seem capable of affording colouring matter or paint. Ginanni describes one under the name of *Fuco tintorio*. This Mr Turner considers as probably F. purpureus, which is very common in the Mediterranean, and gives out a beautiful chocolate dye in fresh water.

It may be mentioned, that in the North of Scotland, a kind of sauce for fish or fowl, somewhat resembling ketchup, is made from sea-weeds; frequently from the cup-like frond or base of F. loreus.

Medicinal species.

The mucus from the vesicles of F. vesiculosus and similar species, has been recommended in diseases of the glands, by Dr Russell; and F. *helminthocortos*, (*Turn.* t. 233.) a small Mediterranean species, though little known in Britain, has long been employed by medical men on the continent as a vermifuge, under the name of Moss or Coralline of Corsica.

Ornamental species.

Some of the small red species are very ornamental when displayed in pictures; and are used not only to embellish the cabinet of the naturalist, but apartments in general. The foreign species chiefly employed for this purpose, is F. *cartilagineus*, which abounds at the Cape, and is remarkable for the regularity and elegance of its form, and the richness of its tints.

F. cartilagineus.

F. coccineus.

The native species most generally used for forming mimic trees or landscapes, is F. *coccineus*. The frond is compressed, in substance between membranaceous and cartilaginous, much and irregularly branched; the ramuli subulate, disposed in alternate parcels of three or four each. As formerly observed, two kinds of fructification are to be found on different individuals of this species; both spherical sessile capsules, and lanceolate siliquæ. It is beautifully figured by Turner (*Hist. Fuc.* t. 59.) and also by Stackhouse, in a frontispiece to one of the fasciculi of his *Nereis Britannica*, (p. 106.) It is singular that this species, though very common, escaped the notice of Linnæus. When it is dexterously expanded on very smooth white paper, or on the glossy interior of large flat shells, the effect is very beautiful. It is generally of a bright red colour, but sometimes tinged white or yellow. It grows about three or four inches long. In minuteness of ramification, it is excelled only by F. *asparagoides*, (*Turn.* t. 101.) a species of much less frequent occurrence.

F. plumosus.

F. *plumosus* is likewise very ornamental. The frond is compressed, cartilaginous, much and irregularly branched; the branches are repeatedly pinnated, producing the feather-like appearance, from which the name has been given. It is of a purple colour, often inclining to yellowish brown. It is generally from three to five inches long; but in the north of Scotland it reaches six or seven inches. Still farther to the north of Europe, as on the northern coast of Norway, it grows to yet a larger size; so that it may truly be reckoned a northern plant. It is generally found attached to old stems of fucus digitatus.

F. alatus.

F. *alatus* is the most abundant of all the small ornamental sea-weeds, being very common on stalks of F. digitatus. The frond is membranaceous, very tender, mid-ribbed, linear, subdichotomous; the segments alternately pinnated. It is three or four inches high, and of a fine purplish red colour.

Preserving of Sea-weeds.

Preserving of sea-weeds.

Many of the fuci, and particularly the Florideæ of Lamouroux, make a beautiful appearance when preserved in a herbarium or hortus siccus. All of them require to be soaked for some time in fresh water, and they are the better for being repeatedly rinsed in renewed basons of water, to cleanse away and extract as much as possible the sea-salt which adheres to them, or with which they are impregnated. The larger sort need no other preparation; but are to be dried between folds of bloating paper, and pressed in the manner of herbaceous plants. The finer leaved fuci must be treated in a different way. After being washed, as above directed, in repeated waters, till no impurities of any kind remain, they are to be separately floated out in a large shallow dish containing water, so that their most minute and delicate branches may be fully expanded. For disentangling the nice ramifications, a common pin, or a sharp-pointed pen, may be employed. A piece of stiff, but fine and smooth writing paper, is then to be gently introduced under the specimen, and the minute branchlets being again spread out where they may have been disordered, the paper is to be cautiously and slowly inclined, and at last drawn out, so as to contain on its surface the plant in its fully expanded state. After this, most of the delicate species, if carefully dried and pressed, adhere to the paper by their own gluten, and require no farther care. Mr Turner mentions that he fixes the non-adhesive kinds by means of a cement made from F. ciliatus and crispus of our shores. These are boiled in water over a quick fire, and soon become melted: on cooling, they form a gluten, not to be relied on as a strong cement, but which is well adapted for a herbarium, as it neither imparts a stain like glue, nor a glare like gum. If the paper be slightly rubbed over with the mucilage, and a delicate membranaceous plant afterwards placed on it, it will become sufficiently fixed merely by moderate pressure. Some collectors, finding that any kind of paper is apt to curl up, expand the delicate species over a plate of glass, and, after allowing the water to drip off, transfer the specimen carefully to the paper.

To inland collectors, who occasionally make an excursion to the shore, it may be useful to know, that all the preparation that is necessary at the sea side is to dry the specimens moderately in the free air, and tie them loosely up in strong brown paper. In this way they may be carried to a great distance, and kept for some days. On being immersed in fresh water, they in general expand as fully as before; but it must be confessed that the colour of some kinds is extremely apt to change. In the *vasculum*, or botanic box, which serves so well for preserving herbaceous land plants, specimens of marine plants very rapidly undergo the putrefactive fermentation. (P. N.)

Fuego.

FUEGO, or TIERRA DEL FUEGO, "the land of fire," was so denominated by Magellan, because he perceived many fires during the night, supposed to have been volcanoes in the mountains, but probably nothing more than the numerous fires kindled by the natives on account of the cold. It is a large island, or rather group of islands, bounded on the north by the straits of Magellan, and on all other sides by the sea; situated between 52½° and 56° South Latitude, and between 65° 10′ and 75° 30′ West Longitude from Greenwich. It is divided by narrow straits into eleven or more islands of considerable size, and extends about 300 miles from east to west, and from 100 to 200 in breadth. From Charlotte promontory, which is the north-east extremity, the coast extends west north-west, to a large promontory, that forms the mouth of the first narrow passage in the strait; and then, in a south south-west direction, forming a circular basin, which terminates at the promontory of Sweep-stakes on the south side of the second narrow channel. The inhabitants on this part of the coast behaved with great humanity to the crew of the Spanish ship Conception, which was wrecked on their shores in 1765; assisting them in saving part of their cargo, and in erecting sheds to shelter them from the weather; and discovered so little of the cruelty common to most savages, that the Spaniards of South America projected a missionary establishment among them. The coast next inclines southward, forming an arch of a great circle, cut by Cape Monmouth, and the inlet of St Sebastian, on to Savage bay, from which a mountainous country stretches south-west, exhibiting the appearance of several narrow straits. Beyond these is Swallow harbour, a well sheltered bay, where there is good landing and a sufficient supply of wood and water; but the surrounding mountains have a dreary aspect, and seem to be deserted by every thing that has life. The coast continues now in a north-west direction, forming many bays and inflexions, inclosed by barren rocks without any appearance of soil, having their summits covered with snow, and their deep vallies filled with immense masses of ice. To this part of the country Sir John Narborough gave the name of "the land of Desolation;" and nothing more dreadful, says Bougainville, can be imagined. It is still high and steep, and terminates in Cape Pillar, the north-west extremity, where the Pacific Ocean opens to the view. This cape is a great mass of rocks, which rise into two huge cliffs resembling towers; and round it are several small islands or rocks named the Twelve Apostles, reaching several miles into the sea. Two leagues south of Cape Pillar is Cape Desire, from which the coast takes a south-east direction, and is broken into various inlets, or rather composed of a number of islands, beyond which appear barren and rocky mountains, spotted with tufts of wood and patches of snow. From Cape Gloucester, which is about 23 leagues from Cape Desire, the coast turns south-south-east for ten leagues, to Black Cape, a steep and high rock, shaped like a sugar loaf; a little towards the east from which is the great bay of St Barbara, supposed to communicate with the Straits of Magellan. Beyond this bay, the country is entirely composed of rocky mountains without the least appearance of vegetation, terminating in dreadful precipices, and raising their craggy summits to an immense height. About 23 leagues from Barbara Bay, appears Cape York Minster, a lofty promontory, terminating in two high towers, with a conical hill between them. To the east of this opens Christmas Sound, in the bottom of which is a deep and secure harbour, named Devil's Bason, so completely encompassed by lofty rocks as to be entirely excluded from the rays of the sun. To the south-east of Christmas Sound is a group of rocks, called the Isles of Ildefonso, nearly east from which is Nassau Bay, whose west point is the most southerly extremity of Tierra del Fuego, and is sometimes denominated False Cape Horn. In front of Nassau Bay lie the Hermit Islands, the south point of which is the True Cape Horn, known at a distance by a round hill over it, and situated in 55° 58′ South Latitude, and in 67° 46′ West Longitude. The coast stretching north-east from Nassau Bay is little known for the space of 30 leagues, to Valentine's Bay, which forms the south-west entrance of the Strait of Le Maire. About the middle of this strait, on the Tierra del Fuego side, is the Bay of Good Success; and on the south-east extremity are two low promontories, called Cape Diego and Cape Vincent, where the strait opens to the east. From these capes to Charlotte Promontory, the eastern coast of Tierra del Fuego is more level, woody, and verdant, than any other part. The soil here in the vallies is rich and deep; and a stream of a reddish hue, but of good water, runs at the bottom of almost every hill.

Interior of the country.

The interior parts of Tierra del Fuego have never been explored, but appeared to consist of continued mountains of immense height and irregular surface. About one-fourth of their ascent is frequently covered with trees of a considerable size. Towards the middle, nothing but withered shrubs appear: next succeed patches of snow and fragments of rock; while the summits, composed of huge crags piled upon each other, and towering above the clouds, are devoted to everlasting sterility. Many of them are nothing but immeasurable masses of rock, naked from the base to the summit, without a single shrub or one blade of grass to be seen upon them; and the intermediate vallies, equally destitute of verdure, are filled with beds of snow, or masses of ice. The climate is intensely cold and stormy; and, even in the midst of summer, the ground is frequently covered with snow. Its severity is fatally exemplified by an accident mentioned in Captain Cook's first voyage, a part of whose crew having attended Sir Joseph Banks and Dr Solander on shore, and having been obliged to pass the night in the open air, though it was upon the most temperate part of the coast, and about the season of midsummer, two of them expired of cold; and Dr Solander himself, a native of Sweden, was saved with great difficulty. Even in this barren soil and dreary climate is found a great variety of plants unknown in Europe. The trees chiefly noticed were, beech, birch, winter-bark or spice laurel, and the holly-leaved barberry. The plains are covered with a kind of spongy moss; and nettles, wild celery, and scurvy-grass, are generally found close to the beech. Cranberries, red and white, are produced in great abundance. Fish may be procured with great facility on every part of the coast, and particularly on the Straits of Magellan. Whales, seals, and sea-lions, are seen in great numbers along the shores, particularly in the Straits of Le Maire. There are great quantities of shell fish, limpets, clams, and especially mussels, some of which are five or six inches in length. Few insects have been observed in the country, and none that were either hurtful or troublesome. Of land-birds there are few varieties: and none have been seen larger than an English blackbird, except a few hawks and vultures. But there is plenty of water-fowl, sea-pies, shags, and the kind of gull generally called Port Egmont hen;

Climate.

Productions.

geese, resembling bustards, smaller than the tame geese of England, but well tasted; and ducks of several kinds, the most remarkable of which, called by the sailors race-horses, are unable to fly on account of the shortness of their wings, but run upon the water with amazing swiftness. Almost the only quadrupeds observed by navigators were dogs in a domestic state, which differed from others of their species bred in America, in possessing the faculty of barking. The traces of larger animals were indeed noticed in some places: but their species could not be ascertained.

The natives of Tierra del Fuego are the most deplorable in appearance, and the most destitute in resources, of the human race,—inhabiting the most inhospitable climate in the world, and possessing no sagacity to provide themselves with those few conveniences, which even their dreary land might supply. They are a little, ugly, meagre, and beardless race, * with long black hair, and the colour of their skin like the rust of iron mixed with oil. Their whole apparel consists of the stinking skin of a seal, sometimes of a guanicoe, thrown over their shoulders, exactly in the state in which it was taken from the back of the animal. A piece of the same skin is sometimes drawn over their feet, and gathered about the ancles like a purse; and a small flap is worn by the women as a fig-leaf. They appeared very fond, however, of ornament, and paint their faces in various forms, generally with horizontal streaks of black and red, with a white ring round the eyes. They wear upon their wrists and ancles bracelets of beads formed of small shells or bones, and delight particularly in every thing that is of a red colour. Their food consists chiefly of cranberries and shell-fish, and sometimes the flesh of whales or seals, which they devour with the greatest relish in a raw and rotten state. Some of Captain Wallis's people gave to one of them a fish, as it was taken alive out of the water: the Indian snatched it hastily as a dog would take a bone; and, instantly killing it, by giving it a bite near the gills, proceeded to eat it, beginning with the head, and going on to the tail, without rejecting either the bones, fins, scales, or entrails. They ate readily whatever food was given to them by European voyagers, but could not be persuaded to take any other drink than water. They appear to have no fixed residence, but to move from one place to another, after having exhausted the supplies of shell-fish around their habitations. Their huts are constructed in the most rude and inartificial manner imaginable, and are merely a few poles set up inclining towards one another, and forming a cone at the top like a bee-hive. They are covered on the weather-side with a few boughs and a little grass, yet not so as to exclude the snow or rain; and, on the lee, nearly an eighth part of the circumference is left open, both as a door and a chimney. Within these wretched hovels no kind of furniture is seen; and a little grass laid round the inside of the stakes, serves the purposes of chairs and beds. The only utensils observed among them were a satchel to hang on the back, a basket to carry in the hand, and a bladder to hold water. Wherever they halt, though only for a short time, in the open air, they always kindle a fire; and are generally affected with sore eyes, from sitting so much over the smoke of their fires. Even in their canoes, they have a fire placed on a heap of sand in the midst of the vessel, around which they huddle themselves as close as possible; and which they seem thus to carry about with them, not only for the sake of immediate warmth, but in order also to have fire ready kindled wherever they may land. Their canoes are extremely slight made, sometimes of planks, but generally of pieces of bark sewed together either with the sinews of some wild beast, or with thongs cut from a hide. A kind of rush is laid into the seams; and the outside is smeared with a resin or gum, to prevent the water from soaking through the bark. About fifteen slender branches, each bent into an arch, are sewed transversely to the bottom and sides; and some straight pieces are placed across the top from one gunwale to the other, and fastened securely at each end. These vessels are about fifteen feet long, three broad, and three deep, are steered with paddles, and have only a seal-skin as a sail. The only appearance of ingenuity among them was in their weapons, which consisted of bows, arrows, and javelins. Some of the bows were neatly made, with strings of gut; and the arrows were formed of wood, very highly polished, with a point of glass or flint, barbed, and fitted to the shaft with wonderful skill. In the use of these weapons they discovered great dexterity, and seldom failed to hit a mark at a considerable distance. They have also a kind of harpoon, which they use in fishing, formed of a fish bone about a foot in length, sharpened at the end, toothed on one side, and fixed to a long pole. No appearance of subordination or government has been observed among them, and no one is respected more than another; yet they seemed to live together in the utmost harmony. Neither do they discover any notions of religion, unless a vehement vociferation addressed to every new object, may be considered as a species of exorcism, and as implying a belief in evil spirits. Both those who were seen by Bougainville and by Cook, though on different parts of the coast, gave themselves the name of Pecheray; and they do not seem to be a numerous people. Their language in general is guttural, and some of their words are expressed by a sound resembling that which is made by clearing the throat; but other expressions are sufficiently soft, such as *hallĕcă*, beads, and *oodâ*, water. They are harmless, and friendly towards strangers; and, either from a contented disposition, or from stupidity of mind, discover no desire for additional possessions and gratifications. When carried on board of European ships, they testified no emotions of surprise, satisfaction, or curiosity; regarded every object, except looking-glasses, and the clothes of the people, with utter indifference; and expressed no wish for any thing whatever but beads. One of their women even offered her sucking child to an officer of Byron's ship; and their whole aspect and manners declared them to be among the lowest and most wretched of human beings. See Byron's, Wallis's, Bougainville's *Voyages*, and Cook's *First and Second Voyages Round the World*. (*q*)

FUEGO, or Fogo. See *Cape de* Verd *Islands*.

FUENTE D'Honores, Battle of. See Britain, p. 731.

FULCRUM. See Mechanics.

FULDA, a town of Germany, in the circle of the Upper Rhine, and capital of the bishopric of the same name, but lately transferred to the Grand Duchy of Frankfort, is situated nearly in the centre of the bishopric, on the banks of the river Fulda. The principal objects of interest at Fulda, are the palace, with its pleasure gardens, where the bishop formerly resided, containing an apartment of optical glasses; the cathedral and its

* A few of the men on the coast of the Straits of Le Maire were larger, and more clumsily made.

Fulda, Fullers Earth.

treasury; the church of St Boniface; the church of St Michael, which is said to have some resemblance to the temple of Jerusalem; and the convent of Franciscans, finely situated out of the town. The University of Fulda was founded in 1739; and in the ancient library are to be found many rare and valuable MSS. Here is a manufactory of porcelain. In the neighbourhood of Fulda are the baths of Bruckenau, which are celebrated for their romantic situation, and for the good society which is to be met with. The celebrated Jesuit, Athanasius Kircher, was a native of this town. Population 12,000. Its position, according to trigonometrical observations, is East Long. 9° 44′ 0″, and North Lat. 50° 33′ 57″. (*w*)

FULDA, Bishopric of, the name of an ancient principality in Germany, which was included by Bonaparte in the Grand Duchy of Frankfort. The extent of this principality was formerly 37 square German miles; its annual revenue 35,000 rixdollars, and its population 900,000. The principality contained many well-wooded mountains, some rich arable land, and several important salt springs. See Confederation *of the Rhine*, Germany, and Catteau de Calleville's *Voyage en Allemagne et en Suede*, tom. i. p. 259, 260, where the reader will find an account of the origin of the town of Fulda.

FULGORA. See Entomology, *Index*.

FULLERS Earth. Two sorts of argillaceous earths are described under the name of *cimolia*, in catalogues of the Materia Medica, *cimolia alba, seu argilla alba*, Pharm. Edinb. the pure white strong clay, called, from the use to which it is principally applied, tobacco-pipe-clay; and *cimolia purpurascens*, (Pharm. Edin.) a compact bolar earth, commonly of a greyish brown colour, called from its use fullers earth. These have been both since expunged, and the name *cimolia* would appear to have been given from Cimolus, the ancient name of an island in the sea of Crete, opposite to the promontory Zephyrus, having the same kind of soil; hence *terra cimolia*, Κιμωλια γη, chalk, or fullers earth, and *Cretosaque rura Cimoli*, Ovid; it is now called *Sicandro*.

Among the useful researches for which we are indebted to the illustrious Bergman, we find one upon lithomarge, or stone marl, which seems to differ from common marl in its composition, chiefly in possessing a much larger portion of siliceous, and less of calcareous earth; the general characters of which are, 1*st*, When dry, it is smooth and slippery, like hard soap: 2*dly*, It is not perfectly diffusible in water; but when immersed in that fluid, it falls into pieces of greater or less magnitude, or in such a manner as to assume the appearance of curds: 3*dly*, In the fire it easily melts into a white or reddish frothy slag, which is considerably larger than before, in consequence of its porosity: 4*thly*, Its fracture is irregularly convex, or concave. Fullers earth is one of the most useful varieties of lithomarge. Its particular characters are, that the colour is greenish white, greenish grey, olive, oil green, greyish ash coloured, brown in all degrees from very pale to almost black; light yellowish green, or yellowish grey, passing into pale ochre yellow; its colours are sometimes disposed in spots or stripes, it occurs only in mass, and is without lustre; it is very hard and firm, of a compact texture, of a rough and somewhat dusty surface; its fracture is uneven, passing into large conchoidal and slaty or fine-grained; it breaks by force into indeterminate, blunt-edged, or slaty fragments; it is unctuous to the touch, not staining the hands, nor breaking easily between the fingers. It has a little harshness between the teeth, melts freely in the mouth, adheres slightly to the tongue. It is opake, and sufficiently soft to be scratched by the nail. It takes a polish by friction, is moderately heavy; but its specific gravity has not been accurately ascertained: thrown into water, it makes no ebullition, or hissing, but swells gradually in bulk, and falls into a fine soft powder, especially when the water is warm: it does not effervesce with acids; before the blow-pipe it melts into a brown spongy scoria. The fullers earth of Hampshire was analyzed by Bergman, from which he obtained the following results:—

Silex	51.8
Alumine	25.0
Lime	3.3
Magnesia	0.7
Oxide of iron	3.7
Water, or moist volatile matter . .	15.5
	100.0

The analysis of other earths included in lithomarge will be found below, under *Substitutes*. There appears to be two distinct formations of fullers earth; or rather two different minerals seem to be confounded under the same name. The fullers earth of Saxony belongs to the primitive rocks, being found under strata of slaty *grunstein*, and passing by degrees into this very mineral; hence it consists of the same materials, either originally deposited in this loose state, or having acquired this consistence from decomposition. The English fullers earth, on the other hand, is always found in beds covered by, and resting upon, that peculiar and hitherto undescribed sand-stone formation, which accompanies and serves as the foundation to chalk.

Fullers earth is found in several counties of England; but in greatest abundance in Bedfordshire, Berkshire, Hampshire, and Surry. For some account of this mineral in Surry, see the article England, vol. viii. p. 713. As a more particular account will naturally be expected under the present article, we shall consider the subject under the following heads: 1*st*, Particulars with regard to the counties of England in which it has been found; 2*dly*, The mode of treatment adopted by manufacturers; 3*dly*, Its various uses; 4*thly*, Legal restraints; 5*thly*, *Substitutes* used either at home or abroad.

Account of the fullers earth in Surry.

In the county of Surry there are great quantities of fullers earth found about Nutfield, Riegate, and Blechingley, to the south of the Downs, and some, but of inferior quality, near Sutton and Croydon, to the north of them. The most considerable pits are near Nutfield, between which place and Riegate, particularly on Redhill, about a mile to the east of Riegate, it lies so near the surface, as frequently to be turned up by the wheels of the waggons. The fullers earth to the north of the road between Redhill and Nutfield, and about a quarter of a mile from the latter place, is very thin; the seam in general is thickest on the swell of the hill to the south of the road. It is not known how long this earth has been dug in Surry; the oldest pit now wrought is said to have lasted between fifty and sixty years, but it is fast wearing out. The seam of fullers earth dips in different directions. In one, if not in more cases, it inclines to the west with a considerable angle. There are two kinds of it, the blue and the yellow: the former, on the eastern side of the pit, is frequently within a yard of the surface, being covered merely with the soil,—a tough, wet, clayey loam. A few yards to the west, the blue kind appears with an irony sand stone, Fullers Earth.

of nearly two yards in thickness, between it and the soil. The blue earth in this pit is nearly 16 feet deep. In some places the yellow kind is found lying upon the blue; there seems, indeed, to be no regularity either in the position or inclination of the strata where the fullers earth is found, nor any mark by which its presence could be detected. It seems rather thrown in patches, than laid in any continued or regular vein. In the midst of the fullers earth are often found large pieces of stone of a yellow colour, translucent, and remarkably heavy, which have been found to be sulphate of barytes, encrusted with quartzose crystals. These are carefully removed from the fullers earth, as the workmen say they often spoil many tons of it which lie about them. There is also found with the yellow fullers earth a dark brown crust, which the workmen consider as injurious also. In Surry, the price of fullers earth seems to have varied very little, at least for these last 80 years. In 1730, the price at the pit was 6d. a sack, and 6s. per load or ton. In 1744, it was nearly the same. It is carried in waggons, each drawing from three to four tons, to the beginning of the iron rail-way near Westham, along which it is taken to the banks of the Thames, where it is sold at the different wharfs for about 25s. or 26s. per ton. It is thence shipped off either to the north or west of England. A considerable quantity is also taken down into Wiltshire by the waggoners, especially when they happen not to have a full load of goods.

The workmen are paid at the rate of 2s. 6d. per ton; this includes the expence of clearing away the upper soil, as well as that of raising the fullers earth. They can work on the *earth* only when the weather is dry; it is then weighed as it is dug out, by means of a rude scale suspended over that part of the pit where they happen to be working, on three or four poles fastened together at the top, and spread out at their lower ends, (an instrument called provincially a triangle). The earth that is not immediately carted off by the waggons, is put under cover in an adjoining shed, in order to preserve it from the rain. During rainy weather, and after it till the earth is pretty well dried, the workmen employ themselves in uncovering the upper soil. The sandstone that lies over the blue fullers earth is broken into pieces; the larger pieces are used for building, and the smaller for the roads; the first brings 4s. 6d. the waggon load, the second 3s. 3d.; of each of which the workmen receive about one half. In the heart of the sandstone, pieces of petrified wood, of considerable size, and sometimes of a very grotesque shape, are often found. The workmen complain, that since the iron rail-way was brought to Westham, the demand for this earth, though equally great, is not nearly so *regular* as it used to be. It is thought that the demand for the Surry fullers earth will be lessened by the recent discovery of a pit of the yellow, or better sort, near Maidstone in Kent. Fullers earth does not appear to hasten or impede, to injure or to benefit, vegetation. See Stevenson's *Surry*, p. 50—53.

In Derbyshire.

The next characteristic stratum, owing to its forming a ridge of conspicuous hills through the country, is the Woburn land, a thick ferruginous stratum, which below its middle contains a stratum of fullers earth, which is thicker and more pure in Aspley and Hogstye End, two miles north-west of Woburn, than in any known place. The upper parts of this land are frequently cemented by the oxidated iron into car stone, and the lower parts contain fragments of silicified wood. See Farey's *Derbyshire*, p. 112.

No stratum of this mineral occurs in Derbyshire; but lumps of it of considerable size, very pure, and much like that of Bedfordshire, are frequently found in the marshy gravel pit one-third of a mile east of Bretby church. Similar lumps occur in the hard gravel rock under Masham town, and smaller ones in the alluvial covering of the gypsum quarries south-east of Chellaston. In Brassington a clay is dug with which cloths are scoured; and at Brathwell, north-west of Tickhill in Yorkshire, considerable quantities of fullers earth are got, probably alluvia on the yellow lime. See Farey's *Derbyshire*, p. 465.

In Herefordshire.

Of the more rare kinds of earths and clays, there have been found red and yellow ochres, fullers earth, and tobacco pipe-clay; but probably from the want of an adequate supply, or some imperfection in their qualities, they are now generally procured from other places. Fullers earth is, however, still dug occasionally for sale in small quantities, on the estates of the late honourable Edward Foley, of Stoke Edith. See Dunscomb's *Herefordshire*.

In Sussex.

Fullers earth is found at Tillington, and consumed in the neighbouring fulling mills. See Young's *Sussex*.

In Middlesex.

Mr Little and Mr Brown, in sinking a well at Paddington in the year 1802, near the one mile stone on the Edgeware-road, discovered a stratum of fullers earth at a considerable depth, but so thin as not to be of any importance. See Middleton's *Middlesex*.

Mode of preparing fullers earth.

The above seems to be nearly all the places in England where this mineral is best found. We have now to give an account of its preparation by manufacturers, for their peculiar purposes. We have seen in the chemical account of this mineral, that it is not perfectly diffusible in water; but when immersed in that fluid, it falls into pieces of greater or less magnitude, or in such a manner as to assume the appearance of curds. Of this the manufacturers are fully aware; but as it is necessary for them that the coarse and fine should be minutely separated, they pursue the following method. That they may effect a complete solution, they bake it for one or two hours, according to the degree of heat. To accomplish greater regularity in the baking, and to make it dissolve much sooner, the large lumps are broken into pieces of a quarter or a half pound each. After baking it is thrown into cold water, when it falls into powder; and the separation of the coarse from the fine effectually accomplished, by a simple method used in the dry colour manufactories, called *washing over*. It is done in the following manner: Three or four tubs are connected in a line by spouts from their tops; in the first the earth is beat and stirred, and the water, which is continually running from the first to the last through intermediate ones, carries with it and deposits the fine, whilst the coarse settles in the first. The advantages to be derived from this operation are, that the two kinds will be much fitter for their respective purposes of cleansing coarse or fine cloth; and without baking the earth would be unfit, as before noticed, to incorporate so minutely with the water in its native state; it would neither so readily dissolve, nor so easily be divided into different qualities, without the process of washing over. When fuel is scarce for baking the earth, it is broken into pieces of the same size, as mentioned above, and then exposed to the heat of the sun.

Uses of fullers earth.

The various uses of fullers earth may be shortly explained. According to the above method, the coarse and fine of one pit are separated; and the first is used for cloths of an inferior, and the second for those of a superior quality. The yellow and the blue earths of Surry are of

Fullers Earth.

different qualities naturally, and are like the above, obtained artificially, and used for different purposes. The former, which is deemed the best, is employed in fulling the kerseymeres and finer cloths of Wiltshire and Gloucestershire, whilst the blue is principally sent into Yorkshire for the coarser cloths. Its effects on these cloths, is owing to the affinity which alumine has for greasy substances; it unites readily with them, and forms combinations which easily attach themselves to different stuffs, and thereby serve the purpose of mordants to some colours; as is the case in the Turkey red. The fullers generally apply it before they use the soap. It may be used also instead of soap on board of ship, to wash linen or the hands with salt water, with which it is well known soap does not unite.

Uses of fullers earth.

Legal restraints.

The legal restrictions on the exportation of fullers earth, may be found in the 12 Car. II. 13 and 14 Car. II.; 9 and 10 William III. c. 40; 6 Geo. I. c. 21. § 22. The penalties are so enormous, that foreign chemists turned their attention to discover substitutes for fullers earth. Cronstedt describes only the lithomarge of Osmund, Tartary, and Lemnos; the Hampshire fullers earth not having come to his hands, probably on account of the severe penalties imposed by the English legislature on its exportation. Bergman examined them all except the second, which is the keffekil of the Crim Tartars, who are said to use it instead of soap, and which he was not provided with a sample. Wiegleb, in Crell's *Journal*, quoted by Kirwan, found that it consists of equal parts of magnesia and silex.

Substitutes for fullers earth.

Lemnian earth.

The Lemnian earth, so called as being found in Lemnos, was highly esteemed for many centuries, for its supposed medical virtues, and till lately sold in Europe under the seal of the grand signior, (hence called *terra sigillata*,) has the external appearance of clay, with a smooth surface, resembling agate, especially in its recent fractures, which are usually either concave or convex. It may be scraped with the nail, is composed of impalpable particles, though a little gritty between the teeth, under which it feels like tallow. When immersed in water, it is spontaneously divided into small pieces, with a slight crackling noise, but they do not become so small as to be invisible or impalpable; pulverization and boiling in water diffuse it in the fluid, which passes almost perfectly clear through double filtering paper. This earth removes impurities like soap, though it affords no froth.

Osmundic earth.

The Osmundic earth comes from Osmund, in the parish of Rutwick, in East Dalecarlia. It colour is grey like cinders; its surface rough, and as if greased; it is harder than the Lemnian earth, breaks into angular pieces, adheres strongly to the lip, and is more gritty between the teeth than that earth: in water it separates into smaller particles, and is detergent. By the humid analysis, Bergman found the constituent parts of the two foregoing earths as follows:

Lemnian earth.

Silex	47
Carbonate of lime	5.4
Magnesia	6.2
Alumine	10
Oxide of iron	5.4
Moist volatile matter capable of being expelled by drying	26
	100

Osmundic earth.

White siliceous powder	60
Lime	5.7
Magnesia	0.5
Alumine	11.1
Oxide of iron	4.7
Moist volatile matter	18
	100

Fullers earth of Saxony.

Amongst the foreign varieties of lithomarge, the fullers earth of Saxony ought not to be forgotten, particularly in this place, where substitutes are treated of: For this, however, we must refer to the beginning of the article, and this head will be concluded by introducing a substance that is very generally found both in Great Britain and abroad. Fullers earth, we have seen, from the general results, is alumine, combined with very fine silex; it is essential to this earth that the particles of silica should be very fine, otherwise they would cut the fine cloth; hence the object in washing over the fullers earth mentioned in a preceding paragraph. It is owing to the strong affinity, as noted before, which alumine has for greasy substances, that it is so useful in scouring cloth; hence pipe clay, the cimolian earth mentioned in the beginning of this article, is frequently used for the same purpose; and it may also be concluded, that *any clay* possessed of this property may be considered, in its uses, as fullers earth; for it is the alumine alone which acts upon the grease in the cloth.

The properties required in good fullers earth are, that it should contribute to the washing away all impurities, and promote that curling and intermixture of the hairs of the woollen cloth, which thicken its texture, and give it the desired firmness. Both probably depend on its detergent quality, that clears away all the unctuous matter of the wool, and renders its parts capable of becoming more perfectly entangled by the mechanical action of fulling; an effect not so likely to take place where the fibres or hairs are disposed by grease to slide easily over each other. The detergent power resides in all clays, but is doubtless greatly increased by the siliceous earth, which may be considered as the brush, while the clay serves as the soap. This is familiarly shewn by the common practice of adding sand to soap, which renders it much more detergent, but, at the same time more capable of injuring the substances to which it is applied, and that more especially when the sand is course. Fullers earth is bad if the sand be not exceedingly fine, and the superior excellence of the Hampshire earth seems to depend more on the fineness of its parts, than on their proportions, as is shewn by the experiment of boiling it in water, after which it passes more plentifully through the filter than any of the other kinds of lithomarge. (s)

FULMINATING POWDERS is a name given to those chemical compounds which are decomposed with such rapidity as to produce a report, with other signs of violence. The most conspicuous of these bodies are the ammoniurets of gold, silver, and mercury; the precipitate formed by alcohol from nitrate of mercury, which has been called *fulminating mercury*, and the powder formed with potash, nitre, and sulphur, called *pulvis fulminans*.

Fulminating gold.

The first of these compounds, viz. ammoniuret of gold, is prepared by dissolving gold in a mixture of equal parts of nitric and muriatic acids; dilute the so-

Fulminating Powders.

lution with three times its volume of water; and add pure aqua ammonia by a little at a time, so long as any precipitate is thrown down. Beyond this point, more ammonia would redissolve the precipitate, which is the substance to be obtained.

In this process, the ammonia combines with the oxide of gold, forming an insoluble yellowish powder. This is to be separated from the liquid, washed with pure water, and dried at a low heat upon filtering paper. When dry, it must be cautiously put into a clean bottle, the mouth of which must not be corked, but slightly covered with paper. Fulminating gold thus prepared has the following properties. It explodes by a smart blow from a hammer, or when sharply triturated in a mortar. It is also decomposed with sudden violence when heated to about 250°. By all these means, the explosion is accompanied with a loud report, and the disengagement of elastic fluids, and is accompanied with light and heat. The hydrogen of the ammonia combines with the oxygen of the oxide of gold, forming water, which is dispersed in the form of highly elastic steam. The azote of the ammonia, at the same time, is evolved, acquiring great expansive force by the disengaged caloric.

Fulminating silver.

Fulminating silver is prepared by first dissolving pure silver in nitric acid. By adding lime water to this solution, the oxide of silver is precipitated; this oxide is now separated by filtering and washing. Pure ammonia is now to be poured upon the oxide, and allowed to remain upon it twelve hours. The liquid part is now to be carefully decanted off, and a black powder remains, which is the ammoniuret of silver, the substance in question. It is now to be transferred with great caution, and by a little at a time, into as many portions of clean filtering paper. This powder is even capable of exploding, while moist, by a blow. When dry, it becomes so susceptible of decomposition as to explode by the slightest touch. The liquid separated from the powder, on being heated in a glass retort, affords azotic gas; and small opaque crystals soon begin to appear, of great brilliancy, having metallic lustre. These crystals are doubtless the true compound of ammonia with oxide of silver, owing their production in the crystalline form to their solubility in water. On being touched, they detonate even when covered with the liquid in which they are formed.

The same explanation which has been applied to the fulminating gold will apply to the substance in question, although the reason is not very obvious why the fulminating silver should be more easily decomposed. Perhaps it will be found, that the silver contains twice the quantity of oxygen with the gold, and that the oxide of the former combines with twice the quantity of ammonia.

Fulminating glass balls.

Fulminating silver has been lately used in making what have been called fulminating balls. These consist of small bubbles of glass a little larger than a pea. A small portion of this compound is introduced at a little opening left for the purpose. The glass is then covered with paper. Any force capable of breaking the bubble produces the explosion.

Fulminating mercury.

Mercury, from its weak affinity for oxygen, forms a detonating compound with ammonia, and other bodies containing much hydrogen. The first of these compounds is formed, by digesting strong aqua ammonia upon the red oxide of mercury for ten or twelve days. At the end of this time, the oxide assumes a white colour in crystals, having the form of small scales. In this form, it fulminates by heat similar to fulminating gold. Its effects, however, are not so strongly marked as the two former, and it gradually loses its fulminating property by keeping. The ammonia is separated, leaving the red oxide unchanged.

Fulminating Powders, Fumigation.

Howard's fulminating mercury.

Another fulminating compound with mercury, was discovered by Mr Howard. It is prepared, by dissolving 100 grains of mercury in one ounce and a half of nitric acid of the common strength. When the solution is cold, add to it two ounces of alcohol. Heat the mixture gradually till effervescence takes place. A greyish white precipitate will now be formed, which must be separated by the filtre, washed with distilled water, and dried at a heat not exceeding 212°.

This powder fulminates with great violence. A few grains laid upon an anvil, and struck with a hammer, gives a report as loud as a pistol. The same effect takes place, by triturating it in a mortar.

It produces a much greater quantity of light than any other of the fulminating compounds, but very little heat. When it is mixed with gunpowder, and a train of the fulminating mercury be laid into the mixture, and fired by the lighted paper, the whole of the fulminating mercury will be consumed without firing the gunpowder.

Whether fulminating mercury be exploded by heat or by percussion, the surface of the bodies near to it become covered with the vapour of mercury.

This compound is said to consist of the oxide of mercury, combined with oxalic acid, and a large quantity of nitrous etherized gas. The explosive effect is to be attributed to the oxygen of the mercury combining with hydrogen in the etherized gas.

Common fulminating powder.

The fulminating compound, composed of three parts nitre, two parts potash, and one of sulphur, has been long known. When a little of this mixture is laid upon an iron shovel, and held over the fire, or placed upon burning coals, or even held over the flame of a candle, it first melts, and then very suddenly explodes with a report equal to that of a musket. Equal parts of sulphuret of potash and nitre form the most perfect compound. Hence it is evident, that during the melting of the first preparation, the sulphur unites with the potash, forming a sulphuret, which at the same moment acts upon the nitre. The explosive effects are to be attributed to the formation and rapid evolution of sulphureted hydrogen and sulphurous acid gases, the disengagement of azotic gas, and the highly elastic steam from the water in the nitre and potash. (c. s.)

FUMIGATION, in medicine, signifies the mutation of different fumes, for the relief of catarrhs, coughs, sore throats, &c. The term is also applied to the process of fumigating rooms during the prevalence of contagious disease. This has been long practised, but perhaps with little success, till the discovery of the method proposed by Dr Carmichael Smith. We cannot expect much benefit to have been derived from the fumes of pitch, nor even from vinegar, which is more modern.

If it be true that contagious diseases are derived from the presence of some elastic fluid existing in the atmosphere, which has been called *miasma*, and since these, of which there must be varieties, as well as the disagreeable odours resulting from putridity, in all probability are inflammable matter, having hydrogen for their basis, it seems highly reasonable, that good effects may result from fumigating the places where they prevail, with substances which easily combine with hydrogen. Hence we are to attribute the good effects which were produced on board ships, and other places where contagious disease prevailed, by the use of the fumes

Fumigation, Functions.

of nitric acid as practised by Dr Smith, who, for this discovery, received a premium from parliament.

After the discovery of the oxymuriatic acid, Guyton Morveau, the French chemist, tried the effects of this gas in the hospitals of France, with such decided success, as to put its efficacy in destroying the contagious matter beyond all doubt. The mixture which furnishes the oxymuriatic acid consists of three parts of common salt, one part of black oxide of manganese, and two parts of sulphuric acid. The salt and manganese are first mixed together, and placed in vessels of stone-ware or glass, in the various rooms. The sulphuric acid is to be added by a little at once, from time to time, observing that the whole must not exceed the proportion above stated. The gas should never be evolved in a quantity, to excite coughing, nor to be otherwise disagreeable to the lungs. When we consider the beneficial effects of this gas, we cannot fail to see the necessity for using some of its liquid preparations for washing the hands and other bodies employed in cases of contagious diseases. These may be the oxymuriate of lime used in bleaching, or simple water impregnated with the gas. (C. S.)

FUNCHAL. See MADEIRA.

FUNCTION, in analysis, is an expression of calculation, formed in any manner whatever from one or several quantities on which its value depends. Thus, if x denote a variable quantity, and $a, b, c, d,$ constant quantities, then $\frac{ax^3+b}{c+dx}$ is a function of x. Again, if x and y are variable quantities, and a and b constant quantities, the expression $axy+by^2$ is a function of x and y. For other distinctions between functions, see FLUXIONS, Sect. I. Art. 2. The term *function* was first introduced into analysis by John Bernoulli.

CALCULUS OF FUNCTIONS.

Sir Isaac Newton, the inventor of the method of fluxions, made its principles depend on the properties of motion, (see FLUXIONS, Art. 20—23); and Leibnitz founded its equivalent, the differential calculus, on the nature of quantities, which might be regarded as infinitely small in respect of others. At first, mathematicians were more eager to explore the rich mine which these philosophers had opened, than to call in question the principles which had led to its discovery. But when these came to be critically examined, it was observed, that as motion was an idea foreign to pure analysis, it could not legitimately be made the foundation of one of its most important theories. Also, that the notion of a quantity infinitely little, was too vague to form the basis of a branch of the most precise of all the sciences. Hence it was thought desirable, that the calculus should have an origin purely analytical, and should depend entirely on the properties of finite quantities.

To accomplish this reform, the late M. Lagrange attempted to model anew the principles of the calculus. He gave his ideas in the Berlin Memoirs for 1772, also in his *Theorie des Fonctions Analytiques*, (1797,) which, he says, " contains the principles of the differential calculus, disengaged from all considerations of infinitely small or vanishing quantities, or of limits or fluxions;" and again in his *Leçons sur le Calcul des Fonctions.*

In the calculus of functions, the variable quantities are denoted by the last letters of the alphabet $z, y,$ &c. and the constant quantities by the first letters $a, b,$ &c. A function of a single quantity, is expressed by placing the characteristic letter f or F before it. Thus fx, or Fx, means any function of x. To denote a function of a quantity, that is itself composed of a variable quantity x, for example x^2, or $a+bx+cx^2$, &c. the compound quantity is included in a parenthesis, thus $f(x^2)$, or $f(a+bx+cx^2)$. A function of two independent variable quantities x and y is expressed thus $f\ (x, y)$; and so of others.

If two functions of two variable quantities x and y are composed exactly in the same manner, and with the same constant quantities, for example ax^2+bx+c, and ay^2+by+c, these are like functions, and may be expressed in the same calculation thus, fx and fy; but if the constant quantities are not the same in both, they cannot be represented by the same characteristic in the same calculation. However, if the constant quantities enter alike into both functions, and only differ in their absolute values, as in ax^2 and by^2, these in the same calculation may be denoted by $f\,(x, a)$ and $f\ (y, b.)$ The general notation we have used in FLUXIONS, art. 18, 23, 28, 45, &c. and in art. 193, Prob. 4. is almost the very same as that of Lagrange.

The theory of functions depends on the change which takes place in the value of a function, when its variable quantity is increased by some indefinite increment, and on the form of the developement of its new value. In the function $fx=x^2$, when x is augmented by the quantity i, then fx becomes $f\,(x+i)=(x+i)^2=x^2+2xi+i^2$, and in the function $fx=x^3$, when x becomes $x+i$, then fx becomes $f\,(x+i)=(x+i)^3=x^3+3x^2i+3xi^2+i^3$, and again, in the function $fx=\frac{a}{x}$, when x becomes $x+i, fx$ becomes $f\,(x+i)=\frac{a}{x+i}=\frac{a}{x}-\frac{a}{x^2}i+\frac{a}{x^3}i^2-\frac{a}{x^4}i^3+$ &c. By an examination of any number of particular cases, it will appear that they have a common property, which consists in the developement of $f\,(x+i)$ the new value of the function having always the form $fx+ip+i^2q+i^3r+$ &c. an expression in which the first term is fx, the original function, and the remaining terms are the successive positive integer powers of i, the increment, multiplied by a series of quantities $p, q, r,$ &c. functions of x, which are entirely independent of i, and which have a determinate form, that depends upon the nature of the original function. The truth of this analytic theorem, first particularly noticed by Euler, may be inferred from induction: As however it must result from the principles of analysis, Lagrange has endeavoured to demonstrate, that if the function $f\,(x+i)$ be developed into a series of the form

$$fx+ip+i^2q+i^3r+\text{\&c.}$$

the terms of which consist each of a single power of i multiplied by a function of x, that is entirely independent of i, the developement shall contain only the positive integer powers of i, and cannot by any means contain either a negative or fractional power of that quantity, provided that the value of x be altogether indeterminate. If, however, particular values be given to x, then the proposition will not be *universally* true. Our limits oblige us to refer to Lagrange's work for the demonstration (*Theorie des Fonctions*), which has in some respects been rendered more complete by Poisson, *Correspondence sur L'Ecole Polytechniques*, No. 3.

It being ascertained that the developement of $f(x+i)$ has in general the form

$$fx+ip+i^2q+i^3r+\text{\&c.}$$

in which p, q, r &c. are new functions of x, which derive their origin from the original function fx, the next thing to be considered is the law of relation which connects these quantities with each other. To determine this, Lagrange supposes x to change its value, and become $x + o$, o being any indeterminate quantity which is independent of i. It is evident that the function $f(x+i)$ will then become $f(x+i+o)$, and it appears also that the same result will be had if in $f(x+i)$ we put $i+o$ instead of i. Therefore also the result must be the same, whether we put $i+o$ instead of i, or $x+o$ in place of x in the developement

$$fx + ip + i^2 q + i^3 r + \&c.$$

By the substitution of $i+o$ instead of i in the series, it becomes

$$fx + (i+o)p + (i+o)^2 q + (i+o)^3 r + \&c.$$

which, by expanding the powers of $i+o$, and writing, for the sake of brevity, only the two first terms of each power, because the comparison of these terms is sufficient for the object in view, is transformed to

(A)

$$\begin{array}{l} fx + ip + i^2 q + i^3 r + i^4 s + \&c. \\ \quad + op + 2ioq + 3i^2 or + 4i^3 os + \&c. \end{array}$$

In order to affect the substitution of $x+o$ instead of x in the same series, we must consider, that seeing the function fx becomes $fx + ip + i^2 q + i^3 r +$ &c. when x is changed into $x+i$, it will become $fx + op + o^2 q + o^3 r$, &c. when x is changed into $x+o$. In like manner, if $p + ip' +$ &c. $q + iq' +$ &c. $r + ir' +$ &c. are what the functions p, q, r, &c. become when $x+i$ is substituted in them in place of x, and they are developed according to the powers of i, we shall have by changing i into o,

$$p + op' + \&c. \quad q + oq' + \&c. \quad r + or' + \&c.$$

for the developements of the same functions, when $x+o$ is substituted in them instead of x. Therefore, by this substitution, the series $fx + ip + i^2 q +$ &c. will become, by omitting the terms which contain the second and higher powers of o,

(B)

$$\begin{array}{l} fx + ip + i^2 q + i^3 r + i^4 s + \&c. \\ \quad + op + iop' + i^2 oq' + i^3 or' + \&c. \end{array}$$

This result ought to be identical with the other, independently of the values of i and o, which may be any quantities whatever. Now, by the theory of indeterminate quantities, this can only be true when the coefficients of like powers, and products of i and o, are identical; hence, by comparing the developements (A) and (B), we get these identical equations,

$$2q = p', \; 3r = q', \; 4s = r', \; \&c.$$

from which again we find

$$q = \tfrac{1}{2} p', \; r = \tfrac{1}{3} q', \; s = \tfrac{1}{4} r', \; \&c.$$

Remarking now that p is deduced from the original function fx, by first substituting $x+i$ for x, then developing the result $f(x+i)$ into a series, proceeding according to the powers of i, and lastly, taking for the value of p that function which is the coefficient of the simple power of i; its origin, and the series of operations by which it has been found, may be indicated by an appropriate symbol. We have already put p', q', r', &c. to denote quantities deduced from the functions p, q, r, &c. exactly as p is deduced from x; we may similarly denote the quantity p by $f'x$, that is, by the symbol for the function from which it has been derived, with the addition of an accent over the characteristic letter. As the function p or $f'x$ is derived from the function fx, so from the function $f'x$, a new function may be, in like manner, derived, which may be indicated by $f''x$; from this last again another function, which may be represented by $f'''x$, may be found, and so on: So that, in fact, the functions $f'x$, $f''x$, $f'''x$, &c. are the co-efficients of i, in the first terms of the developements of the functions $f(x+i)$, $f'(x+i)$, $f''(x+i)$, &c.

We have therefore $p = f'x$, and as p' is the function derived from p, as p was from fx, we have $p' = f''x$, and therefore $q = \frac{1}{2} f''x$. Again, q' being derived from q exactly as p' was from p, or p from fx, we have $q' = \frac{1}{2} f'''x$, and consequently $r = \dfrac{1}{2.3} f'''x$, and so on.

Therefore, substituting these expressions in the series

$$fx + ip + i^2 q + i^3 r + \&c.$$

which is the developement of $f(x+i)$, we find

$$f(x+i) = fx + if'x + \frac{i^2}{2} f''x + \frac{i^3}{2.3} f'''x + \frac{i^4}{2.3.4} f^{\text{iv}} x + \&c.$$

This beautiful analytical theorem was in substance originaly discovered by Dr Brook Taylor (*Methodus Incrementorum.*) Lagrange first demonstrated it independently of the fluxional or differential calculus, and made it the foundation of his theory of functions. The form under which he has given it shews clearly how the terms of the series depend on each other, and, in particular, how the functions which are the coefficients of i may be derived one from another, when the manner of forming the first $f'x$ from the original function fx is known.

Lagrange calls the function fx the *primitive function*, in respect of the functions $f'x$, $f''x$, &c. These, again, in respect of the primitive function, he calls *derivative functions* (*fonctions derivées.*) The function $f'x$ is called *the first derivative function*, or *derivative function of the first order*, or simply the *prime function*; the function $f''x$, derived from it, is called the *second derivative function*, or *derivative function of the second order*, or simply the *second function*; and again, $f'''x$, derived from the preceding, is the *third derivative function*, or *derivative function of the third order*, or *third function*, and so on.

Any function whatever, in respect to that from which it is derived, is its *derivative function*, and this last is the *primitive function* of the other.

Sometimes, instead of using the characteristic letter f, a function of x may be denoted by a single letter y; then, y being used instead of the symbol fx, the symbols y', y'', y''', &c. may represent the characters $f'x$, $f''x$, $f'''x$, &c. According to this notation, y being any function of x, when x becomes $x+h$, then y will become

$$y + iy' + \frac{i^2}{2} y'' + \frac{i^3}{2.3} y''' + \&c.$$

Since every derivative function of the first order is merely the co-efficient of i in the developement of the primitive function fx, when $x+i$ is substituted instead of x, the determination of the derivative function of any power whatever x^n is in fact the same thing as the determination of the term that contains the first power of i in the developement of $(x+i)^n$, according to the powers of i. Now it may be demonstrated by the elementary operations of algebra, that whether n be positive or negative, whole or fractional, the two first terms of the developement of $(x+i)^n$ are $x^n + nx^{n-1}i$, (See ALGEBRA, art. 319; also FLUXIONS, art. 7.); therefore, the first derivative function of x^n is nx^{n-1}. It is now easy to find all the terms of the developement of $f(x+i) = (x+i)^n$. For since from $fx = x^n$, we have $f'x = nx^{n-1}$, from this last we derive

$$f''x = n(n-1)\,x^{n-2},$$

and hence again $f'''x = n(n-1)(n-2)x^{n-1}$, &c. So that from the series

$$f(x+i) = fx + if'x + \frac{i}{2}f''x^2 + \text{\&c.}$$

we get

$$(x+i)^n = x^n + nx^{n-1}i + \frac{n(n-1)}{2}x^{n-2}i^2 + \text{\&c.}$$

which is Newton's binomial theorem.

Next let the function be $fx = a^x$, a being supposed constant, and x variable; then $f(x+i) = a^{x+i}$. Now the common principles of analysis are sufficient to prove that the two first terms of the developement of a^{x+i} are $a^x + \mathrm{A}a^x i$; here A is the Napierian log. of a, (see ALGEBRA, art. 355; also FLUXIONS, art. 14. and 19.) Therefore the first derivative function of a^x is $\mathrm{A}a^x$, that is, $f'x = \mathrm{A}a^x$; hence again $f''x = \mathrm{A}^2a^x$, $f'''x = \mathrm{A}^3ax$ &c. These values substituted in the developement of $f(x+i)$ give

$$a^{x+i} = a^x + \mathrm{A}a^x i + \frac{\mathrm{A}^2}{2}a^x i^2 + \frac{\mathrm{A}^3}{2.3}a^x i^3 + \text{\&c.}$$

Let the function be $fx = \log. x$, then $f(x+i) = \log.(x+i)$; but it may be proved, as in the former cases, that the two first terms of $\log.(x+i)$ are $\log. x + \frac{1}{\mathrm{B}x}i$, B being put for the Napierian log. of the basis of the system; (see FLUXIONS, art. 18. and 19.) Therefore the first derivative function of $\log. x$ is $\frac{1}{\mathrm{B}x}$; and, because $f'x = \frac{1}{\mathrm{B}}x^{-1}$ by the rule for the derivative function of a power, we hence find $f''x = -\frac{1}{\mathrm{B}}x^{-2} = -\frac{1}{\mathrm{B}x^2}$; and again $f'''x = \frac{2}{\mathrm{B}x^3}$, &c. These substitutions being made in the general developement of $f(x+i)$, we get

$$\log.(x+i) = \log. x + \frac{i}{\mathrm{B}x} + \frac{i^2}{2\mathrm{B}x^2} + \frac{i^3}{3\mathrm{B}x^3}\ \text{\&c.}$$

It has been shewn, (FLUXIONS, art. 17, and 19,) that the two first terms of the developements of the sine and cosine of $x+i$ are

$$\sin.(x+i) = \sin. x + i\cos. x + \text{\&c.}$$
$$\cos.(x+i) = \cos. x - i\sin. x + \text{\&c.}$$

Hence it appears that the first derivative function of $\sin. x$ is $\cos. x$, and that the first derivative function of $\cos. x$ is $-\sin. x$: Since therefore in the case of $fx = \sin. x$, we have $f'x = \cos. x$, it follows that $f''x = -\sin. x$, $f'''x = -\cos. x$, &c. and since when $\mathrm{F}x = \cos. x$, we have $\mathrm{F}'x = -\sin. x$, it follows that $\mathrm{F}''x = -\cos. x$, $\mathrm{F}'''x = \sin. x$, &c. These expressions substituted in the developement of $f(x+i)$ and $\mathrm{F}(x+i)$ give

$$\sin.(x+i) = \sin. x + i\cos. x - \frac{i^2}{2}\sin. x - \frac{i^3}{2.3}\cos. x + \text{\&c.}$$

$$\cos.(x+i) = \cos. x - i\sin. x - \frac{i^2}{2}\cos. x + \frac{i^3}{2.3}\sin. x + \text{\&c.}$$

From the brief view we have given of this calculus, its intimate analogy with the method of fluxions, or differential calculus, must be evident. In fact, they all rest upon the same analytical principles, and, the object presented to the mind in each is the same; for the different orders of derivative functions in Lagrange's calculus are identical with the successive differentials, or rather differential coefficients in that of Leibnitz, and with the different orders of fluxions in Newton's theory. The peculiarity of each calculus, as delivered originally by the inventor, consists in that relation between the original function and its prime function, or differential, or fluxion, which the mind selects as a subject of contemplation. We have seen that it is a fundamental proposition in analysis, that if $x+i$ be substituted for x in any function fx, its new value $f(x+i)$ has always the form $fx + ip + i^2q + i^3r +$ &c. p, q, r, &c. being functions of x, which are independent of i. Newton observed, that if x and fx are represented by two lines generated by motion, and if i be the velocity of the point which generates x, then ip, the second term of the developement, will be the velocity of the point that generates fx; (FLUXIONS, art. 20—22.) hence he called ip the *fluxion* of the function fx. Leibnitz again considered, that if x was increased by the quantity i, then fx was augmented by the increment $ip + i^2q + i^3r +$ &c. But supposing i indefinitely small, the first term of this series is indefinitely greater than the sum of all the following terms; therefore rejecting these, and retaining the term ip alone, he called it the *differential* of the function fx. (FLUXIONS, art. 107—110.) Lagrange, regarding the generation of algebraic quantities by motion as incompatible with the principles of pure analysis, and also considering the doctrine of infinitely small quantities, as too slippery a foundation for so sublime an edifice, he rejected both views of the subject, and deduced its principles from the theory of the developement of functions into series.

It is in general admitted, that *the Theory of Analytic Functions* has fulfilled the promise of its illustrious author, "to deliver the principles of the differential calculus disengaged from the consideration of infinitely small or vanishing quantities, also limits and fluxions." We think, however, that he has under-rated the value of the theory of *limits*, as delivered by Maclaurin and D'Alembert, when he says that the kind of *metaphysique* that must be employed in it is, if not contrary, at least foreign to the spirit of analysis, which ought not to have any other *metaphysique* than that which consists in the first principles, and the first fundamental operations of algebra.

The ingenious author, in the discussion of his theory, has adopted a new notation. This has been matter of regret, (Lacroix *Cal. Dif.* vol. i. art. 82, 83.) because the notation of the differential calculus was quite sufficient. In the comparison of methods and formulæ, different notations are perplexing, and the number of arbitrary characters already employed in analysis is a considerable and increasing evil. This, however, is but a small defect, when the luminous views and original methods which the work contains are taken into account.

Functions ‖ Funen.

many of the French mathematicians regard the publication of the *Theory of Functions* as an era in analysis: Indeed, all the works of the differential calculus that have since appeared, have more or less adopted its views See, in particular, Garnier, *Leçons de Cal. Differentiel.* The mathematical reader will of course study the *Theorie des Fonctions* itself; and it may be useful to know that the author published a second and improved edition of the work in 1813, a short time before his death. (ξ)

FUNCTIONS. See PHYSIOLOGY.

FUND, SINKING. See DEBT *National*, and SINKING *Fund.*

FUNDI, or FONDI, the name of a town and lake in Lavora, situated near the confines of the Roman and Neapolitan territories. The town, which is situated in the fertile valley of the same name, is very small, consisting of one street on the Via Appia, which still retains here its ancient form, being composed of large flags, fitted together with great skill, and without any cement. Fundi, which has a gloomy appearance, stands on a plain, surrounded on one side with hills, most of which are covered with olive trees. The whole plain is adorned with orange and citron trees, interspersed with cypress and poplars. The wines of this district were formerly celebrated, and still enjoy some reputation. At the extremity of the town, there is an old castle of little strength.

The lake of Fundi, *Lacus Fundanus*, or *Amyclanus*, which lies between the road and the sea, is a fine expanse of water, formed by several streams which fall from the mountains. Towards the road, its margin is covered with myrtles poplars, and luxuriant shrubs and flowers. The exhalations which arise from the lake and from the marshes, which are produced when it overflows, greatly affect the salubrity of this fertile valley. Mount Cæcubus is seen a little to the right, in going out of Fundi to Itri. Distance from Capua, 40 miles west, and from Rome 56 east. East Long. 13° 30′, and North Lat. 41° 20′. See Eustace's *Travels*, vol. i. p. 472. (*j*)

FUNDI, BAY OF, is the name of a large arm of the sea, extending principally between NEW BRUNSWICK and NOVA SCOTIA. See these articles.

FUNEN, FYON, or FIONIA, is the name of an island and province of Denmark, situated near the entrance of the Baltic, and separated from the continent by the strait called the Little Belt. The island is of an oval form, and is about 35 miles long from north to south, and 30 from east to west. The coasts are in general flat and sandy, and the country is open, with a gently undulating surface. There are several lakes and rivers in the island, but none of them are navigable. This province is more fertile, and produces more grain, than any other in Denmark. The soil is less argillaceous than that of Zealand, but is more susceptible of all kinds of culture. Its principal productions are barley, oats, rye, and pease; and about 10,000 barrels of corn are exported annually to Norway and Sweden. Funen is almost the only place in Denmark where bees are reared with success. Much wax, and honey of a superior quality, is produced, and mead is made in great quantities.

The orchards of Funen supply the kingdom with fruit. There is very little wood in the island, and the inhabitants make use principally of turf for fuel. Many of the Danish nobility have country seats in the island. Odensee, which is the capital of the island, communicates with the sea by a river, the navigation of which is facilitated by a canal. There are about 35 small vessels belonging to the town, but the commerce of the island occupies about 200 or 300. The principal trade of Odensee consists in the exportation of grain and skins. See Catteau de Calleville's *Tableau de la Mer Baltique*, tom. ii. p. 324: and Coxe's *Travels*, vol. v. p. 233. (*w*)

Funeral.

FUNERAL. The disposal of the dead has chiefly been accomplished by inhumation and cremation, the lifeless body being for ever removed from the sight of the survivors. Some nations, however, unwilling to part with it, or actuated by certain religious principles, have preserved it entire; and men have been able to contemplate their forefathers, who existed many generations previous to themselves.

Different modes of disposing of the dead.

The more rude and uncivilized tribes do not possess the same facilities of disposing of their dead that are possessed by cultivated nations. In high and frozen latitudes, they are compelled to abandon them on the snow, which throughout the year is impenetrable, as towards the Lake of Athapuscow, and among the Chipawayan Indians; or they cover them with branches in the woods where they expire. The ancient Colchians, Herodotus affirms, did not bury their dead, but suspended them on trees; a custom witnessed among the Ilinois and Aleutian islanders. And the Tungoose, a Siberian tribe, having dressed the body in its best apparel, inclosed it in a strong coffin, which is suspended between two trees, while the arms or implements of the deceased are buried under it. Others, as the Parsees, or Gabres of Persia and Bombay, are accustomed to expose the bodies of their deceased in an open edifice, where they are devoured by birds of prey; and in Thibet it is usual to deposit them in walled areas, inaccessible alike to wild beasts from below, and the fowls of the air from above. The Parsees, who constitute a large proportion of the population of Bombay, deposit their dead in a hollow tower of large diameter, mostly built up within, and having a sink or well in the centre. When the vultures, which always hover around, have cleaned the bones of their flesh, they are precipitated into the well, which has subterraneous communications. Those of the inhabitants of Thibet who are unwilling to consign their relatives to the ordinary cemeteries, cut their bodies into quarters, and carry them up to the hills, where they may be devoured by birds: but inhumation never takes place. Amidst all these customs, however, few examples occur, in which the dead are committed to the waters: nay, it is not known to be practised by the rudest modern tribes, to whom the disposal of them otherwise must always prove difficult and laborious.

By inhumation.

Inhumations are generally such that the deceased may lie upon his back, or sometimes rest on one side; and the remains of Christians may frequently be recognized in the preceding position, from the arms being crossed on the breast. But the ancient Nasomenes, according to Herodotus, were so averse to this mode of inhumation, that they not only interred the body in a sitting posture, as is done by the modern natives of Hudson's Bay, but prevented an expiring person from thus breathing his last. Some, though not many, inter their dead standing.

Customs of the Greeks and Romans.

Inhumation has been practised alike by savage and civilized nations: either simply in the ground, or in subterraneous structures; in the vicinity, or at a distance from the dwelling of the deceased, or the habitations of the living. Near Sierra Leone in Africa, children are frequently buried in the houses of their parents;

Customs of the Greeks and Romans.

and the Soosoos, an African tribe, often inter the dead in the streets of their villages; but most commonly the place of sepulture is at some distance. The Jews buried their dead; and the same was done by the Greeks and Romans their contemporaries, who practised superstitious ceremonies on the occasion. So intimate a resemblance was observed by the two latter, the one of which derived the greater part of their customs from the other, that the same illustrations may explain the funerals of both. The Romans, however, improved several of those known among the Greeks; and from the greater number of historians which have been preserved, we are better acquainted with them. When a person expired, his body was washed with warm water, anointed with aromatic substances, or embalmed; and each of the members had a particular unguent. It was shrouded in fine linen, which was white with the Greeks, and black with the Romans; or the latter employed a common white toga. If the deceased was a distinguished person, he was clothed in his costume of ceremony, kept seven days during the necessary preparations for the funeral, and exposed on a state couch in the vestibule of the house, with his feet towards the door, at which were placed branches of the cypress or pine, according to his rank. In this we are able to trace the origin of the mutes at modern funerals, stationed at the door, with black plumes mounted on poles. A guard was always placed beside the body, to prevent the commission of any theft; but if it was that of a person of the first consequence, there were only young boys to drive away the flies. The seven days being elapsed, a herald publicly announced that the time of the funeral had arrived, and invited the attendance of all those who chose to assist. None, however, except the friends or relatives of private individuals did so; but public officers, or the people at large, attended, if the deceased had rendered services to the state. The body, according to a law ascribed to Solon, was carried out by the Greeks before sunrise, which was particularly adhered to in the obsequies of the young, in order that the luminary of day might not throw his light on such a melancholy spectacle as their untimely end. The deceased reposed on a bier, ornamented in proportion to his rank, crowned with a wreath of flowers, and having his face exposed, unless when it had been distorted in death. The custom of crowning with flowers, however, was not peculiar to the Romans. Several nations have been profuse in the use of them, and have also employed many varieties. Among the earlier Christians, it was customary to carry evergreens before the deceased to his grave: and even so late as the 17th century, cypress garlands were in great estimation at the funerals of the higher ranks, and rosemary and bay at those of the lower. Dionysius Halicarnassus relates, that at the death of the daughter of Virginius, the women and virgins left their houses, deploring her fate, and some threw flowers and garlands on her couch. A parade and procession followed, of torchbearers, musicians, and the attendant relatives, and among the Romans there was a mimic, whose province it was to wear the same habit, and represent the same manners as the deceased. His own bust, along with the bust of his relations, was carried on an elevated platform, and his spoils in war or insignia of honour were likewise exhibited. Busts, however, were not borne before persons of low origin, nor before those who had been condemned for any crime, though they had been invested with dignities. Next followed hired mourners, women whose employment was to lament the deceased, and who lavishly intermingled his praises with their wailings. His friends and relatives, all clothed in black, joined in the procession; and also his sons with their heads veiled from public view, and his daughters bareheaded, with dishevelled hair, and barefooted, attired in white. Thus the body was conveyed to the place of sepulture, or to the funeral pile, for inhumation and cremation were equally practised both by the Greeks and Romans: only the latter, being a much more expensive ceremony, was particularly reserved for wealthier persons. The original spot of interment was probably not far from their usual dwelling; but afterwards the Greeks selected one at a distance, which is invariably done by tribes removing from their primitive state. Plato says, the bodies of persons deceased should be conveyed to situations useless for other purposes, "because the natural fertility of the earth is not to be impaired either by the dead or the living." But they were careful always to lay the head towards the east, while other nations are indifferent about the position; and the Christians uniformly lay it to the west. Thus in the accidental discovery of cemeteries in Britain, of which no memorial remains, we can ascertain whether they have been used anterior to the introduction of Christianity, by the head lying to the west or otherwise. The laws of the twelve tables prohibited interment within the city of Rome; and therefore cemeteries were prepared in the fields, or near the high-ways, and often consisted of brick or stone buildings, with a number of niches, whence they were called *Columbarium*. Many minor ceremonies took place with these two nations, such as inhaling the dying breath of the deceased, as if to receive his soul; the nearest relation first closing and again opening his eyes, and putting a coin in his mouth, to pay the freight to Charon across the Stygian ferry. These customs are now universally abrogated, from Greece being occupied by Mahometans and Christians, who practise very different ceremonies; and from the Roman territories being inhabited by Roman Catholics only.

Customs of Mahometans.

A greater portion of the surface of the globe is probably possessed by those who profess the religion of Mahomet, than by those who entertain any other tenets. Their funerals are conducted with much solemnity by their priests or Imams, and are attended by the friends and relations of the deceased; but in general, the body of males is accompanied by males only, and those of females by their own sex. The extinction of life is followed by immediate preparations for interment; and this proceeds from an idea, that if the bliss which awaits the true believer is merited by the deceased, not an instant should be lost in conveying him to the cemetery; should it be otherwise, it is incumbent on every good Mussulman to discharge himself as speedily as possible from the service of the wicked. This precipitation, though not common, occurs among other nations: in some, it originates from the necessity of immediate interment in hot climates; in others, it is an established custom, which cannot be traced to any certain source; but it is so great, as to admit of very little doubt, that many persons are committed to the earth before life has fled. A few hours after dissolution, the body, having been previously washed with milk and water, or with water only, is placed on a bier with the face uncovered, and carried with hasty steps to the grave. As Mahomet has declared that whoever shall carry a dead body forty paces towards the place of sepulture will thereby expiate a deadly sin, it is usual for all ranks to tender their assistance on meeting a funeral procession. Being predestinarians in the strictest acceptation, no dread of danger or injury deters them from it; whence a devout Mahometan, even while the plague rages, offers his assistance, and supports, without apprehension, the body of one who has died of it. The interment being finished, and the deceased placed on his right side, and turned towards Mecca, the Imam repeats a prayer, and calls him three times by his name, mentioning also that of his mother, but without the smallest allusion to the name of his father; and when in ignorance of her name, it is not unusual to substitute that of the Virgin Mary. This part of the ceremony bears some analogy to the *Conclamatio* of the Romans, among whom it was customary to call the deceased with a loud voice, after he was laid on the funeral pile, or when he was a person of distinguished rank, to use horns or trumpets. It has likewise been common with many nations of the world, and is so with the lower classes of people in Ireland, to call loudly on the deceased, to interrogate him why he died, and whether he had not every thing in this world that he could desire. With the Romans it has been supposed, but without any rational foundation, as designed to ascertain whether or not the body is inanimate; because instances are given of persons rising from the pile prepared to burn them, and returning in health to their homes. The name of the deceased Mahometan and his mother being pronounced, another ejaculation or prayer follows, and the party returns home. No weeping, or symptoms of distress, are seen at a funeral; all profess unlimited resignation to the will of Providence: Whatever happens is deemed a wise dispensation, which it would be impious to lament. Their cemeteries are of considerable extent, and the graves shallow and separate; for the modern European custom of interring numbers in the same grave is unknown. However, it has not been universally so in Europe; for the canons of the Council of Auxerre declare, *non licet mortuum super mortuum mitti.* The grave is covered with a slab, which, instead of being plain and flat, is perforated in the centre, so as to admit of cypress trees being planted immediately over the body. A hollow square stone is occasionally preferred, which, being filled with earth, admits of the cultivation of trees or herbs within it. Relations frequently visit the cemeteries, and pray on the graves of the deceased; and it is peculiarly interesting to see widows and orphans occupied in this pious vocation.

Some eastern nations preserve the body a long time unburied.

An opposite custom is presented in many respects by the Chinese and Tunquinese, whose numbers far exceed the inhabitants of all the European states combined, and vie with the numbers which are under the sway of the Mussulman doctrines; while they have subsisted under a regular form of administration, and preserved the same ceremonies for the lapse of thousands of years. With the latter, instead of hasty and precipitate interment, the body of a person deceased is preserved a long time, sometimes two years, in order to admit of sufficient preparation for his obsequies. A splendid funeral is the utmost object of ambition. Individuals are content to labour their whole lives, and subsist in penury, that the funeral pomp at their death may be the greater. When this is conducted with uncommon magnificence, it forms an epoch in the history of a family, of which the remembrance is transmitted to successive generations; and nothing can be a more serious reproach than an heir having omitted this essential means of doing honour to his predecessor. Unlike the customs of the western world, a Chinese or a Tunquinese prepares his coffin a long time before he expects that, in the course of nature, it shall receive his earthly remains. Its splendour is the primary consideration, and the wealthy frequently expend a great portion of their property in obtaining one made of some valuable wood, adorned with sculpture or painting, and decorated with inscriptions. It is not unusual for the children of a family, by contributing among themselves, to get an elegant coffin privately made for their father, or for any other near relation, and endeavour to give him an agreeable surprise, by conveying it unexpectedly into his apartment: this mode of presenting a coffin to a parent is a filial act of piety. Its place is in the banqueting chamber, as an ornamental piece of furniture, to be admired by the guests of the owner, who do not fail to compliment him on its beauty. But when the period for its occupation does arrive, and a person breathes his last, the byestanders cover his face with a handkerchief, to which they believe his soul attaches itself, and it is carefully preserved. His body is put into the coffin, which still retains its original place, and along with it clothes, goods, and rice, to serve for his use in the next world. Men are clothed in seven of their best habits; women in nine. The coffin is not nailed, but joined with a very adhesive pitch, and then entirely varnished over, which precludes the escape of any emanations. Meantime regular visits are paid to the deceased, and whatever be the rank of the visitor, on this occasion, he always holds himself inferior, at no time approaching the coffin without four prostrations. At every meal of the family, different kinds of food are offered to the deceased, of which he is entreated to partake; and the principal person of the house, in pronouncing an eulogium on his character, deplores his loss to the survivors, and offers unlimited rewards to heaven for his restoration. The splendour of the funeral is all this time in contemplation. Should the tangible funds of the deceased be inadequate, his lands are sold; and should something still be wanting, his children dispose of their own property, or the friends and relations contribute; and as a record of the greater donations is kept, he who is thus liberal is entitled to singular honour. Particular solemnity is observed in transporting the body to the place of sepulture: the eldest son, or nearest relative, precedes it, having his head wrapped in a faggot of straw, and throwing himself on the ground at repeated intervals, as if to interrupt its passage; and the procession is slow and long, and interrupted by many pauses. Much importance is attached to the place of sepulture; priests are consulted on the subject, and 40 or 50 times greater price is paid for what is judged the most suitable, than for any other spot of land. It is such as is supposed to be most satisfactory to the dead, and favourable to the living. Children who experienced misfortune, after the death of their father, have been known to dig up the body, and deposit it in a preferable place, in order to avert the influence of destiny. One singular ceremony, in Tunquinese funerals, consists in carrying a vase full of water on the coffin, which, if accomplished without spilling a drop, is judged a happy presage, and the bearers are liberally recompensed.

The Jews still preserve some of the ancient ceremonies practised in the burial of their dead, when they were masters of Jerusalem. The thumb is bent into a particular position: the bearers of the corpse wear no sandals, lest the breaking of a latchet should interrupt the procession; they rend their garments; and throw dust on their heads. But they had a pomp and solemnity equal to those of the other nations, which they gradually rose to rival or excel. Josephus relates, that the bier of Herod consisted of gold, ornamented with precious stones, and a purple couch, whereon the body lay, covered with purple; there was a crown of gold on the head, and a sceptre in the right hand; the army marched in solemn procession, and five hundred of the royal domestics and freedmen followed, bearing sweet spices in their hands.

Cremation practised both by the ancients and moderns.

Inhumation is practised universally in Europe, throughout Africa, and in most parts of America; while cremation, though an unusual custom, is a common mode of disposing of the dead in Asia. This has prevailed from remote antiquity, for many years antecedent to the Christian era, and, as well as another ceremony closely connected with it, and to which we shall soon advert, has undergone little alteration. The ancient Greeks and Romans burnt their more illustrious dead. The body, clothed in its best attire, was deposited on a pile, formed of combustible wood, with a piece of money in the mouth, to pay, as before observed, the freight to Charon. The whole pile was environed by boughs of the cypress tree, liquids fit to disseminate an agreeable odour were poured on it, and the nearest relative applied a lighted torch. The arms of the deceased, and other things most regarded by him, were thrown into the pile and consumed; and to do him honour, the byestanders contributed their offerings in the same manner. But in order to preserve some remains of the body, it was enclosed in an envelope of incombustible cloth, and the ashes being collected along with the fragments of bones unconsumed, were washed with milk and wine, placed in an urn, and along with lachrymatories containing the tears shed for the deceased, consigned to a tomb wherein were frequently deposited sepulchral lamps. No custom has been more widely practised than that of burning the dead; we find it among the most polished nations of antiquity, and among the rudest modern tribes. It was practised in Britain, in Gaul, and many other countries whose names are transmitted to us by history. At this day, the Tshutchi, a nation inhabiting a rigorous climate at the north-eastern extremity of the Asiatic continent, burn their dead, and the spot where it is done is marked by stones laid in such order, as to bear some resemblance to the figure of the human body. A large stone is placed at the head, which is anointed with marrow and fat, and a small pile of deer's horns, heaped up at a little distance, which receives a yearly accession when the place is visited by the relatives of the deceased, who recapitulate his feats and qualities. In the island of Japan, and in the kingdoms of Ava, Siam, Thibet, and throughout many parts of Hindostan, cremation is not uncommon. But in the former countries it is chiefly the bodies of the wealthy which are treated with that distinction. What proves an affliction to other nations of the earth, is the source of rejoicing among the natives of Ava; the dead seem to excite no regret, or, to use the words of a modern author, much ingenuity is shewn in the means of abating it. At the same time there is great semblance of grief, for the widow and her friends repair to the spot where the pile was erected, and with loud lamentations collect the half-calcined bones and ashes; some days being previously occupied in dancing and festivity. The Siamese display particular funereal pomp in the cremation of their dead. The intestines are previously removed; perfumes and wax lights are burnt around it, and it is carried forth on a gilt wooden bier. All the family and friends dressed in white, attend the pile, which is kindled amidst the sound of instruments. But the honour of cremation is not conferred on every one indiscriminately; those who have suffered a capital sentence of the law; all who have been exposed to a violent death; and women who have died in parturition, are consigned to the earth, which is regarded as disrespectful to the dead. The pile is composed of precious woods, generally erected near some temple; and the ceremony is embellished by fetes and theatrical exhibitions. But we shall afterwards speak of the remarkable ceremonies adopted on such occasions in further detail.

The Chinese do not always consign the coffin to the earth, nor do all those nations, which remove the body from view without destroying it, practise interment. The poor of Aracan, who have none to pay the expence of a funeral, are carried to the side of a river, to be washed away as it flows. Some tribes in the neighbourhood of Caffraria, sew up the corpse in skins, and carry it to a distant thicket. The Araucanians, on losing a relation, seat themselves on the ground around him, and weep during a long time. The body, clothed in its best attire, is then exposed on a high bier, remaining there during the night, which is either employed in lamenting with those who come to offer consolation, or in eating with them; and this meeting is called *curicahuin*, or the black entertainment, from the symbol of mourning. One, two, or three days after death, the body is carried in procession to the cemetery, surrounded by women bewailing the deceased, and accompanied by another woman, who strews ashes on the road. It is now laid on the ground along with weapons if it is the body of a man, or feminine implements if it is the body of a woman, and with a quantity of provisions for subsistence during the passage to the other world. The spectators take leave of the deceased, and wishing him a prosperous journey, raise a pyramid of earth or stones above the body, on which a quantity of the country beverage is poured. Perhaps the Highland cairns, the *carnedds* of Wales, and *tumuli* of other regions, have all a similar origin, and may have originated without actual inhumation.

The bones preserved for the cemetery.

Several of the North American tribes testify a very great solicitude concerning the bones of the deceased. Nor is this confined to the inhabitants of the North; for the same is seen among those towards the opposite extremity of the continent; and the historians who consider the inhabitants of America as descended from the Jews, think that they find some analogy here. The Choktahs, or Chactaws, after three months previous inhumation, dig up the body, and place it on a scaffold opposite to the hut of the deceased, around which the family and friends convene, jointly participating in great lamentation, and a subsequent feast. A person, whose particular office it is, despoils the bones of their flesh, which are then carefully collected, and being placed in their natural order in a small chest, are carried in solemn procession to the bone-house. This resembles a shade elevated on posts, open at both ends, and those of the different tribes are kept separate. It is even judged impious to mix the bones of strangers with those of their own kindred; and therefore, if necessity compels them to deposit the bones of different tribes under one roof, they are still kept separate. Sometimes the skull, on these occasions, is painted red, and if the deceased has been a man of note, the chest is taken down a year after, when the friends weep once more over the bones, and the red colour being refreshed, the whole is consigned to everlasting oblivion. Should a party of Indians, engaged in war or hunting, lose any of its number, the body is elevated on a scaffold, and covered with logs of wood. The survivors return when the flesh is supposed to be consumed, and the bones thoroughly dried, and carry them home to be solemnly deposited. An author well acquainted with their customs, observed "some Indians return with the bones of nine of their people, who had been two months before killed by the enemy. They were tied in white deer skins separately, and when carried by the door of one of the houses of their family, they were laid down opposite to it, till the female relations convened with flowing hair, and wept over them half an hour, and then buried them with their usual solemnities." The Abipons, a nomadic South American race, immediately strip the flesh from the bones of those killed in a foreign country, and carry them to their proper cemeteries. Dobrizhoffer, a German missionary, relates, that he saw seven skeletons thus brought to a village, and kept nine days in a hut previous to interment. The Pampas and Moluches, other South American tribes, and also the Serranos, entrust some of their most distinguished women with removing the flesh from the bones of the dead, and burying them until the remaining fibres decay, or with bleaching them in the sun. While the work of dissection is going on, the Indians walk round the tent covered with long mantles, their faces blackened, singing a mournful tune, and striking the ground with their spears, to drive away the evil spirits. This anxiety is shewn by different nations: in beating on kettles, and most likely the ringing of bells has originally had the same object. The bones being prepared, are packed up in a hide, and conveyed on a favourite horse of the deceased to the cemetery of the family, sometimes 300 miles distant. Being disposed in their natural order and tied together, they are clothed with the deceased's best attire, and ornamented with beads and feathers, which are cleaned once a year. Different members of the family are thus placed in a sitting posture in a pit or excavation, with their weapons and other implements, and the pit is covered over. But it is farther the office of some matron of the tribe to open the pit every year, and to clean and clothe the skeletons. The carcasses of horses killed on the occasion, that the deceased may ride on them in the next world, are placed around the mouth of the pit, supported on stakes.

Exposure of the dead to animals of prey.

Among the Gabres or Parsees of India, the body is left exposed on the ground, and a dog enticed to take some certain morsel out of the mouth, which, on being accomplished, is deemed a favourable omen. But it is otherwise should the animal refuse; and during this period of expectation, prayers are pronounced by the priests. The body is then consigned to the sepulchre, which is described to be "an object of the most dreadful and of the most horrid prospect in the world; and much more frightful than a field of slaughtered men." Bodies are seen in all different stages of decay; either undergoing the decomposing process of nature, or bleeding and mangled by the vultures surrounding the walls, some of them so gorged with human flesh as almost to be incapable of taking flight. A day or two after being deposited there, the relatives are said to examine which eye has been lost, and should it prove to be the right one, a period of unexampled felicity is anticipated. See Gabres.

It has been the general practice of most nations of the globe, to burn or inter along with persons deceased those things that were most useful or interesting to them in life. The ruder tribes, as well as the more civilized, have entertained an infinity of vague and contradictory sentiments regarding the state of the soul after death; some believing that it hovers long around the body; that it is immediately transferred to regions of bliss; that it has a long journey to accomplish; or that it subsists in an intermediate condition, uncertain of reward or punishment, until all mankind shall be judged. Ancient nations often buried treasures of great value in the tomb of royal or opulent persons. Thirteen hundred years after the decease of David, we read that a high priest of Jerusalem took three thousand talents from his sepulchre, to bribe Antiochus to raise the siege of the city. Now there are sometimes found in the tombs of the ancient Tartars, whole sheets and plates of solid gold.

Sacrifices of mankind and animals to the dead.

The Jukati of Siberia inclose provisions in the coffin, expressly "that the deceased may not hunger on the road to the dwelling of souls." His favourite riding horse is accoutred, and led to the place of interment along with a mare. Two holes are dug under a tree, in one of which the deceased is deposited, and his horse being killed is buried in the other, while the mare is also killed, but is devoured by the guests. The arms, domestic implements, and feminine articles of the deceased, have been either interred in the same grave, or consumed on the same funeral pile. But by a more barbarous custom, as if the destruction of inanimate substances, or the preservation of them for the use of the deceased, were alike inadequate, the sacrifice of living animals, as we have seen, and even of human beings, has been in general practised. Slaves and captives were murdered at the foot of the funeral pile of the ancients, and consumed by the same fire that reduced the body to ashes; and wives were mercilessly put to death, that they might accompany the souls of their husbands to those regions, which were supposed ready to receive them. But so remarkable and unnatural a ceremony in funeral rites demands further illustration, especially as, instead of expiring with the name of the Greeks and Romans, we find it still existing at the present day.

Mankind, in the early stages of society, have inferred, that a future state bears an intimate resemblance to their condition in the world they inhabit; that they have the same necessities, and the same propensities and enjoyments. Hence the horse is killed, and the slave or the wife murdered, that their souls, transferred along with his own, might contribute to the use of the owner. By certain refinements, however, which can only be discovered in the sanguinary disposition of man, a sacrifice was deemed requisite, to appease the manes of the dead; and in this mixed character, the shedding of the blood of man and animals must be viewed. As the sentiments of a nation changed, the actual immolation ceased; but, as happened among the Romans, the combats of gladiators at a funeral pile were substituted, wherein one or both commonly perished. And with the Chinese there is a figurative sacrifice, in the images of men and animals consumed at the time of the obsequies. Yet it is not long since this was introduced; for an emperor of that nation, whose reign terminated in 1661, ordered 30 persons to be sacrificed to the manes of a favourite queen, and directed that her body, deposited in a valuable coffin, should be burnt, along with a prodigious quantity of precious materials.

Voluntary sacrifice.

Likewise, when an empress of the same people died in 1718, four youthful females, her attendants, proposed to sacrifice themselves on her tomb, which the emperor her son, a wise and politic prince, Funeral.

humanely prohibited. Sometimes the slaves and friends of the ancients voluntarily sacrificed themselves on the pile of the deceased; and those wives, who were not dragged to be murdered at the tomb, or by a horrible solemnity buried alive in the same grave, sometimes perished by voluntary immolation. It is recorded in history, that one of the earlier kings of Sweden having, in the heat of battle, vowed to sacrifice himself in ten years to the gods, should they then propitiate his cause; his queen accidentally discovered the fact, and, to anticipate the necessity of being buried alive when the event should happen, separated from him during life. The northern nations believed in a kind of elysium, or ethereal palace, where their resurrection would take place amidst their usual earthly enjoyments; and slaves conceived, that admission would be denied them, unless they accompanied their masters, whence a contempt of death, unknown to posterity, was inspired. Among the ancient Thracians, it appears that the favourite wife was put to death by her nearest relations at the tomb of her deceased husband, and interred along with him; and if he had more than one wife, a contest arose for permission to offer this token of affection. Diodorus the Sicilian relates, that about eight years subsequent to the death of Alexander the Great, the two wives of an Indian commander, who had fallen in battle, contended for the honour of being burnt along with his body; a singular custom introduced, as Strabo affirms, from the women of those climes being wont to become enamoured of young men, and poison their husbands. The elder being pregnant at the time, preference was given to the younger, and preparations were made for the ceremony. The widow approached the pile, and divesting herself of her numerous personal ornaments, as rings, necklaces, and jewels among her hair, distributed them as tokens of remembrance to her friends and attendants. Having taken leave of all, she was placed by her own brother on the pile, while the army of Eumenes, then contending for the Macedonian empire, marched three times solemnly around it with their arms. Meantime, without betraying the smallest apprehension at the crackling of the flames, she turned towards her husband's body, and heroically closed her earthly career to the great admiration of the spectators.

It is remarkable that now, after the lapse of thousands of years, the most intimate coincidence is witnessed in this voluntary sacrifice of the Hindoo females on the funeral pile of their departed husbands; we say voluntary, but it can scarcely be called so, for although there is no compulsion, it is not creditable to evade it. When a Hindoo expires, it is of no importance whether a person of rank or otherwise, his widow, if belonging to that particular cast, enforcing it, declares her resolution to perish; it not only entails credit on her memory, but aids her husband in obtaining celestial privileges. Attended by her friends and relatives, she approaches a consecrated spot, where a pile is erected by Bramins, generally near a river, wherein she sometimes bathes. No apprehension is ever betrayed by the youngest; she walks with a firm step thrice around the pile; mounts it unassisted, and sits down by the body of the deceased; then taking off her personal ornaments, she distributes them, with great composure and precision, to her female attendants, and gently reclining towards her husband, draws a cloth over her face. Meantime the Bramins perform certain ceremonies, and continue building up the pile several feet above both the bodies: they supply combustible substances; and pouring oil upon it, the whole is kindled by the nearest relation, and blazes forth amidst the shouts of the multitude. There are examples of the torch being applied by the children of the widow while almost in infancy, and it is thus that by common consent of nations the last offices are committed to the nearest relative. Although this horrible and barbarous custom is established among the Hindoos, it is unquestionably on the decline, and, in those places to which Europeans have common access, it is now of rare occurrence.

In other countries there are sanguinary scenes of an analogous description, practised to appease the manes of the dead. Formerly, in North America, a number of wives were strangled at once, with a single cord, on the decease of a husband. In Kodiak, an island on the northwest of that continent, when a chief is interred, some of his most confidential labourers are sacrificed and buried along with him. In the kingdom of Assam, several wives of a rajah or sovereign, a number of servants, and a quantity of oil and provisions, were all wont to be enclosed in the pit which received his body, and either instantaneously destroyed, or left to die a lingering death. In the island of Nukahiwa, if a priest dies, three human victims must immediately be offered up for the repose of his soul; and those whose province it is to procure them, lie in ambush where the unsuspecting natives resort in their canoes for food, and are soon enabled to fulfil their bloody mission. Yet all this is inconsiderable when compared with what are called the *Customs*, an annual ceremony in Dahomy, an African state. There the king "waters the graves of his ancestors," with the blood of victims in thousands; pyramids are absolutely constructed of human heads. Most of those unhappy beings are prisoners of war, who are mercilessly sacrificed. On the decease of the king himself, his women immediately begin to break and destroy every thing around them, and then to massacre each other, which continues until a successor is named, who takes possession of the palace and interrupts the carnage. On an occasion of this kind in 1774, 285 women perished, besides six said to have been buried alive with the king; and more recently, in the year 1789, when a king died, the number amounted to no less than 595. There is still another waste of human life at the funeral of some of the African and Australasian tribes. If a mother dies while suckling her child, it is buried alive in the same grave along with her. This, however, is not to be viewed in the light of a sacrifice; it originates in a different principle, which seems to be that among savages the care of their own children is all that they can accomplish; the infant, therefore, is doomed to destruction, from the belief that no female can be found willing to preserve it. Modern example therefore proves, that we may safely credit what is recorded of the immolation of human victims at the tomb or the funeral pile of the ancients.

Festivals at funerals.

It seldom happens that the assistants at a funeral simply dispose of the dead with the ceremonies now alluded to, as a greater or lesser festival almost always follows. This has already been partly illustrated. In our own country, we know that the obsequies of those, even in the most humble station, are always attended with the distribution of bread and wine, or less costly liquors. In some places it is preparatory to a more ample feast, in such profusion, as to prove of serious inconvenience to the successor: it lasts whole days, and, as among savage nations, resembles a rejoicing for the liberation of the deceased from his earthly tenement, more than a lamentation for his loss. Mirth and merriment prevail; and, in the Highlands of Scotland it has been carried to such an extent, that when given before the funeral, where the successor always presides, examples have occurred of the party setting out for the place of interment, and leaving the corpse behind them. This is identically the *Silicernum* of the Romans, at which certain viands were served up, or distributed to the people. In the north of England, the entertainment is called *arvil*, and the bread employed *arvil bread*—names of uncertain etymology; and, in Scotland, the subsequent carousals are said to be drinking the *dirge* of the deceased. The origin of these ceremonies is doubtful. A feast wherein much lavishness and extravagance are displayed, is given by the Washington islanders, on washing and laying out the body; and twelve months afterwards another, equally profuse, is given to thank the gods for having permitted the deceased to arrive safe in the other world. These throw considerable light on the purpose of the entertainment, which is perhaps jointly for oblation and commemoration. It is repeated successively for years by various nations; by the Tunquinese it is considered disgraceful to be sparing; and the South Americans, in pouring some of their first made beverage yearly on the graves, drink to the good health of the dead. The inhabitants of Thibet have an annual festival in honour of the dead, which takes place at night, and then innumerable lamps are lighted up, amidst the sound of mournful music. We shall abstain from speaking of the festival of souls, said to have been practised by certain American tribes, from being ignorant whether it is not entirely discontinued; but at intervals of ten or twelve years, the dead were dug up, and carried on the backs of their relatives to their huts, where great entertainments ensued; after which, they were, in like manner, replaced. The Greeks and Romans performed the obsequies of the great with uncommon splendour: Races, games, and theatrical entertainments, were all exhibited; and at present, with some Eastern nations, whole fleets and armies are put in action, for the greater pomp, on the funeral of an emperor.

In many countries, independent of the natural lamentations by the relatives of one deceased, it has been customary to employ hired mourners, whose shrieks and despair might enhance the display of grief. In scripture, it is said, "wailing shall be in all the streets: and they shall say in all the high ways, alas! alas! and they shall call the husbandman to mourning, and such as are skilful in lamentation to wailing." At the modern funerals of the lower classes of Ireland, the women collect, and utter hideous outcries, emphatically called the *Hoolaloo*, mixed with the praises of the dead, and with the questions, "Why did he die? Had he not a wife and family? Had he not every thing he could wish? Why did he leave this world?" and the like: a savage custom, characteristic of a barbarous state of society.

A funeral hymn has been prevalent, as well as the performance of music, at the obsequies of persons deceased, as also an eulogium or oration upon them. The funerals of the Greeks and Romans were attended by the sounding of pipes, and sometimes of trumpets and horns; but the lyre, being consecrated to Apollo, was prohibited; and a hymn, song, or dirge, called *Nænia*, was sung by girls or adults. The singing of psalms at modern funerals is part of these customs preserved; and a solemn requiem takes place among Roman Catholics for the repose of the soul. Frequently the most celebrated composers are entrusted with the composition of this piece of music; and it has been said of Mozart, that the requiem he composed for a German prince was first performed for himself. A musical solemnity sometimes attends the funeral of celebrated musicians, as of Rameau in Paris in the year 1764; and there was a commemoration of Handel in 1786, in Westminster Abbey, 27 years after his decease. The music composed or performed on these occasions in more humble life, is called a dirge or lament, as in the Highlands of Scotland, ; and there is yet known a lament composed and performed by some freebooter for himself, while leading to the gallows. Solemn music is an invariable concomitant of military funerals; that of our officers being attended by a full band, and that of a private soldier by fifes and drums. But in marching from the place of interment, a lively air always succeeds the mournful tune.

Funeral hymn or dirge.

A number of minor ceremonies preceding interment, are in use in different countries, and in different districts of the same country. Of this number are ringing the passing bell for a person expiring—wakes or watching with the dead, often rendered a scene of the grossest debauchery—placing a platter of salt on the corpse, or candles around it, and the like. Sometimes it is the custom to have funerals by day, sometimes by night. The colour of the fringes of the pall, and the gloves worn by mourners in Britain, denote that the deceased was unmarried if white; and it was lately the custom of some parts of England, for six maidens to bear the pall of a young man, and six youths to bear that of a young woman. In Wales, the graves of the deceased are adorned with flowers: The white rose always decorates that of a virgin: Those of persons distinguished by piety and benevolence are planted with red roses. The road to the grave of unmarried persons is also strewed with evergreens and sweet-scented flowers. In Scotland, the body is lowered into the grave by the nearest relatives; no funeral service is performed, and but rarely a funeral sermon on the subsequent Sabbath, in commemoration of the virtues of the deceased. Suicides are denied the right of interment in consecrated ground; and infants dying before baptism, are interred on its confines. But these rules are not strictly enforced.

Ceremonies in Britain.

Commission of suicide has generally been viewed as a criminal act: By the usages of Britain, the body should be buried in the highway, and a stake driven through it; of which recent examples are to be found. In the later periods of the Jewish history, when despair prompted the miserable objects of conquest to self-destruction, their leaders endeavoured to avert their intentions, by representing the ignominy to which their bodies would be exposed, by the privation of sepulture. The Fantees, a modern African tribe, testify their abhorrence of the deed, by refusing to pay the accustomed rites to the bodies of suicides.

A great variety of customs has been practised among nations, in respect to the remembrance of the dead. By some, the ashes have been scattered in the air, and all memorials of them consigned to oblivion. By the Abipons of South America, every thing that may recal the image of a person deceased is destroyed; his cattle are killed, all his implements burnt, and his hut is overthrown; his wife and family migrate elsewhere, and his name never is again repeated. The

Funeral.

Knisteneaux of North America destroy all that belong to him; and the Chipewyans never employ what has served for his use.

Mourning.

Mourning is a ceremonial also much diversified by the custom of nations. In general, it is more rigid on the widow of the deceased, than on the rest of his relatives. The Theodosian code adjudged a woman to be infamous who married ten months or a year from the decease of her husband. In Britain, it is rather understood that second nuptials should not take place within a year; and the period of mourning extends to two. The women of some North American tribes must live three or even four years in a state of widowhood: and in eastern countries, the eldest son cannot marry during the time of mourning for a parent, which is two years; and he should all the while sleep along with the rest on mattresses, not in beds, and subsist on very simple fare. Wearing particular colours, as white, black, or purple, is emblematic of mourning in different countries; and shaving the hair close is a particular mode of testifying grief for one deceased. But sometimes only half the head is shaved; or the hair, if generally worn long, is simply shortened. A more decided mark of sorrow consists in severe lacerations of the persons of the survivors, their faces are disfigured, they slash their limbs with knives, or sharp-pointed bones; and some, to shew a more indelible testimony of affection, are successively deprived of a joint of one of their fingers for every relation whom they lose. See *Herodotus*, lib. iv. *Strabo*, lib. xv. *Dionysius Halicarnassus*, lib. xi. Nicolaus Damascenus *Apud Excerpta Valerii*, p. 520. Nicolaus *De luctu Græcorum.* Kirchmannus *De funeribus Romanorum.* Gutherius *De jure Manium.* Porcacchi *Dei Funerali dell' Antichi.* Moresinus *Papatus seu depravatæ Religionis origo et Incrementum.* Ugolinus *Thesaurus antiquitatum sacrarum.* Roman's *Natural History of Florida.* (c)

FUNFKIRCEN, or Five Churches, is the name of a town in Hungary, situated in a fertile country between the Drave and the Danube. It is principally celebrated for its university, which was founded by Louis I. and which was at one time attended by about 2000 students. It was ruined, however, by the capture of the place by the Turks. Population about 12,000. East Long. 18° 9′, North Lat. 46° 61′. (w)

FUNGI.

Fungi.

Character of the Fungi.

The most conspicuous of the plants to which we propose to direct the attention of the reader in this article, are, in general termed by the English *Mushrooms* or *Toad-stools*, and by the Scots *Paddock-stools.* By the Greeks they were called Μυκῆτες; and they are now known to botanists under the general appellation of *Fungi*, a term sufficiently expressive of their soft, spongy, coriaceous texture. They constitute the first link of the great chain of vegetable life, and serve to connect organised bodies with inorganic matter. In simplicity of form and structure, they differ widely from the other vegetable tribes, as they present neither leaves nor flowers. Destined to spring up in the midst of corruption, and to draw their nourishment from putrefaction, the fastidious observer turns from them with disgust; and the true naturalist, while aware of their importance in the scale of being, finding them too perishable in their nature to be easily preserved in his cabinet, too capricious in their growth to be cultivated in his garden, and too sportive in their forms to be successfully delineated with his pencil, leaves them with regret to rot on the dunghill and to wither in the wood. Hence they are fancifully characterised by Linnæus as *Nomades, autumnales, barbari, denudati, putridi, voraces. Hi flora reducente plantas hyematum, legunt, relictas earum quisquilias sordesque.*

The botanists of the first age, such as Theophrastus, Dioscorides, and Pliny, attributed the origin of mushrooms to a certain viscosity arising from putrefying vegetables. This notion very generally prevailed, until the immortal Harvey unfolded his second grand discovery, *omne animal ex ovo.* After this period, the germination of plants was investigated with greater care, and many able botanists applied themselves to the elucidation of the obscure physiology of the fungi. Clusius had long before maintained that mushrooms spring from seeds; but it was reserved for Boccone, Mentzel, and Tournefort, to establish the truth of the assertion. These eminent botanists were soon followed in the same track by Battarra, Micheli, Dillenius, Gleditsch, Linnæus, and Hedwig; and more recently by Bulliard and Persoon. It is now demonstrated that mushrooms are as regularly organised vegetables as the phenogamous plants; that they consist of fibres, vessels, and roots; that they have peculiar organs appropriated for the production of the seeds; and that without these seeds, no regeneration can take place. In short, they spring up, flourish, and decay, like other organised beings, after having transmitted the principles of that vitality which they possess, to a new race, exactly similar to themselves.

Seeds.

In order to obtain the seeds of mushrooms, it is in general only necessary to place them in a fresh state upon a plate of glass, the surface of which will soon be copiously covered with them. These seeds differ widely, like other vegetables, as to size, shape, and colour, and still more as to situation, insertion, and number. Some can easily be seen by the naked eye, while others can with difficulty be detected by the highest magnifiers. These seeds are many of them so light as to be dispersed through the air, from whence they are precipitated upon the ground and upon plants by rain and snow. They seem in fact to be everywhere. They are the constant attendants on decaying vegetable and animal matter. Is an apple rotting in a damp place, it is speedily covered with a mucor, sending forth its slender diverging stems, and forming a glory round it? Is even the dead hoof of a horse exposed for any time to the weather, it also will become covered with a fungus peculiar to itself? These plants cover the damp walls of cellars and caves, and seem formed to flourish in those places which are unfit for the support of the more perfect vegetables. If we take these circumstances in connection with the infinite multitude of animalculæ, which seem equally profusely distributed, we will be irresistibly led to the conclusion, that the earth itself is a mere re-

Fungi. ceptacle of germs, each of which is ready to expand into vegetable or animal forms, upon the occurrence of circumstances favourable for its developement. In the early stages of the earth's existence, the germs of a few zoophytes only were unfolded, afterwards those of the testaceous mollusca expanded, and finally those of the mammiferous animals. In the course of these changes, one generation succeeded another, but the generation which followed was not the unaltered progeny of the preceding. The zoophytes of the first period differ from those of the last; no living proofs of their existence remain, their memorials only are to be found imbedded in the solid rocks. It has happened to plants as to animals. At first the germs of the filices and the palms expanded into leaves; and finally the surface of the earth became covered with the stameniferous vegetables. But the ferns of the first period no longer exist; the circumstances which favoured their growth are no more; and their place is occupied by other ferns, the germs of which have expanded under a new arrangement. In this survey, the mind is astonished when it considers the infinite number of those germs, prevented by the absence of favourable circumstances from ever expanding into maturity. Here the followers of Harvey are bewildered; and here the theory of equivocal generation, which suggested itself to the inhabitants of the banks of the Nile, and to which Aristotle gave form and currency, seems calculated to soothe a reflecting and philosophical mind. The history of the earth countenances such a theory, and the phenomena of the mineral kingdom yields it many powerful analogies, we had almost said direct proofs. It does not consider the generation of plants as the result of chance, any more than philosophers do the production of lightning, of rain, or of snow. All result from those laws which Omnipotence has imposed on the material and intellectual world.

Those grains which are considered as the seeds of mushrooms, are by some supposed to be merely buds or germs. This opinion, which was first proposed by Gaertner, and since that time maintained by many able botanists, is considered as supported by the analogy of the zoophytes. To us this seems to be a mere dispute about words. It is unwarrantable to expect a close resemblance between the seeds of mushrooms and the seeds of stameniferous plants when they differ so widely in their general form. The seeds of the former may, for aught we know, resemble the parent plant in miniature; and by the simple enlargement of their parts, without the production of any new organs, arrive at maturity. But experiments are still wanting to determine this point.

Classification. If the examination of the mode of growth of the fungi be involved in such obscurity, in what condition may we expect to find their systematic classification? In the system of Linnæus, they constitute the last order of the class Cryptogamia; and were distributed by him into the following genera: Agaricus, Boletus, Hydnum, Phallus, Clathrus, Helvella, Peziza, Clavaria, Lycoperdon, and Mucor. Since his days, the species have been investigated with great care, and many curious facts in their history have been ascertained; yet still they have not obtained from botanists that attention to which they seem entitled, on account of the curious forms which they exhibit, the substances which enter into their composition, and the economical uses to which they have been applied. In this department of botany, no one is deserving of higher praise than M. Bulliard. This author has contributed, more perhaps than any other, to the illustration of this intricate tribe, in his work entitled, *Champignons de la France*. This work, besides containing accurate descriptions of the different fungi of France, exhibits at the same time faithful delineations of their form. In the same rank we must place the *British Fungi* of Mr Sowerby, the most splendid botanical publication which has appeared, in reference to our native plants. But here we must observe, that although the figures are admirable, the accompanying descriptions are extremely imperfect. This deficiency, however, we trust, will soon be amply supplied by the learned President of the Linnæan Society, in the fourth volume of that classical work, the *Flora Britannica*, which for the space of ten years has been anxiously wished for by the British botanist. But it is to Persoon that the world is indebted for the most judicious and systematic arrangement of the Fungi. It was necessary to take a comprehensive view of this tribe of plants as a whole, to overlook the old genera, and to form anew the various species into natural groups or genera, characterised by permanent differences in habit, form, and structure. This task Persoon has in a great measure accomplished, and has published the result of his labours, in two works entitled, *Tentamen Dispositionis Methodicæ Fungorum*, and *Observationes Mycologicæ*.

In the Natural Method of Jussieu, the *fungi* form one of the orders of the acotyledonous division of plants. They do not admit of generic arrangement according to the parts of fructification, so conveniently as the phenogamous plants, yet still the position of the seed-vessel furnishes the means of the more general classification; while their form, colour, and consistence, aid us in the discrimination of the species. By Persoon they are divided into two great tribes, according as the capsule is situated on the outside or in the interior of the plant.

The Gymnocarpi have their capsules or seed-vessels situated on the external surface. In form as well as in structure, the plants of this tribe present very remarkable differences, and even the parts destined for the production of the seed, exhibit very various appearances. These differences, however, are not without their use, as they enable us to combine the various genera under different families, and thus assist the student, by diminishing the labour of investigation. This tribe is accordingly divided into five families, and contains twenty-one genera.

The Angiocarpi have the capsule placed internally; and in some it is contained in a receptacle which is closed on all sides, at least in the young stages of the plant. To this receptacle Persoon has given the name of *peridium*. This tribe is divided into four families, and includes twenty-five genera.

We now propose to consider more minutely these various genera, and to explain the characters upon which their existence depends. That their number will surprise the Linnæan student accustomed to refer to Hudson, Withering, and Lightfoot, we are prepared to expect; but we request his attention to the following circumstances. Accurate observers of nature are become numerous; botanists are now in possession of more powerful instruments, and better methods of analysis; and their studies are greatly facilitated by accurate representations. Hence it is that new species are daily brought to light; the history of old species elucidated;

and new genera formed by almost every observer, in consequence of the discovery of new relations. The formation of new genera, is the necessary consequence of the enlargement of the science. Linnæus was not acquainted with an hundred species of fungi; now, their number has increased more than ten-fold. To us therefore the Linnæan genera have become useless. They mark the former state of the science, and they have contributed their share to the advancement of the study; our systems and our genera, must, in like manner, yield to the more extensive and accurate information of future observers. While we approve of the formation of new genera, therefore, where the state of the subject demands it, we condemn that zeal so conspicuously displayed by some, in the frittering down of the old genera into as many new ones almost as there are species. Such naturalists mistake the object and the end of these subdivisions, imprudently attempt to pass beyond the bounds which limit the present state of the science, and endeavour to anticipate those changes which other discoveries and more enlarged views will render necessary. In this account of the genera, we have confined ourselves to those which are sanctioned by high authority. These are principally derived from the works of French naturalists, who, unrestrained by the fastidious reserve of the British character, and possessed of more ample means through national munificence, have of late contributed materially to the enlargement of systematic botany and zoology. The description of one species at least will be subjoined to each genus, together with a reference to those works where faithful representations of them may be found.

TRIBE I. GYMNOCARPI.

FAMILY I. *Composed of Filaments.*

1. BYSSUS. GENUS I. BYSSUS. The plants which are now referred to this genus, exhibit the appearance of fine down or velvet, and consist of small filaments, which are simple, branched, anastamosing, or interwoven. They occur of various colours, as white, yellow, red, or brown. Almost all the species included in the first section of the genus Byssus of Linnæus still remain under this title.

As an example of this genus, we may mention the *Byssus candida*, (Dill. *Musc.* tab. 1. fig. 15. A.) Its substance is tender, woolly, of a white colour, and closely pressed to the substance on which it grows. From its broad and mucilaginous base arise many slender branches, spreading more in breadth than height, elegantly subdivided, the extremities ending in capillary fibres variously branched, or in a thin expanded surface like fine paper. It grows upon dead leaves and rotten wood. It is the *Himantia candida* of Persoon.

Every person must have observed in the beginning of summer a greenish scum, floating on the surface of small ponds, rendering the water greenish, turbid, and hardly drinkable. This substance was considered by Linnæus as belonging to the present genus; but subsequent naturalists have referred it to the genus Conferva. Be that as it may, it often proves a great nuisance in wells; and the discovery of any method of destroying it must necessarily be acceptable. In the spring of 1815, when the workmen were engaged in the erection of the new light-house on the Isle of May, under the inspection of that eminent engineer Robert Stevenson, Esq. they were much incommoded by the appearance of this substance on all the wells and pools of the island. Quicklime in considerable quantity was thrown into the wells, without retarding or destroying the growth of this vegetable. At last the wells were enclosed with walls sufficiently high to exclude the light from the water, and this contrivance fortunately succeeded in the extermination of a plant which at one time threatened to prove a very serious evil.

2. MONILIA. GENUS II. MONILIA. The plants of this genus are composed of slender stalks, which are either simple or branched, and resemble the filaments of the preceding genus. These stalks bear on their summits small articulated threads composed of spherical globules, which separate when the plant grows ripe. The species of this genus bear a very near resemblance to those included in the genus Mucor; but their naked capsules, joined to the want of a vesicular peridium, forbid such a union as the incorporation of the two genera.

Monilia glauca, (Mich. gen. 212. t. 91. f. 1.) This is the Mucor glaucus of Linnæus. Its stalks are white, simple, and slender; the capsules are agglutinated, the one before the other, in diverging lines, representing little tufts of feathers, of a spherical form. The capsules are round and diaphanous; white at first, but turning green as the plant reaches maturity, at which period they separate from one another. This plant grows in tufts, and sometimes scattered, on fruits which are in a putrefying state. Another species of this genus, Monilia digitata, the Mucor crustaceus of Linnæus, is found on corrupting meat, but it differs from the preceding in having the seeds disposed in an umbel.

3. BOTRYTIS. GENUS III. BOTRYTIS. In this genus, the stalks are straight and branched, bearing upon their summits naked capsules, in a head, or in clusters, the one not agglutinated to the summit of the other. They closely resemble the genera Manilia, Mucor, and Ægerita. They possess an evanescent existence. They are distributed into two sections, the first comprehending those with upright branched fibres, and the second those which form a sort of bed from which the upright stalks proceed.

Botrytis lignifraga. Sowerby, tab. 378. fig. 14. may be mentioned as an example of the first. It grows upon the bark of trees, but especially on the birch, imbedded in the external layers of the bark, piercing the epidermis, and forming on the outside small tubercular masses. These are at first white, and resemble cotton; but they afterwards change to a deep green, and become powdery. The stalks are slender, crowded, upright, and interwoven. The capsules are rounded, and very small. Mr Sowerby considers this species and Monilia glauca as varieties of the same plant, and as constituting the much-esteemed blue mould in rotten cheese.

Botrytis rosea may be given as an example of the second section. It is the Mucor roseus of Sowerby, Tab. 178. fig. 11. This forms small knobs, which are at first white, round, and of a hairy aspect; afterwards they lengthen out, become of a vermilion colour, and emit a reddish powder: the base consists of strong, straight fibres, from which proceed, at right angles, upright, simple, slender stalks, bearing at their summits from two to five oval capsules. It grows chiefly on the bark of trees, especially the Alder, also on the decayed kernel of nuts and on rotten wood. When growing upon trees, this plant usually appears at the opening of the glands, or near the place where some insect has made a puncture.

4. AEGERITA. GENUS IV. AEGERITA. To the naked eye, the plants

Fungi. of this genus present nothing but a tubercle or convex crust; under the microscope, however, they exhibit a number of separate spherical capsules, attached to branched and extremely slender fibres, which form the base. They resemble the plants of the preceding genera in form, but their aspect is glabrous and fleshy, the others being hairy or fibrous.

Aegerita aurantia, the Mucor aurantius of Withering. Bulliard's *Champ.* p. 103. tab. 504. fig. 5. The filaments are slender, branched and creeping, supporting without order minute rounded seeds. This plant forms little plates of a golden yellow colour on the bark of decayed wood, the hoops of casks, and the corks of bottles.

Conoplea. GENUS V. CONOPLEA. This genus contains plants, which are composed of branched filaments, resembling the Byssi, bearing, here and there, the capsules, which are nearly globular, and easily detached like powder.

Conoplea puccinioides. This species grows on the dead leaves of the carices, forming very minute black tubercles, which are easily destroyed. These, when examined with a microscope, are found to be composed of branched pellucid filaments, bearing upon their whole surface, opake, angular globules, which are large when compared with the size of the stalk.

Erineum. GENUS VI. ERINEUM. This genus consists of tubes, frequently cylindrical, and truncated at the summit. They grow in numerous groups on the leaves of living plants. It is not as yet ascertained whether the capsules are internal or external.

Erineum vitis. This plant grows on the inferior surface of the leaves of the vine, where it forms numerous irregular patches of a red, or rather of a rust colour. Under the microscope, it appears to be composed of a multitude of simple, crisped, cylindrical tubes, truncated at the summit.

Stilbum. GENUS VII. STILBUM. In consistence this genus resembles the Mucor, but is somewhat firmer. The stem supports a rounded head, which is solid; at first watery or gelatinous, afterwards compact and opake; and which, according to Tode, bears the seeds at the external surface.

Stilbum rigidum. Pers. *Syn.* 680. The stem of this plant is stiff, cylindrical, permanent, and of a black colour. The head is globular, at first watery, of a white colour, or slightly yellow; it afterwards becomes grey, and separates from the stem at maturity. It is found on rotten wood in the spring.

FAMILY II. *Fungi which do not decay into a pulp, and in which the fertile surface is united or continuous.*

Helotium. GENUS VIII. HELOTIUM. The plants included in this genus have a regularly convex pileus, or cap, supported on a stalk, and smooth on both sides. The capsules are produced on the upper surface, and are disposed in the same manner as in the following genus.

Helotium agariciformis. Helvella agariciformis of Withering. Sower. tab. 57. The stem is cylindrical, about the thickness of a pin; the cap is thin and hemispherical, with a regularly rounded margin. The whole plant is very small, of a white colour, and resembles an Agaric in its appearance. It is found on rotten wood in moist and shaded places.

Peziza. GENUS IX. PEZIZA. The Pezizæ consist of a cup-shaped receptacle, either concave or hemispherical; the superior surface is smooth, and the seeds which it bears escape in the form of a fine powder. According to Hedwig, the seeds are contained in membranaceous capsules, each of which contains in general eight seeds. These fungi vary very much in their general appearance. Some are supported on footstalks, while others are destitute of them. They live upon the ground, on rotten wood, and even in water. As to substance, they are either coriaceous, fleshy, or waxy; characters which serve to distribute the species of the genus into the three following sections.

SECT. 1. *Coriaceous. Peziza coriacea.* Bull. p. 258. tab. 438. fig. 1. This plant is glabrous and ash-coloured, the skin is thick and coriaceous, the inferior part produced into a slender stem contracted at the base. Above it is salver-shaped, ferruginous towards the centre, and plentifully covered with a grey powder. It is found on the dung of the stag, the horse, and the ass.

SECT. 2. *Fleshy. Peziza fructigena.* Sower. tab. 117. This species is about half an inch in height, with a slender stalk tapering downwards. The upper part is more or less concave, opake, leathery, and fleshy. It is often found on coriaceous fruits, and, after Withering, we have found it in clusters on rotten sticks.

SECT. 3. *Waxy. Peziza acetabulum.* Sower. tab. 59. This is among the largest of the genus. The stalk is woody, short, and brown, branching up the base of the cap. The cap is upwards of two inches in diameter, and at first bell-shaped; afterwards it becomes more shallow, waved at the edges, reddish brown within, and paler without. It is found on rotten wood, and also on the ground.

GENUS X. TREMELLA. The Tremellæ consist of a gelatinous substance of various forms, containing the seeds scattered over their surface. The genus Tremella of Linnæus has undergone a considerable revolution. The green coloured species inclosing a gelatinous mass, containing filaments, now rank with the ALGÆ in the genus *Nostoch* of Vaucher; others are inserted among the *Aegeritæ*, and a few will be found with the *Gymnosporangiæ*. 10. Tremella.

Tremella amethystea. Bull. tab. 499. fig. 5. The substance of this species is gelatinous, and divided at the base into variously shaped lobes; the colour is purple, more or less deep; the surface glabrous, often furrowed. It is only found on rotten wood.

GENUS XI. HELVELLA. The fungi of this genus are furnished with a stem, terminated by an irregular cap, smooth on both sides, and throwing out the seeds at the inferior surfaces only. In appearance they resemble the Merulii, but the want of veins or gills beneath, form a sufficient mark of distinction. 11. Helvella.

Helvella mitra. Sower. tab. 39. The stalk is two or three inches high, a finger thick or more, irregular, hollow, deeply furrowed, often full of holes, or sinuses, and generally of a white colour. The cap is deflexed, and commonly divided into curled or folded lobes, which adhere to the stalk, but is extremely irregular and variable, and has neither gills nor pores. Its colour is generally a yellowish white, sometimes fuscous, livid, or black purple; the substance is waxlike and friable, the surface soft like sattin. The seeds are oval, and are thrown out by sudden jerks.

GENUS XII. SPATHULARIA. This genus contains such fungi as possess a stalk, with a cap, compressed vertically on each side of the stem. They make the nearest approach to the *Clavariæ*. 12. Spathularia.

Spathularia flavida. Helvella spathula of Sower. tab. 35. This plant is of a yellowish colour; the stalk is cylindrical, wrinkled, and compressed towards the top, which bears a vertical cap, obtuse at the summit, and produced on each side of the stalk. Hence it resembles a spathula. It is found in autumn in pine groves. When in perfection, if the heads are touched, a smoke arises from the edges, which is thrown out with considerable force, and continues to rise for some time, glittering in the sun like particles of silver.

13. Clavaria. Genus XIII. Clavaria. The fungi of this genus consist of simple or branched expansions, generally fleshy, sometimes coriaceous, destitute of a cap, and emitting the seeds from all parts of the surface. They are, in general, club-shaped, and have been divided by Persoon into several genera. The present genus excludes those Linnæan species which are known to possess distinct receptacles for the seed.

Sect. 1. *Fleshy, simple. Clavaria pistillaris.* Sower. tab. 237. This is the largest and thickest species of the genus. It is from one to two inches high, simple, glabrous, and club-shaped. The skin is very close and filamentous at the summit, which is at first rounded, and afterwards parts lengthwise into fungous threads. It grows upon the ground and among moss, is of a yellow or straw colour, and of a friable substance like suet.

Sect. 2. *Fleshy, branched. Clavaria coralloides.* Sower. tab. 278. This plant is brittle and plump, simple, or in two or three divisions, each of these subdivided into a number of smaller branches, like some species of coral. These branches are round, or slightly compressed, and often waved at the edges. The colour is in general yellowish, rarely reddish, sometimes white. The flesh, or internal substance, is white. It grows upon the ground, and is subject to great variation in form and colour. It is admitted to the table, and esteemed one of the best of the esculent fungi.

Sect. 3. *Coriaceous, simple. Clavaria ophioglossoides.* Sower. tab. 83. This plant is readily distinguished by the blackness of its colour, and softness to the touch. It is about two inches high, and half an inch over at the broadest part. The stalk is club-shaped at the summit, sometimes divided into two parts, generally grooved, and often twisted. The surface is glabrous, and covered with a very fine black powder. It is white within, and hollow when old. It grows upon the ground in moist situations.

Sect. 4. *Coriaceous, branched. Clavaria laciniata.* Sower. tab. 158. This forms at first a shapeless crust, which, as it grows old, divides into flat expanded branches, jagged at the ends. It varies much in its appearance. Its colour is white or grey, but the extremities of the branches are often tipt with reddish brown. The substance is solid and tough. It grows upon the ground.

14. Thelephora. Genus XIV. Thelephora. The Thelephoræ possess a coriaceous cap, of an irregular form, sessile, and adhering to other bodies by the side or the back; the outer surface is smooth, or covered with a few papillæ, and bears the seeds. They are found attached to the stems of trees, by their barren surface; afterwards they lose in part their attachment, and become horizontal, thus placing the fertile surface beneath. They constitute several very well marked and natural sections.

Sect. 1. *Cap entire, funnel-shaped, adhering by the centre. Thelephora caryophyllea, Auricularia caryoph.* Sower. tab. 213. This plant is fleshy, thick, and soft. The upper surface is beautifully zoned; the under side is smooth and waved, and covered with globules disposed in fours, which are visible with a microscope. It is sometimes simple, at other times divided into many parts, covering each other like the tiles of a house. The margin is frequently torn. In some cases it adheres by the side, and in others appears to be furnished with a short peduncle. It varies greatly in colour, through different shades of brown. It is annual, and grows upon the ground, and upon putrid wood.

Sect. 2. *Cap semicircular and attached by the truncated side. Thelephora reflexa.* Sower. tab. 27. This is a very common plant, growing on decayed trees, pales, and gates. The upper surface is zoned and hairy; the under surface close, and sometimes variegated. In colour and shape it is subject to much variation. The substance, when young, must be gelatinous, as it is often pierced by blades of grass, but when old it is tough and coriaceous. The under surface has always a reddish hue.

Sect. 3. *Cap attached by the barren surface. Thelephora papyrina.* Sower. tab. 349. This is slender, soft zoned, and hairy above. The inferior surface is at first united, afterwards it is zoned and pitted with pores of various sizes. The prevailing colour is yellow or red. It grows on the trunks of trees.

Genus XV. Hydnum. The inferior surface, and sometimes the superior, of this fungus, is hedge-hogged, with awl-shaped substances, pointing to the earth. These prickles are soft, solid, cylindrical or conical, emitting seeds from near their extremities. The plants are either fleshy or coriaceous, and grow upon the ground or upon the trunks of trees. 15. Hydnum.

Sect. 1. *Without a distinct cap, branched. Hydnum coralloides.* Sower. tab. 252. This is the largest species of the genus. It is sessile, at first white, and afterwards yellow. The base, which is fleshy and brittle, sends out a number of branches, whose under surface is beset with prickles. The last divisions of the branches form imbricated bushes, each bearing a tuft of long, awl-shaped, crooked and parallel prickles. When young it is very like a cauliflower. It grows upon dead stumps and aged trees.

Sect. 2. *Without a distinct cap, base spreading on the trunks of trees. Hydnum barba Jovis.* Sower. tab. 328. This fungus is coriaceous, sessile, membranaceous, and applied to the substance upon which it grows by all the points of its superior surface. When young, it is of a white colour, becoming afterwards of a yellowish red. The inferior surface is covered with numerous white simple mammellar protuberances; from the summit of these, yellow simple or branched filaments proceed; and in the latter stage of the plant, others are protruded, which are of an orange colour, and covered with hairy spiculæ.

Sect. 3. *Pileus distinct, prickles cylindrical or conical. Hydnum auriscalpum.* Sower. tab. 267. This plant is coriaceous, tan-coloured at first, afterwards becoming of a dark brown. The stalk is thick, short and solid, supporting a rounded, zoned, and sometimes downy cap, which is at first vaulted and smooth above; afterwards the cap becomes funnel-shaped, and the inferior surface studded with small cylindrical prickles. It grows upon old rotten cones, and decayed branches of the fir tree, lying half buried in the ground.

Sect. 4. *Cap more or less distinct, prickles lamellar. Hydnum sublamellosum.* Sower. tab. 112. This Hydnum is tender, white, and furnished with a short, solid, cylindrical stem. The cap is very thick, and the prickles are formed into small straight plates, variously waved. It grows on the ground, either singly or in groups.

Fungi.

Family III. *Fungi having the fertile surface furnished with tubes.*

16. Fistulina. Genus XVI. Fistulina. Cap with separate tubes underneath, containing the seeds. The plants now included in this genus were formerly ranked with the Boleti, from which they seem sufficiently distinct.

Fistulina hepatica. Sower. tab. 58. This plant is very plentiful in autumn among oak trees, growing on their trunks or spreading roots. Its vegetation is most rapid in wet weather. When very young, it resembles a strawberry; and, advancing in growth, it becomes hispid, with tubular protuberances, shaped like florets. By degrees it acquires a distinct underside of a pale yellow, with similar protuberances, and as these become more distinct, the upper ones lose their form. At length the under surface becomes covered with distinct and separate tubes, entire at their orifice, turning brown, and emitting seeds at their edges, which often hang in festoons, or little cobwebs formed by spiders. The fungus afterwards either rots, or turns black in decay. It varies in shape and size, but commonly resembles liver, being saturated with a blood-coloured fluid, which adds to the resemblance. Its taste is like that of the common mushroom, and some persons reckon it nearly as good.

17. Boletus. Genus XVII. Boletus. In this genus the cap has tubes underneath, which are united, and contain the seeds. It is indispensably necessary, in so extensive a genus as this, to subdivide the species into sections. Linnæus was acquainted with but few species of Boletus, and was satisfied with distributing them into two sections, the first containing such as are parasitical and destitute of a stem, and such as are furnished with a stem. In the *Flore Francaise*, they are divided into four sections; the first comprehending the Fistulinæ; the second such as have an imperfect cap, with the tubes scattered over different parts of the plant; the third, with the tubes united together, and inseparable from the flesh of the pileus, is subdivided into those without stems, those with lateral stems, and those with central stems; and the fourth having the tubes united, but easily separated from the flesh. The arrangement of Withering, however, appears both the most obvious and the most natural. It is founded on the condition of the stalk; the plants being either without a stem, having a central stem, or a lateral one. The subdivisions of his sections, founded on the colour of the tubes, is more artificial and inadmissible, as it is a character in the Boleti which is liable to many changes.

Sect. 1. *Stemless. Boletus ungulatus. Bol. igniarius* of Sower. tab. 132. This plant is coriaceous, attached by the side, and shaped like a horse's hoof. The cap is hard, rubbing to a polish, marked with concentric bands or ridges, each broad ridge indicating the growth of the year, and three or four small ones that of the different seasons of the year. The tubes are very slender, equal, the colour of tanned leather, in old plants stratified, a fresh layer being added every year. It grows on various kinds of trees, and subsists for several years. It is the *Agaricus Chirurgorum* of Pharmacopœias.

Sect. 2. *Stem central. Boletus piperatus.* Sower. tab. 34. The stem is cylindrical, greenish yellow, and nearly two inches high. The cap is yellow, flat, smooth, thin, at the edge, and about three inches over. Flesh thick, tinged with yellow. Tubes decurrent, short, deep orange, or earthy red; pores brown and irregular. This species grows upon the ground, and has a pungent effect upon the throat like that of a capsicum.

Sect. 3. *Stem lateral. Boletus betulinus.* Sower. tab. 212. This stem is nearly two inches in length, and half an inch in diameter, of a black colour. The cap is pink, brown, oblong, convex, curled at the edge, thin and flexible, and often divided into tongue-shaped lobes. The flesh is white; the tubes white and short; the pores very minute. It grows upon the trunks of old trees.

Family IV. *Fungi, having the fertile surface furnished with gills or prominent ridges.*

Genus XVIII. Merulius. The plants of this genus are fleshy or membranaceous; the cap is furnished with gills or veins underneath, of the same substance with the plant. 18. Merulius.

Sect. 1. *With a stem and gills underneath. Merulius umbelliferus.* Bull. tab. 519, fig. 1. A. The stem is whitish, smooth and hollow, not thicker than a horse hair in the smaller plants. The cap is white, thin, convex, a little bossed with the sides, and plaited. The gills are white, fixed mostly in pairs in the small, and in fours in the larger plants, the long ones being about 18 in number. The delicate structure of this plant causes it to tremble when held in the hand. The cap is so delicately transparent, that the edges of the gills appear plainly on the upper side, and have caused it to be described as striated. It is common in the autumn months at hedge bottoms, and amongst moss, adhering to dead leaves and half rotten sticks.

Sect. 2. *With a stem and veins underneath. Merulius infundibuliformis.* Bull. tab. 465, fig. 2. The stem in this plant is fluted, hollow, running insensibly into the pileus, which is also hollow. The gills are silvery grey, and branched like nerves. The whole plant is tough, elastic, and of a greyish mouse colour.

Sect. 3. *Stemless. Merulius membranaceus.* Sower. tab. 348. The whole plant is somewhat like wet parchment, lobed and waved irregularly. It grows in a vertical direction, the one side containing fibrils by which it adheres to other bodies, and the other side is furnished with fine branched anastomosing veins. It grows on moss in damp places, and on thatched houses.

Genus XIX. Agaricus. The agarics are fleshy and membranaceous; the cap is furnished with gills underneath, of a different substance from the rest of the plant, and composed of two plates containing the seeds. 19. Agaricus.

When Linnæus published his *Systema Naturæ*, he was acquainted with only 27 species of agarics, which he subdivided into two sections, Stipitati, pileo orbiculato, and Parasitici, acaules demidiati. Since the days of the illustrious Swede, the number of species has increased prodigiously; so that in Britain alone, nearly 300 are known as native plants. Various attempts have accordingly been made to introduce accurate divisions into so extensive a genus. But difficulties nearly insurmountable have hitherto rendered such efforts abortive. All that the generality of naturalists observe, is the last state of the existence of the plant; impregnation has probably taken place before it rises above the surface of the ground, so that nature exhibits to us the ripening and dispersion of the seeds only, and the final dissolution of the individual. Since we are not permitted to inspect those organs which, among the phenogamous plants, serve so admirably for their artificial, we had almost said for their natural division, all that remains for us is, to examine with care those characters which are least liable to change, even although these should be but remotely connected with any of the primary functions of their nature. Among the French writers, many subdivisions have been adopted, but almost all of them are artificial, founded upon characters either difficult of detection, or inconstant and fugacious. This will be better illustrated, by stating the characters of those subdivisions, as they appear, for example, in the *Flore Francaise*, which are as follows: 1. *Pleuropus.* Destitute of a wrapper or volva, stem wanting, or lateral, or eccentric. The sessile species are usually coriaceous; those having a stem are fleshy, with an irregular pileus. As an example, we may refer to the *Agaricus quercinus* of Sowerby, tab. 181. 2. *Russula.* Destitute of a wrapper, stem central, gills equal among themselves, and not terminating in a collar surrounding the stem, as *Agaricus pertinaceus*, Flor. Fran. No. 369. 3. *Lactarius.* Destitute of a wrapper, stem central, gills unequal, juice milky, generally white, sometimes yellow or red, *e.g. Agaricus deliciosus.* Sower. tab. 222. 4. *Coprinus.* Destitute of a wrapper, stem central, naked or furnished with a ring; gills unequal, dissolving into an inky fluid when old; cap membranaceous, *e. g. Agaricus cylindricus.* Sower. tab. 189. 5. *Pratella.* Destitute of a wrapper, stem central, naked, or furnished with a ring; gills turning black, but not dissolving as they grow old; cap fleshy. *e. g. Agaricus cyaneus* of Withering. 6. *Rotula.* Destitute of a wrapper, stem central, gills equal, ending in a collar surrounding the stem, *e.g. Agaricus rotula.* Sower. tab. 95. 7. *Mycena.* Destitute of a wrapper, stem central, hollow, gills not blackening with age, cap not umbilicated, *e.g. Agaricus pratensis.* Sower. tab. 247. 8. *Omphalia.* Destitute of a wrapper and ring, stem hollow or solid, cap umbilicated, gills generally decurrent, and not blackening with age, *e. g. Agaricus dryophilus.* Sower. tab. 127. 9. *Gymnopus.* Destitute of a wrapper and ring, stem solid, cap fleshy, gills not blackening with age, and either decurrent on the stem, as *Agaricus miniatus,* Sower. tab. 141, or adhering to the stem, as *Agaricus roseus,* Sower. tab. 72, or having the gills loose, as *Agaricus aurantius.* Sower. tab. 381. 10. *Cortinaria.* Destitute of a wrapper, stem central, gills not blackening with age, but covered when young with an incomplete curtain, which leaves upon the stem a filamentous ring, *e. g. Agaricus collinitus.* Sower. tab. 9. 11. *Lepiota.* Destitute of a wrapper, stem central, gills not blackening with age, covered when young with a curtain, which rends, and leaves on the stem a ring, *e. g. Agaricus cepestipes.* Sower. tab. 2. 12. *Amanita.* Furnished with a wrapper or membranaceous covering, which envelopes the mushroom when young, afterwards rending, and sometimes leaving its remains upon the cap. Of these, some have the wrapper imperfect, as *Agaricus verrucosus* of Bulliard, tab. 316; while in others it is complete, as *Agaricus bulbosus.* Sower. tab. 130.

With regard to the *wrapper,* the *volva* of some authors, but not of Linnæus, it appears to belong but to a very few species; and even in these, to be sometimes so imperfect as to lead authors to deny its existence. It seems to be confined to the plants with solid stems only; nor has it been found attendant even upon these when the gills are decurrent. It envelopes the whole plant in its early stage, and afterwards bursts asunder, leaving its remains in the form of warts upon the cap in some instances, and in others disappearing entirely. On a character so uncertain, is the genus *Amanita* of Persoon founded.

The *cap,* or *pileus* as it is called, is the most obvious part of the mushroom; but it is apt to vary both in shape and colour. The last character is very uncertain; the former is a little more permanent. The cap is either conical, convex, flat, or concave and funnel-shaped. It is constantly varying in the same plant, but is pretty uniformly the same in the same species, when the plant is in perfection; that is, when fully or nearly expanded, and before it exhibits symptoms of decay. In some mushrooms, both the cap and the stem exhibit a viscidity or clamminess on the surface. This character, however, is not much to be depended on, as in dry weather some of the viscid spaces shew no symptoms of a moist or even adhesive substance; and in a moist atmosphere, many, at other times dry to the feel, become more or less viscid.

The *stem* is less variable than the cap. Its shape, the proportion of its length to its breadth, and of both to the cap, afford tolerable distinctive marks; and its colours, though subject to change, are perhaps rather more fixed than those of the cap. But the most permanent characters afforded by the stem, depend upon its position and internal structure. The Agarics are either destitute of a stem, the cap sitting close upon the root, or the stems are central or lateral. When the stem is cut across with a sharp knife, it appears hollow or tubular in some species. The tube is not always proportioned to the size of the stem, though it is uniform throughout its whole length. It is sometimes entirely empty, sometimes loosely filled with a pithy substance; but its regularity is not affected by that circumstance. In many species, the stem when cut appears solid, varying greatly, however, in the degree of solidity. It may be as solid as the flesh of an apple, or as spongy as the pith of elder; but still it is solid, that is, there is no regular hollow pervading its whole length, though the more spongy and larger stems sometime show irregular and partial hollow places from the shrinking of the pithy substance as the plant grows old; but this can never be mistaken for a regular, uniform, and native hollowness.

The *gills* are the flat thin plates found on the under side of the cap, and attached to it. They are of a texture evidently different from that of the stem or the cap, and vary much in their respective lengths. Each gill consists of two membranaceous plates, between which the seeds are formed. They are always attached to the pileus, and sometimes to that only. They often also adhere to the stem, and frequently extend along it downwards. These fixed and decurrent gills are attached to the stem by their ends, which are next the centre of the cap, and not by their edges, as is sometimes the case in some of those species whose caps are nearly cylindrical. Among those which have loose gills, (or not attached to the stem), there are a few species in which these organs terminate in a collar, not unaptly compared to the nave of a wheel, the hollow centre receiving the stem like an axle. The number of gills varies even in the same species. Sometimes they are all equal in length, at other times there are between the primary gills which extend from the margin to the centre of the cap, a few secondary ones, reaching from the circumference a short way inwards. Those gills which have four in a set, are by far the most common; but in those which have four in a set when young, the gills very often increase to eight when fully expanded, some of the longer gills bearing from the stem. Characters taken from the number of the gills, are therefore very uncertain and variable. The *colour of the gills* is an obvious, and fortunately, at the same time, a permanent circumstance; and when we reflect that their colour is principally, if not solely, caused by that of the fructification or seeds within them, we might *a priori* have expected what experience has taught in this case, that it is the most fixed, the most certain characteristic on which to found the distinctions of the species; and that this, together with the structure, will be at all times sufficient to afford permanent specific distinctions. It is allowed, that these colours change when the plant begins to decay, but no botanist would complain that the characters are wanting, in a subject collected in a rotten state. The colour of the flat sides of the gills is what ought to be attended to, because the colour at the edge in some plants is different through all the stages of its growth, and in others it changes sooner than that of the sides, evidently from the discharge of the seeds when ripe. The colour of the whole of the gills being sometimes influenced by the ripened seeds, it is clear that this colour ought to be described where it is liable to such a change, not only in the perfect and vigorous state of the plant, but also in its mature and nearly decaying state, taking its character from the former. Thus, in several of the deliquescent agarics, especially such as dissolve in decay to an inky liquor, the plants, when very young, have white gills; these become grey when the seeds are formed, and black when quite ripe, and dissolve in decay. These circumstances may be properly noticed in the history of the plant, but no one would think of taking its character from its yet but half unfolded state, any more than from its state of decay; such a plant, therefore, must be placed amongst others whose gills are grey.

Some of the agarics have a *curtain*, the *volva* of Linnæus, extending from the stem to the edge of the pileus. This curtain is torn as the pileus expands, and soon vanishes; but the part attached to the stem often remains, forming a *ring* round it. This ring is more or less permanent as its substance is more or less tender; but some of the species appear some years with, and other years without, a ring; so that though it forms a very obvious character, it cannot be admitted as the ground of specific distinction. Major Velley, when speaking of *Agaricus æruginosus*, says, "in the autumn of 1788, in several hundred specimens, I never found one that had a ring on the stem; but the following year, almost every one that occurred had this distinguishing mark."

Many of the agarics, when wounded, pour out a milky juice; but this circumstance is by no means uniform in the same species. Some plants, apparently healthy and vigorous, shew no signs of milk when wounded, while others of the same species, on the same spot, and at the same time, pour out their milk in abundance. This frequently happens with the *Agaricus exampelinus.*

Taking all these characters in connection, and allotting to each a conspicuous place, in proportion to its permanency, our countryman, Dr Withering, in his "*Arrangement of British Plants*," presented to the public a classification of the agarics, more simple, obvious, and applicable, than any of those subdivisions which have hitherto appeared. Without venturing to give a description of any of the species belonging to the different divisions, we content ourselves with presenting an outline of the whole.

A. Stem central.

I. Solid and Decurrent.

1. Gills white. 2. Gills brown.
3. Gills red. 4. Gills buff.
5. Gills yellow. 6. Gills purple.

II. Solid and Fixed.

1. Gills white. 2. Gills brown. 3. Gills purplish.
4. Gills buff. 5. Gills yellow. 6. Gills grey.

III. Solid and Loose.

1. Gills white. 2. Gills brown. 3. Gills red.
4. Gills buff. 5. Gills yellow. 6. Gills grey.

IV. Hollow and Decurrent.

1. Gills white. 2. Gills red.
3. Gills yellow.

V. Hollow and Fixed.

1. Gills white. 2. Gills brown. 3. Gills red. 4. Gills purple.
5. Gills yellow. 6. Gills buff. 7. Gills green. 8. Gills grey.

VI. Hollow and Loose.

1. Gills white. 2. Gills brown. 3. Gills red.
4. Gills buff. 5. Gills yellow. 6. Gills grey.

B. Stems Lateral.

1. Gills white 2. Gills brown.
3. Gills buff.

C. Stemless.

GENUS XX. MORCHELLA. The plants of this genus have no wrapper; their ovoid cap is supported by a cylindrical stem, not perforated at the summit, but raised below into anastamosing nerves, forming polygonal cells, in which the seeds are concealed. These plants were formerly associated with the genus Phallus, but in consequence of their want of a wrapper, and the seeds not being enveloped in a slimy liquor, they have been disjoined by Jussieu, Lamarck, and Persoon. 20. MORCHELLA.

Morchella esculenta. Phallus esculentus of Linnæus, Sower. tab. 51. The stem is cylindrical, solid, or hollow; white and smooth; the cap is hollow within, ovoid, adhering to the stem by its base, and latticed on the surface with irregular sinuses: the height is about four inches. This plant is well known in Britain by the name of Morel, and is eaten with safety.

FAMILY V. *Fungi in which the fertile surface decays into a pulp, the plant issuing from a wrapper.*

GENUS XXI. PHALLUS. Stem enveloped by a wrapper at the base, supporting a cap, which is perforated at the top, marked with a network of cells, and furnished with a slimy liquor, in which the seeds are lodged. 21. PHALLUS.

Phallus impudicus. Sower. tab. 329. This is one of the most singular productions of the whole tribe. It arises from the earth under a wrapper, shaped exactly like a hen's egg, of the same colour, having a long fibrous radicle at the base. This wrapper is composed of two coats or membranes, the space between which is full of a thick, viscid, transparent matter, which, when dry, glues the coats together, and shines like varnish. In the next stage of growth, the wrapper suddenly bursts into several lacerated permanent segments, from the centre of which arises an erect, white, cellular hollow

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stalk, about five or six inches high and one thick, of a wax-like friable substance, and most fœtid cadaverous smell; conic at each end, the base inserted in a white, concave, membranaceous, turbinated cup, and the summit crowned with a hollow conical cap, an inch long, having a reticulated cellular surface, its base detached from the stalk, and its summit umbilicated, and either perforated or closed. The under side of this cap is covered with a clear, viscid, gelatinous matter, similar to that found between the membranes of the wrapper; and under this viscid matter, concealed in reticulated receptacles, are found the seeds; which, when magnified, appear spherical. As soon as the wrapper bursts, the plant begins to diffuse its intolerable odours, which are so powerful, and widely expanded, that it may be readily discovered by the scent only, before it appears to the sight. At this time, the viscid matter between the coats of the wrapper grows turbid and fuscous; and when the plant arrives at its full maturity, the clear viscid substance in the cap becomes gradually discoloured, putrid, and extremely fœtid, and soon afterwards turns blackish, and, together with the internal part of the cap, melts away. It is common in woods and hedges.

22. Clathrus. Genus XXII. Clathrus. The receptacle for the seeds in this genus is formed of fleshy, arched, anastamosing branches, which form a kind of vault. The branches emit, on all sides, a viscous liquor, concealing the seeds; the receptacle is inclosed in a wrapper in the young state of the plant.

Clathrus cancellatus. Bull. p. 190, tab. 441. This plant is sessile, globular, and white. The wrapper soon breaks from the summit, and discloses the receptacle or cap, which is often of a red colour. The branches of the receptacle form an ovoid vault. The seeds are mixed with a stinking liquor. It is found on sandy grounds, and in dry woods, in the middle parts of Europe.

TRIBE II. ANGIOCARPI.

Family I. *No peridium, the plants parasitical, protected, when young, by the epidermis of the plant upon which they grow.*

23. Gymnosporangium. Genus XXIII. Gymnosporangium. The plants of this genus exhibit a gelatinous mass, at the surface of which seed vessels are found, composed of two conical cells, joined at the base, and separating at maturity. These capsules are placed at the summit of weak slender filaments, which proceed from the base, and traverse the gelatinous mass. All the plants of this genus are parasitical on the different species of junipers.

Gymnosporangium fuscum. Tremella sabinæ. *Dicks. Crypt.* i. p. 14. This is of a reddish or brown colour, issuing from beneath the epidermis on which it grows. It is somewhat narrow at the base, almost cylindrical, obtuse, sometimes marked by a longitudinal groove. Its consistence is a little gelatinous. The microscope discovers, on the surface, numerous seed vessels, supported by slender filaments, proceeding from the base of the plant. It grows upon the *Juniperus sabina*, &c.

24. Puccinia. Genus XXIV. Puccinia. The plants of this genus present themselves under the form of compact gelatinous tubercles, upon which the seed vessels are raised; these are supported upon stiff stems, are in general divided into two or more cells, by transverse partitions, and emit the seeds by the summit or by the sides. They grow upon the leaves and young shoots of plants, sometimes under the epidermis, which they pierce in order to reach the air, and sometimes upon the epidermis itself. In autumn there is scarcely a plant that is not infected with these parasites. They are divided into three sections.

Sect. 1. *With three or four cells. Puccinia rubi.* Sower. tab. 400, fig. 9. This is a very common plant, growing on the under side of the leaves of the common bramble in autumn, spotting their backs with little sooty-looking clusters; which, when magnified, are found to consist of a number of transparent stems, tapering upwards, each with three or four oval heads, resembling little black beads placed on each other, the uppermost somewhat acute at the apex.

Sect. 2. *With two cells. Puccinia graminis.* The *Uredo frumenti* of Sower. tab. 140. This species, too well known in this country by the name of *blight*, grows on the leaves and stalks of various species of gramina, thereby stinting and weakening the plant. It forms linear patches, which are at first yellowish brown, and afterwards become black; the seed vessels are supported on short stems, somewhat clavate; the cells are two in number, the one at the extremity somewhat larger than the other. It is common on wheat, in low grounds, or where too closely sown, especially after rain in the early part of autumn.

Sect. 3. *With one cell. Puccinia pisi.* Sower. tab. 393, fig. 8. This parasite attacks the stems, leaves, and tendrils, of the common pea. It grows in brown pustules, which are a little prominent, and scattered oblong on the stem, but rounded on the leaves. The epidermis is first raised, and afterwards bursts and forms a border around the pustules. It consists of unilocular ovoid capsules, supported on very short stems.

Genus XXV. Bullaria. These grow in groups, under the epidermis of dead stalks, which they raise, and afterwards burst, each group consisting of a multitude of articulated and sessile capsules. These differ from the genera Puccinia and Uredo, in growing upon dead stalks, and not upon living leaves. 25. Bullaria.

Bullaria umbelliferarum. Persoon's *Obs. Myc.* tab. 2. fig. 5. This species is common on the dead stalks of umbelliferous plants, growing under the epidermis, which it raises up in the form of an oval greyish bladder, and then pierces it longitudinally; a reddish-brown mass may then be distinguished, almost pulverulent, which presents, under the microscope, sessile capsules, separated into two cells by a partition, or rather a transverse stricture, giving them the form of the figure 8.

Genus XXVI. Uredo. This genus exhibits merely a naked powder growing under the epidermis of living leaves, which it bursts, and issues by the orifice, the torn margin resembling a small receptacle; the seeds or capsules are ovoid or globular, without transverse partitions. In autumn these fungi are to be found on almost every leaf. Several species infest the willows. 26. Uredo.

Sect. 1. *Powder black, brown, or red. Uredo segetum.* Bull. page 90, tab. 472, fig. 2. It is painful for us to record the name of another parasitical fungus, as destructive to our crops as the blight, but known by the name of *Smut*, and attacking the ears of wheat, oats, and barley. It consists of small spherical globules, a little adhering together, and of a brown or blackish colour. It grows under the epidermis, and sometimes destroys the whole parenchyma of the ear.

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SECT. 2. *Powder yellow. Uredo linearis.* Sower. tab. 139. This species grows on the leaves of many of the grasses, forming linear patches visible on both sides, rising under the epidermis, which at last bursts in the direction of the nerves. The powder is at first yellow, afterwards brown, composed of ovoid globules.

SECT. 3. *Powder white. Uredo tragopogi.* This is found on the leaves of the goat's-beard, in the form of a white powder.

FAMILY II. *Peridium membranaceous, filled with Powder not intermingled with Filaments.*

27. Ecidium. GENUS XXVII. ECIDIUM. The fungi of this genus appear at first as simple tubercles, which soon open at the summits into a circular orifice, more or less deeply toothed. The inside contains a farinaceous powder. They are all parasitical, growing upon the leaves of living plants.

SECT. 1. *Tubercles scattered. Ecidium anemones.* Lycoperdon anemones, Pultn. *Lin. Trans.* vol. ii. p. 311. This grows on the inferior surface of the leaves of the *Anemone nemorosa*, in the form of scattered tubercles. They appear at first under the cuticle, and afterwards burst forth like white buds, with a pore in the summit, and then expand into a cup with a laciniated border. The powder is white, and composed of ovoid globules, scarcely cohering. This plant can scarcely be mistaken for any of the other parasitical fungi with which this anemone is infested, as the Ecidium punctatum, in which the powder is brown, the Uredo anemones, and the Puccinia anemones.

SECT. 2. *Tubercles closing into a circular ring. Ecidium tussilaginis.* Sower. tab. 397, fig. 1. This grows upon the under surface of the leaves of several species of tussilago. The leaf appears with a reddish-white spot on the upper surface, and below the receptacles are disposed in spots, rounded and serrated, or often formed into a ring. Powder orange, sometimes white.

SECT. 3. *Branched in irregular clusters. Ecidium berberidis.* Sower. tab. 397, fig. 5. This grows upon the back of the foliage of the common barberry, in rounded convex tufts, the space of each appearing on the upper surface like a red spot. The common base is reddish, supporting small yellow tubercles, which divide at the summit into a circular opening, the margin furnished with fine teeth. Powder yellowish-orange. Found principally in the spring.

28. Mucor. GENUS XXVIII. MUCOR. The plants of this genus have a membranaceous globular or tufted receptacle, seated on a stem, at first watery and transparent, afterwards opake, and full of naked powder, not mixed with filaments, and but little cohering.

Mucor mucedo. Sower. tab. 378, fig. 6. This species, which every one knows, is common on all fermenting and decaying vegetable or animal matter. The stalks are simple and slender, bearing upon their summits a globular seed-vessel, at first white and transparent, afterwards brown and opake. The seeds are numerous, round, and greenish while inclosed in the seed-vessel. This seed-vessel bursts with an elastic force, as may be seen when viewing it under the microscope.

GENUS XXIX. LICEA. The fungi here referred to have a sessile, membranaceous, brittle peridium, bursting in various ways, and containing a powder without filaments. They are destitute of a membranaceous base. 29. Licea.

Licea circumsissa. Sower. tab. 258. This plant is sessile, rounded, and a little flattened. It opens irregularly across, and contains a golden yellow powder, among which one or two filaments may be discerned with difficulty. It grows at the end of autumn on dead wood.

GENUS XXX. TUBULINA. The plants of this genus possess a membrane which supports many sessile peridiums, which are generally cylindrical. The powder is destitute of filaments. 30. Tubulina.

Tubulina cylindracea. Bull. tab. 470, fig. 3. The peridiums are sessile, and rest upon a white obvious membrane: They are cylindrical and lengthened, and terminate in an obtuse point, of a rusty brown colour, with a white point. These burst irregularly towards the upper end, and allow the rusty brown powder to escape. This plant grows upon moist dead wood.

FAMILY III. *Peridium membranaceous, filled with Powder, intermingled with Seeds.*

GENUS XXXI. TRICHIA. The peridiums of this genus are sessile or pedunculated, supported upon a membrane which is very apparent in the young state of the plant. These inclose the filaments, which are attached to a stem, or to the partitions of the peridium, and support numerous pulverulent globules. They are divided into several sections, which might with propriety be constituted into genera. 31. Trichia.

SECT. 1. *Peridium ovoid, spherical, sessile, or pedunculated, bursting irregularly. These form the Spherocarpus of Bulliard. Trichia turbinata.* Bull. tab. 481, fig. 1. The base is white, membranaceous, and very apparent; the stems are simple, smooth, slender, lengthened, cylindrical, terminating in an orange-coloured peridium, at first in the form of a rounded tuft, afterwards as if truncated, and finally concave at the summit; at which time it might be taken for a Peziza, if the interior of the peridium were not filled with long-haired network, covered with a greyish-red powder. It grows on dead wood.

SECT. 2. *Peridium bursting in such a manner as to form a persisting calyx on the summit of the stalk. This is the Arcyria of Persoon. Trichia nutans.* Sower. tab. 260. The base consists of a white coriaceous membrane, supporting the little fungi; the peridium is lengthened, becoming cylindrical, and at the same time decaying at the top, leaving at liberty the powder and the filaments. It grows upon dead wood.

SECT. 3. *Peridium destroyed in whole or in part, in such a manner as to leave anastamosing nerves, through which the powder issues.* The *Crebraria* of Persoon. *Trichia semi-cancellata.* Sower. tab. 400. fig. 5. The base is a coriaceous white membrane, supporting numerous stalks, which are simple, striated, of a brownish-black colour, tapering towards the summit, straight, or leaning in old age. The peridium is globular at first, opake, of a fine yellow before and reddish after the emission of the seeds. The lower part is membranaceous, and persisting in the form of a denticulated calyx; the upper part is formed of fibres, disposed in a net-work, vanishing after the emission of the powder, which is yellow.

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32. Stemonites. Genus XXXII. Stemonites. The plants of this genus are usually inserted upon a membrane in groups; the peridiums are pedunculated, and traversed by an axis, which consists of a lengthening of the peduncle.

Stemonites typhoides. Sower. tab. 50. The white membrane of the common base supports a number of slender stalks, which traverse the peridium, and remain after the escape of the powder. The peridium is cylindrical, soft, of a milk-white colour when young, but becoming black afterwards. It bursts laterally in many places, and throws out a brown powder. It grows during the summer on rotten trunks of trees.

33. Diderma. Genus XXXIII. Diderma. In this genus many individuals arise from a common membrane, having a peridium with a double covering, containing powder intermingled with filaments. This genus bears the same relation to the Trichia as the Geastrum does to the Lycoperdon.

Diderma floriforme. Bull. tab. 371. This plant is altogether of a coriaceous consistence, and of a pale yellow colour. The base consists of a thick obvious membrane, supporting many slender, smooth, cylindrical stalks, with a globular smooth head. At length the outer bark opens into five or six unequal rays, exposing a true peridium, pear-shaped, wrinkled, and permanent, bursting irregularly, and emitting a brownish-coloured powder.

34. Reticularia. Genus XXXIV. Reticularia. This genus consists of plants, which are at first pulpy, shapeless, and soft. Internally they present cells full of powder, forming a kind of slender net-work; finally, they are reduced into a fine powder.

Reticularia hortensis. Sower. tab. 399. This is common on tan in hot-houses. It at first appears to ferment as it were in a kind of whitish froth, in a few hours becoming yellowish, and seemingly mixed with a powder; at length it grows fragile, flattens, and assumes a lightish brown colour on the outside, being replete with dark powder, or seeds in irregular divisions within; after which it soon falls to pieces. In the fresh state it smells not unlike rotten cheese.

35. Spumaria. Genus XXXV. Spumaria. The plants of this genus resemble the preceding, but their pulp conceals coriaceous and membranaceous cases, inclosing the seeds.

Spumaria mucilago. Sower. tab. 280. This plant is of a white colour, soft, and flaky like scum. Internally the coriaceous cases are shaped like coral, and inclose a black powder. It dries up quickly, and by the touch is reduced to powder, nothing remaining but the black cases. It grows upon the stalks and leaves of dead and living plants.

36. Leucogalia. Genus XXXVI. Leucogalia. In this genus the peridium is membranaceous, rounded, and filled while young with a liquid pulpy mass, afterwards changed into a powder mixed with a few filaments. This peridium opens in a regular manner at the sides, or on the summit.

Leucogalia argentea. Sower. tab. 272. This plant is sessile, or prolonged at the base into a very short peduncle. Its form approaches to spherical; its colour is white when young, afterwards it turns red or brown. The pulp changes into a powder, at first grey, afterwards rust coloured, and at last brown. The seed-vessel bursts at the side. This species grows solitary, on putrid trunks, in autumn.

37. Lycoperdon. Genus XXXVII. Lycoperdon. The plants of this genus are composed of a peridium generally globular, solid when young, with whitish close flesh, changing into a powder intermingled with filaments. At maturity it opens at the summit, in a manner more or less regular. Several species of this genus are so well known in this country by the name of *Puff-balls*, as to render any farther description unnecessary.

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38. Geastrum. Genus XXXVIII. Geastrum. The plants of this genus are globular at first, then the external covering opens at the top, and divides into many rays, curling backwards, and raising the peridium on a vaulted pedestal. The peridium is globular, and opens at the summit by an orifice bordered by fading hairs. The inside is full of brown powder, intermingled with filaments, dispersed, and indistinct. The external covering is coriaceous and thick, the internal is membranaceous; between these there is sometimes found a fugaceous wrapper.

Geastrum hygrometricum. Sower. tab. 80. The external covering is of a chesnut colour, divided into five or six nearly equal rays, which are bent backwards. The peridium is spherical and sessile, mouth ciliated, and usually bordered with a circle of a paler colour. For a more minute account of the species of this genus, the reader is referred to an excellent paper of Mr Woodward's, on the stellated Lycoperdons, in the *Linn. Trans.* vol. ii. p. 32—62.

39. Tulostoma. Genus XXXIX. Tulostoma. The peridium is solid, globular, fleshy, white, and becomes converted into a fine powder, intermingled with fine filaments. It is supported on a cylindrical stalk, hollow throughout, having an opening at the top, with a cartilaginous border.

Tulostoma brumale. Bull. tab. 294, and 471. fig. 2. This plant is of a white colour, the stem is cylindrical, generally glabrous, sometimes imbricated; peridium globular, opening at the summit by a round orifice which is flat, or a little prominent. It grows in sandy grounds in winter, and in the beginning of spring.

Family IV. *Peridium membranaceous or fleshy, and without powder.*

40. Cyathus. Genus XL. Cyathus. The fungi of this genus consist of little cups, the orifice of which, at first, is vested with a membrane, and the inside filled with a viscid limpid juice; afterwards the membrane bursts, the liquid evaporates, and there remain in the bottom of the cup from three to five lenticular capsules, adhering to the base by a slender filament, and filled with jelly, in which grains are observed supposed to be seeds.

Cyathus striatus. *Nidularia striata* of Sower. tab. 29. This plant is conical, woolly on the outside, and scored within. The capsules are smooth above and woolly beneath. It grows on the ground, and on rotten wood.

41. Stictis. Genus XLI. Stictis. This genus exhibits little membranaceous cups, half way inserted into the barks of trees, full of a substance not powdery, inclosing the seeds; these are closed when young, but open afterwards into a cup.

Stictis immersa. *Peziza immersa* of Sower. tab. 369. fig. 9. This little fungus is wholly black, sometimes a little woolly on the underside. It forms holes in the wood on which it grows.

42. Pilobolus. Genus XLII. Pilobolus. In this genus the receptacle is thread-like, widening at top into a vesicle filled with water, at the summit of which there is found a fleshy substance, supposed to contain the seeds in the inside.

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Pilobolus urceolatus. Sower. 300. This curious production may be found on horse dung, in damp or dewy mornings or evenings almost all the year. At first it is cylindrical, with a small yellow head. In a few hours the stipes inflates towards the top, and becomes pitcher-shaped, and at the same time the head gradually changes brown, by degrees becoming totally black. The plant being arrived at perfection by its inflation or expansion, it bursts and projects the head to the distance of three or more inches, probably to disperse the seed.

43. Thelebolus. Genus XLIII. Thelebolus. Receptacle cortical, globular, entire at the margin, when young inclosing a vesicle, which afterwards pushes out, containing a great many loose capsules, lengthened, pointed, and filled with seeds.

Thelebolus hirsutus. This species grows upon the bark of living trees, forming a greyish membranaceous base supporting many small globular heads, with a rounded orifice at the top, by which the internal matter containing the seeds escapes.

44. Erysiphe. Genus XLIV. Erysiphe. The fungi here referred to have a fleshy receptacle, containing many oval acute seed-vessels, and surrounded with a white pulp prolonged into many articulated simple or branched rays. These grow upon the living leaves. The receptacles of all the known species are at first yellow, then red, and at last black; the extension of the base is always white, often covering the leaves with a retiform membrane or powder.

Erysiphe fraxini. Mucor erysiphe of Linn. This plant grows on the inferior surface of the leaves of the common ash, forming at first a thin white crust, which afterwards supports small tubercles, at first yellow, then orange, brown, and at last black; these are bordered with seven or eight pointed hairs, swollen at the base. These hairs are at first upright, then they become horizontal, and finally are obliterated.

45. Tubercularia. Genus XLV. Tubercularia. The plants of this genus present merely a fleshy sessile tubercle, simple or composite, the seeds contained in a thick liquid in the inside. They grow upon the bark of trees and certain plants, and are all remarkable for their red colour.

Tubercularia vulgaris. Bull. tab. 284. This plant is not absolutely without a stem, but the stem is very short, and nearly as thick at the top, entering into the substance of the bark on which it grows. In some specimens the top part is of a full vermilion, and the lower part of a yellowish colour. In other specimens this order of colour is reversed. It is common in this latter variety to find young shoots growing up close to the stem of the older plants, the heads of which have the full vermilion colour. It varies from the size of a pin's head to that of hemp-seed. It is found plentifully on pieces of half rotten sticks in the autumn.

46. Sclerotium. Genus XLVI. Sclerotium. The sclerotia present merely a hard bark or covering of a more or less compact fleshy substance, without visible veins, in which the seeds are supposed to be nestled. They differ from the genus Tuber in the absence of veins, and from Tubercularia in the flesh being firmer, and the bark more coriaceous. They are the productions of spring.

Sclerotium durum. Pers. *Syn.* 121. This grows between the bark and the wood, upon the dry stalks of herbs and shrubs. It is oblong or oval, a little flattened, and of a black colour. The substance is firm and hard, and in the interior the flesh is white and coriaceous.

47. Tuber. Genus XLVII. Tuber. The plants of this genus are fleshy, round, subterraneous, solid, not becoming powdery, nor opening at the top, but containing veins in various directions. By Linnæus they were united with the lycoperdons.

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Tuber cibarium. Sower. tab. 309. *Truffles,* as the plants of this species are called in England, are globular, seldom the size of a hen's-egg, without any root, and of a dark colour approaching to blackness. The surface is uneven and rough; the flesh firm, white while young, but when old it becomes black with whitish veins.

Having thus concluded our proposed review of the different genera of Fungi, it may be proper here to remark, that, under the term Hypoxyla, which we have added as an Appendix to the present article, the reader will find some of those genera described, which he probably expected to meet with under the title Fungi. Such as the genus Rhizomorpha of Rothes, and that extensive genus, or rather tribe of plants, the Sphæria of Linnæus.

Preservation of the Fungi.

Before proceeding to offer some remarks on the physiology of the Fungi, it may be proper to state the methods which have been employed for the purpose of preserving them in a fit state for subsequent inspection and comparison. The difficulty, indeed, of preserving such soft and perishable objects has always been found one of the most formidable obstacles to the study. Dr Withering, to whom the British botanist lies under so many obligations, after a long continued attention to the subject, discovered the following method, which he found to answer the purpose. Take two ounces of vitriol of copper, (sulphat of copper,) reduced to powder; pour upon it about a tea cup of cold water, stir them with a piece of stick or quill for about a minute, then pour off the water and throw it away. On the remaining vitriol pour a pint of boiling water, and when the whole is dissolved and grown cool, add to it half a pint of rectified spirit of wine; filtre it through paper; keep it in a bottle closely corked, and call it the *pickle.* To eight pints of pure spring water, add a pint and a half of rectified spirit of wine; keep this in corked bottles, and call it the *stronger* liquor. To eight pints more water, add one pint of spirit of wine, and call it the *weaker* liquor. Be provided with a number of wide-mouthed glass jars of various sizes, capable of holding from two ounces to two pints, all very well fitted with corks.

Whatever fungus, whether Agaric or Boletus, &c. you wish to preserve, should be suffered to lie upon your table as long as it can be trusted without danger of its decaying, so as to allow some part of its moisture to evaporate; the thick and fleshy plants should lie the longest, but the deliquescent ones, and those which are very thin and delicate, should be put into pickle almost immediately after they are gathered.

Pour some of the pickle into a square jar, and into this immerse the specimens to be preserved. The specimens should remain in the pickle from three hours to three days, according to their bulk and fleshiness. Then remove each specimen into the jar in which it is to be kept, suiting the size of the jars to the size of the specimens. If they are of the large juicy and fleshy kind, fill up the jar with the *stronger* liquor, but the weaker will suffice for the smaller and thinner plants. Whichever liquor be used, the jar must be quite filled with it, and immediately corked very tight. Cover the cork and the top of the jar with Venice turpentine, by means of a painter's brush, and then tie a piece of wetted bladder very tight over the top of the jar. These

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precautions are necessary to prevent the access of air and the evaporation of the liquor, because, if either of these happen, the specimens will soon be spoiled. The Boleti are in general more difficult to preserve than the Agarics, and such of either as abound with a milky juice are apt to foul the liquor, which must then be changed. Mosses and Lichens may be preserved in great perfection by this method of pickling. But we must add, that a collection formed in this manner will be both bulky and expensive.

Another method, still more simple, has sometimes been practised, namely, to dry them in a stove of clean sand moderately heated. Almost all the coriaceous agarics may in this manner be preserved with ease, so as to exhibit not only their form, but also in a great degree their colour. The sand must be fine, clean, and dry, and poured into the dish with care, observing to fill the spaces between the gills gently with the sand, without bruising them or altering their position.

But a vast number of the fungi noticed above cannot be preserved by any of those methods which we have detailed. Many of them consist almost entirely of water, so as to be incapable of drying without total destruction, while the characters of others depend so much upon the colour, and at the same time are of a substance so fugaceous, that no liquor can preserve their delicate tints, or their still frailer forms. Hence the mycologist must employ his pen to describe, and his pencil to copy these productions, whose characters he investigates, otherwise his conceptions of the species will be both obscure and indeterminate.

In addition we may mention, that agarics may be transported to almost any distance with little damage by the following method. Put them into an earthen jar upon a layer of moss a little pressed down; cover them with more moss, carefully filling up the interstices; and then go on stratifying them until the jar be quite full; pour in the pickle above described as long as the moss will continue to imbibe any, then stop the mouth of the jar securely. It may be useful to observe, that when several species are put into one jar, they may be labelled with slips of card paper written with a black lead pencil.

Physiology.

In attending to the physiology of this intricate class of vegetables, there is no circumstance in their history more surprising than the rapidity of their growth. The space which intervenes between their germination and maturity is seldom more than a few days, or at most a few weeks, and in many cases a few hours only are required. Withering relates, that a young plant of the Agaricus cylindricus put into water, and covered with a glass bell, grew three inches and a quarter in twelve hours. Sowerby when describing the Phallus caninus, says, "I have often placed specimens by a window, over night, while in the egg form, and they have been fully grown by the morning," and he adds, "they have never grown with me in the day time. The absence of light, indeed, to this tribe of plants, does not seem so prejudicial, as it does to the stameniferous vegetables. Some of them live under the ground, others in the recesses of caves and in dark cellars.

In regard to situation, the fungi present many remarkable differences. A few grow upon the ground, and seem to derive their nourishment from the soil. Others spring up on the various putrid substances presented by nature or art. Rotten fruit, cheese, meat, dung, are all destined to support particular species of fungi. But these parasites are not confined to dead plants and putrid matters, otherwise we might consider them like the *Silphides* among the insects, and style them nature's scaffingers. But they likewise attack living vegetables. They presume not to infest animal matter until the spark of vitality has fled; but they prey upon the very juices of vegetables, seat themselves on the stalks, the leaves, and the flowers, and occasion their stinted growth and decay. Some are peculiar to one plant, while others infest the foliage of several plants, provided in general they belong to the same natural family. They make their appearance in pastures and corn-fields, on way sides, in marshes, and in woods. In one season, you may observe multitudes rising in a particular spot, where none will be found in the subsequent season. So uncertain are they in their growth, that it is not likely they will ever enter into the composition of ornamental gardening. We are told by Gleditsch, that morels are observed to grow in the woods of Germany in the greatest plenty, in those places where charcoal has been made. Hence the good women who collect them to sell, receiving a hint how to encourage their growth, have been accustomed to make fires in certain places of the woods, with heath, broom, and other materials, in order to obtain a more plentiful crop. This strange method of cultivating morels being, however, sometimes attended with dreadful consequences, large woods having been set on fire and destroyed by it, the magistrate thought fit to interpose his authority, and the practice is now interdicted. We may add, that the beautiful little moss called the Dicranum purpureum makes its appearance in precisely similar situations.

We cannot take leave of this part of the subject, without stating to our readers the following observations, which were made by that eminent naturalist, the late George Montagu, Esq. on a Scaup duck, which came into his possession, and which died a few days after.—"The cause of death" (says he) "appeared to be in the lungs, and in the membrane that separates them from the other viscera; this last was much thickened, and all the cavity within was covered with *mucor*, or blue mould. It is a most curious circumstance to find this vegetable production growing within a living animal, and shews that where air is pervious, mould will be found to obtain, if it meets with sufficient moisture, and a place congenial to vegetation. Now the fact is, that the part on which this vegetable was growing was decayed, and had no longer within itself a living principle; the dead part therefore became the proper pabulum of the invisible seeds of the *mucor* transmitted by the air in respiration; and thus nature carries on all her works immutably, under every possible variation of circumstance. It would indeed be impossible for such to vegetate on a living body, being incompatible with vitality; and we may be assured that decay must take place before this minute vegetable can make a lodgement to aid in the great change of decomposition. Even with inanimate bodies, the appearance of mould or any species of Fungi is a sure presage of partial decay and decomposition." *Ornith. Dict.* sup. Duck Scaup.

But the most uncommon circumstance in the mode of growth of the fungi remains to be mentioned, and is their disposition to grow in circles. Many of the Agarics, for example, are solitary, while others are uniformly gregarious. Those of the last kind frequently rise up in a somewhat regular manner, and form circles more or less complete. These circles for a long time perplexed the naturalist, ever more anxious to employ singular and uncommon agents in accounting for the

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phenomena of nature, than to trace the various steps of the process by the slow but certain road of fact and observation. For an account of the various hypotheses which have been formed, in order to account for these circles, or fairy rings as they are called, see the article FAIRY RINGS. Before, however, dismissing the subject, we must remark, that the disposition to assume regular figures in the course of vegetation, does not seem peculiar to the fungi. Every person at all acquainted with the lichens, must have observed similar appearances of a circular growth in many of the crustaceous species. And no one who has ever traversed the sandy downs of a sea-shore, can have failed to remark the lineal growth of the Carex arenaria, running under the sand and protruding its stalk in a straight line, as if planted by a skilful gardener. How careful, therefore, should we be to prefer observation to conjecture, and fact to hypothesis.

The season of the year in which the fungi appear most numerous is towards the end of autumn and beginning of winter. They observe particular seasons of the year in which to rise with as much regularity as the more perfect plants, and hence some of the species naturally allied may with tolerable certainty be discriminated. The Agaricus Georgii, which is found in Essex in considerable quantities, and collected for the London market, is known by the name of St George's mushroom, because they usually spring up in greatest quantities about St George's day.

The fungi exhibit some of the finest colours of the vegetable kingdom. In the coloured drawings of the more perfect plants, the artist is sometimes too profuse in tints, and the figures exhibit a gaudy aspect; but in the colouring of figures of the fungi, he need be under little apprehension of committing excess. Nature having withheld from this portion of her plants those flowers which form the chief beauties of the higher orders, and even the leaves with which they are clothed, has profusely scattered her colours over the whole surface of the mushrooms, ornamenting the cap with one colour, the gills with a second, and the stem with a third. Let but the lover of natural beauty free his mind from prejudice, and then examine the forms and colouring of the fungi, and he will be compelled to admit, that many of them rival in symmetry and splendour, the rose and the lily, those gaudy ornaments of Flora.

In general the fungi emit scarcely any smell, and appear entirely destitute of any volatile particles; or they possess a cadaverous smell, which renders them exceedingly offensive. A few, however, emit effluvia by no means disagreeable, nay, in some instances remarkably pleasant. Thus the Agaricus pratensis diffuses an agreeable odour like almond kernels. The Agaricus fragrans powerfully sends forth the pleasant smell of new mown hay, similar to the Anthoxanthum odoratum. While these odours please the sense of smell, others are by no means so agreeable, as Agaricus murinus, which smells like mice; and in this respect resembles the Cynoglossum vulgare. It is impossible for us to determine what important purpose in the economy of the fungi the scent which they emit serves; but in some cases it is most destructive to the animal creation. Thus in the case of the Phallus impudicus, the fœtid cadaverous odour which it emits allures multitudes of flies to light upon its cap, where they are entangled by the slimy matter with which that organ is so plentifully supplied. In this case, it is probable that the plant obtains some nourishment from the decay of the flies to enable it to perfect its seeds. Similar arrangements in the economy of nature have been observed to prevail in the higher orders of vegetables, as in the Drosera rotundifolia, or common sundew, frequent on our turf bogs. The Laplanders burn some of the Boleti about their habitations: and the smoke, as they think, drives away a species of gadfly which is fatal to the young rein-deer.

In respect to taste, the mushrooms present as remarkable variations as they do in regard to smell. Many of them are vapid and tasteless. Others, though by no means unpleasant in the mouth, leave a disagreeable roughness in the throat. Thus the Agaricus aromaticus yields to the tongue the agreeable coolness of peppermint; but leaves on the throat a roughness which remains for a considerable time. This is remarkably the case with almost all the lactescent agarics.

Scarcely any two agarics agree in regard to substance. Some are replete with a watery fluid, while others are dry and coriaceous. Some decay and wither into a substance like leather; whereas others either deliquesce into a black atramentous liquor, or are changed into a powder easily dispersed.

The investigations of the chemist have scarcely been extended to this tribe of vegetables, although ample encouragement be given, by their external properties, to expect some new substances. When exposed to the destructive distillation, they yield the ordinary products of vegetables, together with a quantity of ammonia, indicating the existence of some ingredients nearly related to the animal kingdom. They leave but a scanty residuum of charcoal; and the earthy and saline contents of the ashes have never been examined with care. Dr Scott of Dublin was the first who detected oxalic acid in nearly a pure form, in a young plant of Boletus sulphureus, which he found about the middle of August, on the trunks of an old decaying cherry tree. Having preserved a specimen, he, after some time found a singular crystallization on the upper surface, and which he observed to have ruptured the investing coats of that surface. These needle-like crystals were formed on the fungus, in consequence of its drying only, as none were observable while it remained on the tree. That they were pure oxalic acid, or at least combined with a very small portion of vegetable fixed alkali, was evident from the taste, and by the tests of solutions of lime and barytes. This fungus, after being freed from the saline matter, was distilled in an earthen retort, during which a quantity of watery fluid came over, a thick tar-like extractive matter, carbonic acid gas, carbonated hydrogenous gas, and lastly hydrogenous gas. It was not observed whether azotic gas was among the first products; but it probably was, as the watery fluid which came over in distillation contained ammonia, which appeared by the odour, and the fumes that were exhibited on holding a paper moistened with diluted muriatic acid over a mixture of the former with quicklime. The coaly residuum, when burnt in the open air, afforded by lixiviation some vegetable fixed alkali. "That the oxalic acid" (says Dr Scott) "is produced or evolved in the course of vegetation, in many plants of the higher ranks, is well known; but that it should be found in any of the fungus tribe, (which have hitherto been supposed to produce only an ammoniacal salt, and on that account considered as a link between vegetables and animals,) is a curious and I believe an isolated fact. How far the production of oxalic acid in this fungus might depend on its place of growth, or soil as it may be termed, I cannot say, but it is worth while to repeat the observation on other fungi similarly situated." *Linn. Trans.* vol. viii. p. 262.

The odour of some of the fungi, particularly the Agaricus pratensis, would dispose us to expect to find prussic acid as a part of its composition; but the experiment has never been tried. We recommend it, however, to those who have leisure and favourable opportunities.

Few of the mushrooms have been subjected to a regular chemical analysis. Dr Lister, so far back as 1672, published in the Philosophical Transactions, an account of his experiments on the Agaricus piperatus. He found it to yield a milky juice with a taste hotter than pepper, not discoloured by exposure to the air, nor by the blade of a knife. This juice speedily coagulated when kept in a glass vessel, but did not lose its hot taste. Trommsdorf (*Ann. de Chim.* vol. xxii.) afterwards examined the same plant, and besides the acrid matter which Lister had observed, and which is well known, he found it to yield a considerable quantity of albumen. It also yielded by distillation a considerable quantity of carbonate of ammonia.

It is to Buillon la Grange that we are indebted for the most accurate set of experiments on three kinds of mushrooms, which may serve to give us a correct idea of the composition of the tribe.

The *Tuber cibarium,* which we have described above, well known in Britain by the name of *truffles,* was grated down small, and then washed with water upon a searce, till the liquid ceased to carry off any thing. A blackish fibrous matter remained upon the searce. The liquid let fall a brown coloured matter when left at rest. It produced no effect upon vegetable blues. The brown deposite does not resemble starch in its properties. Water produces but little effect upon truffles. Warm water, however, dissolves a portion, which possesses the characters of albumen.

When the plant was treated with nitric acid, a solution was accomplished; nitrous gas, carbonic acid, and azotic gas were disengaged; and the solution by distillation, yielded a liquor containing prussic acid. The residual liquid yielded bitter principle, an oily matter, and small crystals, which Buillon la Grange considered as a combination of oxalic acid and bitter principle. He suspected also the presence of malic acid.

Alcohol dissolves a small portion of a brownish bitter matter, which acquires the properties of resin by exposure to the atmosphere. When truffles are left in the state of a paste with water, they acquire the smell of cheese. When mixed with sugar and water, they undergo fermentation, carbonic acid is disengaged, and alcohol formed.

When distilled, truffles are found to yield an acid liquid, a black oil, carbonate of ammonia, carbonic acid, and carbonated hydrogen. The charcoal contains magnesia, phosphate of lime, iron and silica. See *Ann. de Chim.* vol. xlvi.

Boletus laricis. This plant in a dry state is used on the continent as a medicine, and sold under the name of Agaric. It is in pieces which are white, light and friable. The outer skin is leathery, and dark coloured. Its taste is at first sweetish, but leaves a bitter and acrid impression in the mouth. When steeped in water, it communicates a yellowish colour and a sweetish taste to the liquid. The infusion reddens vegetable blues; and holds in solution sulphate of potash, sulphate of lime, and muriate of potash.

When this substance is boiled in water, the liquid acquires a gelatinous form as it cools. Evaporated to dryness, and treated with lime, the odour of ammonia becomes perceptible. Alcohol boiled upon the boletus acquires a red colour, and when mixed with water lets fall a copious precipitate, which exhibits the properties of a resin. This resin has a yellow colour, is brittle, semitransparent, and has a sour and bitter taste. When treated with lime, and the solution afterwards decomposed with muriatic acid, a quantity of benzoic acid is obtained from it. From these experiments, it is evident that this substance contains resin, benzoic acid, different salts, some extractive, and some animal matter, to which the gelatinous form of the decoction must be ascribed.

Sulphuric acid dissolves and rapidly chars the boletus. Nitric acid acts with energy, nitrous gas is disengaged, and the boletus becomes brown. By continuing the action of the acid, crystals of oxalic acid are obtained; malic acid is likewise formed, together with some resin, and a substance which approaches the nature of wax in its properties. The fixed alkalies give it a red colour, render it gelatinous, and a great quantity of ammonia is disengaged. See *Ann. de Chim.* vol. li.

Boletus igniarius of British authors, is not uncommon in this country on the trunks of trees. When boiled in water, the liquid acquires a deep brown colour, and a slightly astringent taste. It holds in solution sulphate of lime and muriate of potash. When evaporated to dryness, it leaves a brown coloured extract, which attracts moisture from the atmosphere. This substance when incinerated left a white ash, containing a considerable portion of potash; and when dissolved in water, exhibited by re-agents the presence of lime and of muriatic and sulphuric acids. The residual portion of the boletus being calcined, was found to contain phosphates of lime and magnesia, and some iron.

Alcohol has scarcely any action on this boletus; but when assisted by heat, it dissolves a small portion of resin. Nitric acid dissolves it readily; malic and oxalic acids are formed, and probably also a portion of bitter principle, while carbonic acid and nitrous gas are disengaged. Alkaline leys dissolve it with difficulty, forming however a soapy liquid, and separating a small portion of ammonia. From these experiments we learn, that this boletus differs in many respects from the preceding. It contains much less resin, and a much smaller proportion of animal matter, and yields no traces of benzoic acid. See *Ann. de Chim.* vol. liv.

Little more was done by chemists towards bringing into notice the composition of mushrooms, until M. Braconnot directed his attention to this curious tribe of plants, and succeeded in making us acquainted with the properties of two new combinations; to the one he gave the name of *fungin,* and the other he called *boletic acid.* The one is represented by the solid matter of the plants, the other constitutes the chief ingredient of its juices.

Fungin may be obtained pure, by boiling it in a weak alkaline solution. In that state it is whitish, soft, insipid, possesses little elasticity, and readily yields to the teeth. It would appear, that fungin thus purified may be used as an article of food, from what mushroom soever it has been obtained. The poisonous qualities of mushrooms it would seem reside in the juices, not in the fungin. This substance when dried burns with considerable splendour, emitting an odour similar to that of burning bread, and leaving behind it a white ash. Dried fungin, when distilled in a retort, yields about half its weight of a liquid product, consisting partly of a brown oil, and partly of water, holding a good deal of ammonia in solution. It yields no acid, which distinguishes it very much from wood. The charcoal remaining in the retort, amounts to rather more than one-fourth of the dried fungin subjected to distillation. This charcoal exhibited traces of sulphureted hydrogen, and contained sand, phosphate of lime, and traces of carbonate of lime, and phosphate of alumina.

Fungin does not dissolve in alkaline solutions, in which respect it differs essentially from lignin, which is readily dissolved by a weak alkali; but if fungin be boiled in a very strong alkaline ley, it is partly dissolved, and a saponaceous product obtained. Ammonia dissolves a small portion of fungin, and lets it fall again in white flocks, when exposed to the air.

Weak sulphuric acid has no action on fungin; but when concentrated this acid chars it, and at the same time sulphurous acid and vinegar are formed. Muriatic acid dissolves it very slowly, and converts it into a gelatinous matter. It is thrown down in flocks, by the addition of potash to the acid. Chlorine passed over dry fungin suspended in water, converts it into a yellow matter, having at first an acrid taste, which it gradually loses by exposure to the air.

When digested in diluted nitric acid, azotic gas is disengaged. Heated with concentrated nitric acid, it swells and effervesces at first violently, but the action soon subsides. When the acid is driven off, there remains a liquor containing oxalate of lime, some prussic acid, and two fatty matters, the most abundant similar to tallow, the other to wax. By evaporating the liquid, a considerable quantity of oxalic acid in crystals was obtained. The mother water still contained oxalic acid, and a portion of the bitter principle from indigo.

When fungin is steeped in an infusion of nut galls, it imbibes a considerable portion of the tannin, and acquires a fawn colour. When left to putrefy spontaneously in water, it emitted first the odour of putrefying gluten, then that of putrid meat. Neither acid nor ammonia was found in the water; but it contained a portion of mucilage, which gave it viscosity, and the property of precipitating with acetate of lead. The fungin itself assumed the aspect of gluten, without however possessing its properties.

The other substance which we have to notice is the *boletic acid*, which M. Braconnot obtained from the juice of the Boletus pseudo-igniarius, by the following process. The juice was boiled, filtered, and evaporated cautiously to the consistence of a syrup. This syrup was repeatedly digested in alcohol, the insoluble portion was dissolved in water, and precipitated by nitrate of lead. The white precipitate thus obtained was mixed with water, and decomposed by sulphureted hydrogen gas. The water being now evaporated, yields numerous crystals, which constitute *boletic acid*, the properties of which are as follow:

When purified by solution in alcohol and crystallization, it is white, not altered by exposure to the air, and consists in irregular four-sided prisms. Its taste is similar to that of tartar. It requires 180 times its weight of water to dissolve it at the temperature of 68°. It is soluble in 45 times its weight of alcohol.

The aqueous solution reddens vegetable blues. Nitrate of lead occasions a precipitate in it, which is redissolved by agitation. It precipitates the red oxide of iron completely from its solutions in the form of rust coloured flocks; but it does not throw down the black oxide of this metal. It precipitates nitrate of silver in the state of a white powder, which is soluble in nitric acid. Nitrate of mercury is precipitated in the same state, but the solution dissolves with difficulty in nitric acid. Neither lime nor barytes water produce any effect upon the aqueous solution of this acid. When boletic acid is heated, it rises in white vapours, which irritate the throat, and condense on surrounding bodies in the form of a farinaceous powder. When distilled, the greatest part of it sublimes unaltered, excepting that it afterwards crystallizes more regularly. At the same time a little liquid appears, having a strong smell of acetic acid.

Boletate of ammonia, is a salt which crystallizes in flat four-sided prisms, and is soluble in 26 times its weight of water at the temperature of 68°. Its taste is cooling, saline, and somewhat sharp. When heated it melts, swells, and sublimes. It precipitates red oxide of iron; but does not alter sulphates of lime, alumina, or manganese. It slowly precipitates nitrate of copper in blue silky needles. *Boletate of potash* is very soluble in water, and crystallizes with difficulty. Acids precipitate the boletic acid from it. When boletic acid is heated with carbonate of lime, it dissolves it with effervescence. The *boletate of lime* crystallizes in flat four-sided prisms. This salt has little taste, and requires at least 110 times its weight of water, at the temperature of 72.5°, to dissolve it. It is decomposed by oxalic and sulphuric acids. *Boletate of barytes* is an acidulous salt in white plates, little soluble in water or nitric acid. When thrown on a red hot iron it burns rapidly, with a red flame and striking scintillations, leaving for residue carbonate of barytes. When boletic acid is heated with iron filings and water, hydrogen gas is emitted, and a yellow liquor is obtained with an inky taste. See *Ann. de Chim.* vol. lxxx.

From the preceding account of the composition of mushrooms, it must strike the most careless reader, that in their nature the fungi hold a middle rank between animals and vegetables, or, in other words, that they partake of the nature of both. It was necessary to be acquainted with this circumstance, before noticing an opinion concerning the animal nature of mushrooms, which has been sanctioned by the authority of very respectable names.

It is well known that the zoophytes, or the various kinds of corals, and corallines, and sponges, were, by the older botanists, considered as belonging to the vegetable kingdom. Scarcely had the conjectures of Peyssonell been rendered probable by Trembley, and demonstrated as true by that ornament of our country Ellis, and the animal nature of those bodies established, than botanists began to suspect, that they were swaying the sceptre over tribes which were aliens in their kingdom. The zoophytes were thus removed from them, and they anticipated a still farther reduction of their subjects, in consequence of the mixed nature of the fungi. A circumstance now took place in botanical opinion, which we have often witnessed happen to other creeds. Destroy the validity of one tenet, and you pave the way for suspicions as to the soundness of the remainder. One class of bodies formerly considered as plants, were now demonstrated to be of an animal nature; and, led away by false or imperfect analogies, other tribes of reputed vegetables were considered as having equally strong claims to advancement in the scale of being. In particular, the *fungi* were considered as having so near a resemblance to the zoophytes in many respects, that Butner, Weiss, Muller, and Scopoli, gave it as their opinion, that they possessed animality. This opinion has been generally rejected by botanists, as well as by zoologists. We pretend not to decide the important question; but we venture to assert, that the claims of the fungi (many of them at least) to rank as

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zoophytes, have never been substantially invalidated, and we deem it an act of justice to state these claims.

By the aid of chemistry, the composition of the fungi has in part been ascertained. The existence of albumen has been demonstrated, and in their ashes the phosphoric salts seem to prevail. When burnt, they emit the odour of burnt animal matter, and ammonia is disengaged. When they decay, they emit a fetid cadaverous scent, unlike the putrescent remains of any other tribe of vegetable. Hence it is that in the last stages of their existence they are fed upon by those insects, which at other times resort to putrid carcases. These are points of resemblance which we consider as very remarkable. They lead us not to any positive general conclusion, although well calculated to raise curiosity, and excite suspicion. But we have even more to say upon this subject. In form and appearance, the resemblance between some of the zoophytes and the fungi is complete. Compare, for example, the figure of the "Mucor botrytes" of Sowerby, tab. 359, with the "Corallina omnium minima, vesiculis nunc ramorum, nunc racematum, dense dispositis" of Ellis: *Coral.* tab. 13. no. 22. B. So closely do they agree in form, that one drawing may serve for both. Who is there acquainted with both classes of beings, that does not perceive a resemblance between the Pezizæ and the cup-shaped sponges, and the Boleti and Milleporæ? But to conclude; upon what claim is the genus Corallina admitted to rank as a zoophyte? Its calcareous substance causes it to approach the millepores, and upon this ground it ranks with the zoophytes. Why is a sponge placed in the animal kingdom? It contains albumen, so do the fungi; when burnt it exhales an ammoniacal odour, so do the fungi. In short, the points of resemblance are so numerous, that the opinion of the animal nature of mushrooms, though not proven, is still plausible. Nature employs the zoophytes as the connecting link on the one side, and the fungi on the other, for the purpose of forming a union between the two kingdoms; but it is impossible for us to ascertain with accuracy, the precise point where animal life ends, and where vegetable life begins. There is probably no such point, both kingdoms being merely parts of one great whole.

Uses of the fungi.

It now remains that we consider the uses to which the plants of this tribe have been applied, and the important purposes which they serve in the economy of nature.

The Boletus igniarius of Withering has been highly recommended as a styptic, and various trials of its efficacy have been made, both in Britain and on the continent. It is beaten out into soft square pieces, and is well known to surgeons by the name of *Agaric*, or Agaric of the oak. It has been much celebrated for stopping the bleeding of arteries in amputations and wounds. But It has by no means proved so successful as Brossard and some of its admirers anticipated.

An excellent touch-wood is made from the same fungus, in Germany. The upper rind is first pared off; it is then boiled in a solution of saltpetre, and afterwards dried and pounded with a hammer; it is then boiled a second time in the same solution, and, after being dried, it is fit for use.

But the same Boletus is employed in a still more extraordinary way in Franconia. In that circle of Germany, as we are informed by Gleditsch, the inhabitants beat this fungus into square pieces, which resemble the softest leather, and sew them together in a curious manner into garments.

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The Agaricus muscarius has been applied to as many useful purposes nearly as the touchwood Boletus. In Kamtschatka, the inhabitants prepare a liquor from an infusion of this agaric, and the runners of the *Epilobium angustifolium*, which, taken in a small quantity, exhilarates the spirits, but in a larger doze brings on trembling of the nerves, intoxication, delirium and melancholy. When mixed with milk, it kills flies, according to Linnæus; and the same author also tells us, that the expressed juice rubbed on walls and bedsteads, effectually expels bugs. The same plant administered in dozes of from ten to thirty grains in vinegar, is prescribed by Swediaur in cases of epilepsy and palsy, subsequent to the drying up of eruptions. It is also recommended to be sprinkled in powder on bad ulcers and gangrenes.

There is a species of Boletus termed by Linnæus *suaveolens*, which, as that author informs us, the Lapland beaux carry in their pouches by way of perfume, and to render their persons agreeable to their mistresses. It is strange that among so simple a people, such a recommendation should be found necessary, and it is equally surprising that a mushroom in a lover's pouch should secure success.

Mr Sowerby, in his Preface to the *British Fungi*, after stating the uses to which this tribe of plants has been applied, has the following observations: "The Lycoperdons afford, in their ripe state, different browns, very copiously, in a fine impalpable powder, fit for immediate drawing, when mixed with a little gum arabic water. I intend, when I figure some of the Lycoperdons, to use their own powder to represent itself." This pledge he has redeemed in the case of the Leucogala argentia, tab. 272. the lowermost figure of that plate being coloured with the powder of the plant itself.

The fumes of the Lycoperdon proteus, when burnt, have a narcotic quality, and hence they are sometimes employed to produce stupor in bees, in order to obtain the honey without destroying the hive.

These are a few of the uses to which this tribe of plants has been applied. Some of them may excite a sneer, while others will provoke a smile. The time may come when the fungi shall hold a more conspicuous place among the useful vegetables than they now occupy. Not above half a dozen of species have as yet been chemically examined. Yet these analyses have brought to light several important facts, and even furnished us with two new vegetable principles. The history of the one may throw some light upon their respective merits as articles of human food, while the other appears to furnish the chemist with a new instrument of analysis.

Mushrooms have long been employed as articles of human food, and as the basis of several sauces. In this country, a very few species only are made use of, but on the continent very many kinds are employed. By the Russians in particular, few are rejected. Even the most acrid and suspicious of the whole tribe, as the Agaricus piperatus, is eaten in great quantity. Nay, so fond are they of this mushroom, which in this country is deemed poisonous, that they fill large vessels with it in the autumn season, or pickle it with salt, and reserve it for winter food. The kinds which are held in the highest estimation are, however, few in number. The truffle seems to hold a most conspicuous place in the estimation of the epicure. It is found from two inches to two feet under the surface. It is chiefly found in a light sandy soil, although it also inhabits rich loam, open pasture ground, and woods of oak and chesnut. Its scent is so penetrating, that dogs and swine smell it at a distance. The former of these animals are taught to hunt it out, and when they come to the place, they bark a little, and begin to scratch up the earth with their feet. Sometimes the herds attentively watch the swine when rutting up the ground, and deprive them of their hard-earned morsel by appropriating it to themselves. Truffles are found in various parts of England and Scotland. They are regularly sold in Covent Garden market, and are principally employed to thicken soups and sauces, and to give them a fine flavour. Morels are used for the same purpose, and are reckoned but little inferior.

But the most common mushroom in use at our tables, is the *Agaricus campestris*. In this species the cap is white, changing to a brown when old, and becoming scurfy; regularly convex, with the margin inflected, becoming flat with age. Flesh white, firm, and solid. The stem is short, white, and solid, nearly cylindrical, about a finger thick, and surrounded with a membranaceous ring, the remains of the curtain which at first covers the gills. The gills are loose, pinky red, changing with age into a liver colour, in contact with but not united to the stem; very thick set, irregular in disposition, some forked near the stem, some next the edge of the pileus, some at both ends, and generally in that case excluding the intermediate smaller gills. They differ very much in size, the head varying from two to nine inches in diameter. It is principally found in rich dry old pastures, where the turf has not been ploughed up for many years. In such situations it may be found in abundance during the months of August and September, of a much finer flavour, and firmer in the flesh than those which are raised by gardeners. Several other agarics are also in use, as the *Oreades*, which is rather tough, but of a fine flavour; the *Mouceron*, which is held in very high estimation in France; the *Deliciosus*, which the ancient Romans esteemed as one of the greatest luxuries of the table, and which is still brought to the markets of Italy for sale: it occurs also in this country, but is here seldom employed.

These mushrooms are either eaten while fresh, stewed or boiled, or preserved when pickled or pulverised. For these purposes, both the skin, the gills, and the stem are taken away, and the fleshy part which remains, termed the button, is employed. When sprinkled with salt, and allowed to remain for some time, a considerable quantity of juice is obtained, which, when boiled up with various kinds of spiceries, forms the well known sauce called *ketchup*. This sauce is often very successfully counterfeited with bullock's liver, which is said to produce a liquor equally savoury and agreeable, at least in stews.

Stone which produces mushrooms.

Since these vegetable bodies are in such request, we need not be surprised to find, in books of gardening, various directions concerning the culture of mushrooms. The most simple and easy method of raising these curious productions is mentioned in the *Trans. Swedish Acad.* 1797, where we are informed that there is a stone used in Italy for producing mushrooms, by keeping it moistened with water in a cellar. There appear to be two kinds of it; one found in the chalk hills near Naples, resembling a white stalactite, intermixed with fine roots of shrubs; the other is a hardened turf from some volcanic mountains near Florence. This loses by calcination about 15 per cent. and the residuum gives .46 silica, .23 alumina, .07 lime, .20 oxide of iron, with some traces of magnesia and potash. To render these stones more productive, and prevent their quality of producing mushrooms from being exhausted, it is necessary, we are told, to water them with water in which mushrooms have been washed! thus furnishing them, no doubt, with a store of the minute seeds of the plant.

Method of forming mushroom beds.

Gardeners contrive other methods of propagating mushrooms, so as to produce them at all seasons of the year. These plants do not require light during their vegetation, so that they may be raised on beds made on purpose, within doors, under sheds, in lofts, stables, or cellars. These beds should be made of the best warm stable dung, which ought to be first mixed up in a heap, that the whole may ferment together equally; and after the first great heat is over, it may then be employed in the formation of the bed. But before proceeding to this part of the process, it is necessary to obtain a sufficient quantity of good *mushroom spawn*, as it is called. The *natural spawn*, as it is termed, and which consists of white fibrous radicles, is frequently found in the dung of old cucumber or melon beds; it is also often to be met with in old heaps of horse dung, which have lain for two or three months. It is frequently to be found in pasture grounds, in stable yards, and in mill tracks. In all these situations it is in lumps of dry rotten dung or mould, of a white fibrous substance, and possessing the smell of a mushroom. Such spawn is sold by the market gardeners, and may be conveyed with safety to any distance. Having obtained a supply of spawn, the next part of the process is to prepare the bed. Choose a dry lying place, and having levelled the surface, make the fermented dung into a bed from 3 to 4 feet in height, and let the whole be finished in the form of the ridge of a house. The dung in this case must not be too closely pressed, and it must remain for a fortnight or three weeks before the spawn is put in, or until the heat is become quite moderate. If the spawn is put in when the bed is in its warmest state of fermentation, it would be entirely destroyed. When the bed has been brought into a proper state, let the spawn be divided into small lumps, and plant it in rows lengthwise of the bed, observing to begin the first row within about five or six inches of the bottom. Plant the spawn immediately under the surface of the dung in lines six inches distant, and leave the same space between the pieces in the rows. When this is done, let the surface of the bed be made smooth, and then let every part of the bed, from the bottom upward, be covered with some rich dry earth, about an inch and a half thick, making the surface smooth with the spade. When this is done, let the whole be covered with clean dry straw, a foot thick at least, to keep out the wet and cold. Such a bed, with proper care, will begin to produce mushrooms in five or six weeks, and will continue bearing for several months.

This mode of culture supposes that you have procured roots of the plants which you wish to cultivate; but, according to other methods, the use of this spawn is superseded, the seeds of the mushroom seeming to be everywhere, and merely requiring favourable circumstances to ensure their germination. According to this last method, a floor is laid of ashes or bricks, so as to keep the bed quite dry, and free from under damp. Upon this place a layer of horse droppings, six inches thick. These should be new from the stable, and must not be broken, and the drier they are so much the better. They may be collected every day, until the whole

Fungi. Method of forming mushroom beds.

floor be covered to the above thickness; but they must not be allowed to ferment or heat. During the formation of the bed, the materials should be as much exposed to the air as possible; and if out of doors it should be defended from rain. When this first course is quite dry, and judged to be past a state of fermentation, cover it to the thickness of two inches with light dry earth, if sandy so much the better. The use of the earth here is for the spawn to run in. After this lay another course of droppings, and earth them over as above, when past a state of fermentation; then a third course, which in like manner earth over. This finishes the bed, which will be a very strong and productive one if properly managed afterwards. But the tyro in gardening will naturally enquire from whence the plants are to spring in this bed. Where is the seed? The seeds are contained in the droppings of horses, which have been employed. These produce mushrooms more plentifully, and with greater certainty, than the dung of other animals. The digestive organs of horses seem to have less power to hurt the vegetative quality of these seeds, which must be collected along with their food, than the stomachs of other animals. Or it may be that the dung of horses is a better nidus for the seeds than other dungs, and that these seeds are very widely diffused. The droppings of hard fed horses only are useful. Those of horses fed with green food will of themselves produce few or no mushrooms. Hence the dung of carriage or saddle horses, fed entirely on corn and hay, is generally the most productive.

Whether the bed be in the open air or in a house, it must not be watered until the spawn begins to *run*. This may be known by thrusting in the hand into the bed a few inches deep, and examining the state of that which is brought up. It ought to smell exactly like mushrooms, and have the appearance of small bits of thread. But generally you will be forewarned of the spawn running, by a previous crop of spurious fungi, which rise more or less abundantly according to the fineness or grossness of the materials of which the bed is composed. These fungi have all a nauseous sickly smell; and although some of them belong to the genus Agaricus, they do not possess those salmon-coloured gills which characterise the cultivated species. When it is thus ascertained that the spawn is fully formed, give the bed two or three hearty waterings, in order to set it a growing, for otherwise it will lie dormant, and show no symptoms of vegetation. But beware not to damp the bed too much, as thereby the growth of the spawn would be greatly retarded. If a few old mushrooms be previously steeped and broken in the water, you sow innumerable seed at the time of watering, and thus ensure future crops.

When the bed is in full perfection, it should be examined two or three times a week to gather the produce, turning off the straw covering very carefully. Two methods are recommended by gardeners to be observed in collecting the mushrooms. According to the first, they are to be detached clean to the bottom by a gentle twist, as if the stump is left, it is apt to become maggoty, and infect the rest of the bed. According to the opinion of other gardeners, they ought never to be pulled, but always cut; as by pulling, many young ones might be destroyed, there being always a number of these forming or clustering about the roots of the old ones, which should not be disturbed. If the spawn be deeply situated in the beds, mushrooms will often form and come to maturity entirely under the ground. They may be easily recognised, however, as they are generally large, and push up small hills above their heads.

On the use of mushrooms as aliment.

Mushrooms, although eagerly sought after by many, are by no means a nourishing article of food. Their fibres are tough, and very difficult to digest, swelling in the stomach like a sponge; and there are instances on record of their remaining three days in that organ in an undigested state. So indigestible are some of the Boleti, for example, that they have been found as bezoars in the intestines of some of the inferior animals. Thus the Boletus igniarius has occurred disposed in layers, and cemented by an animal matter. (*Ann de Mus. d'Hist. Nat.* iv. 335.) But it would be fortunate if no objections could be urged against their being used in diet, but those which arise from their coriaceous indigestible nature, and their want of nourishing particles. All of them are a doubtful and suspicious food, and the most innocent of them have often proved prejudicial, nay *poisonous*.

It would be desirable if we could draw the line of distinction between the harmless and the noxious. But neither the eye of the botanist, nor the laboratory of the chemist, can render us assistance. No reliance can be placed on either taste, smell, or colour. The qualities of the same species are different when the plant grows in wet ground, from what they are when it obtains a dry situation. The same species is sometimes innocent when young, but noxious when old. From these considerations it has even been recommended, and with much propriety, to erase their names from the list of aliments. Not a year passes in which instances do not occur of the deleterious effects of mushrooms. The newspapers abound with such, and yet these warnings are not sufficient to deter the inexperienced from using them. The reason is obvious; they hear that some kinds are in common use at the tables of the great; and trusting to colour and shape, they too often gather the hurtful in place of the harmless.

The effects produced upon the constitution by the use of the noxious kinds, are of the most alarming nature. In cows and other cattle, they have been known to create bloody urine, nauseous milk, swellings of the abdomen, inflammations in the bowels, stoppages, diarrhœas, and death. In sheep, they bring on a scirrhous liver, a cough, a general wasting, and dropsy. In men, nearly the same symptoms have appeared, with vomitings, fainting, trembling, and death. In such cases, when persons have unhappily eaten deleterious kinds, vomiting ought to be excited as speedily as possible, and gentle laxatives administered; and after the first evacuation, a drachm of sulphuric ether, in a glass of water of marshmallows, may be given.

Some few attempts have been made for the purpose of ascertaining whether the poisonous matter resides in the substance or in the juice of the mushroom. M. Parmentier, in order to determine the matter, took some mushrooms of the deleterious kind, and distilled them with water in an alembic. The water which came over into the receiver was administered to a dog, without producing on the animal any visible effects. Having emptied the contents of the alembic in a vessel, and mixed with some food to disguise them, he administered these to a dog; but the residue differed widely in quality from the condensed vapour, for the poor animal expired in a few hours after. The same author informs us, that having administered some poisonous mushrooms along with some food to a dog, he observed the following symptoms: The dog first began to shew symptoms of uneasiness and stupidity, afterwards it

Fungi. vomited up the food and mushrooms which it had swallowed. After a short interval, it again began to vomit, and emitted a thick viscous matter. This continued until the death of the animal, which happened soon after. Upon opening up the stomach and intestines of the dog, no appearances of corrosion presented themselves, the inflammatory symptoms were merely those which might have arisen from violent vomiting.

Parasitical fungi noxious to plants. The fungi often appear as the formidable enemies of man, in his fields, his gardens, and his houses. The diseases called the *blight* and the *smut* are, as already noticed, both caused by parasitical fungi, whose history deserves to be attentively studied by every farmer. These little plants destroy the leaves, the stem, and the ear, and produce the most dismal havoc in the fields. No remedy has been discovered to impede or remove the disorder after it has once made its appearance. The pickling of the seed before sowing it, with salt, quicklime, or urine, and the frequent change of seed from different places, are the only known, though not always efficacious, preventives.

The parasitical fungi sometimes attack fruit trees. One species is figured by Mr Sowerby, tab. 379, as infesting the apple-tree leaves, covering them with a very fine white powder, with dark brown particles, scarcely visible to the naked eye. The form of these particles is somewhat ovate, but irregular. Mr Knight observes, that on shaking a leaf over a plate of glass, he detected little oval bodies, which shrivelled a little in drying. Some of these were transferred to other trees, and the disorder along with each, every one producing its own species.

The dry rot is another of those evils which have been supposed to be occasioned by a parasitical fungus of the genus Boletus. It is not our intention in this place to endeavour to ascertain the point, whether the fungus is the cause or the consequence of the disease, although we are rather inclined to suspect that decomposition has commenced before the fungus begins to grow. That the fungus may aid the process of destruction, we can easily suppose; but we also believe that wood in a fresh sound state would offer but a bad soil for the germination of such parasites.

Uses of fungi in the economy of nature. The fungi serve several important purposes in the economy of nature. They accelerate the process of dissolution, by converting the woody fibre of dead trees and branches into a softer and more deliquescent substance. They supply with a grateful food many insects which feed upon them, and even hatch their young in them. And lastly, they furnish, by their uncommon forms, an agreeable variety to the eye of the botanist, when contemplating the scenery of the vegetable kingdom, and lead him to adore that Being who is exhibited in all his works as powerful, kind, and wise.

In Plate LXXV. the reader will find figures of the four following species:

Agaricus campestris, or common mushroom.
Phallus esculentus, or morel.
Tuber cibarium, or truffle.

APPENDIX.

HYPOXYLA.

This order of the class Cryptogamia was first employed by Lamarck and Decandolle, in their arrangement of the native plants of France. It seems to connect the *Fungi* with the *Lichenes*, and consists of plants which have many of the characters of both these orders. The Hypoxyla are either of a coriaceous or corneous texture, or resemble cork in consistence. The receptacles, which are almost always of a black colour, sometimes comprehend the whole plant; in other instances they are inserted upon a stem, which is straight, solid, filamentous, or pulverulent. Whatever be their position, these receptacles are rounded or oblong, open at the summit by having a pore or slit, and filled with a mucilaginous pulp, which is more or less evident in some shape, until the period of maturity. This pulp encloses the seeds. Some species present here and there parcels of white fugaceous powder, which many naturalists consider as the male organs of the plant.

The plants of this order are chiefly found on the trunks of trees; some of them grow upon decaying leaves; and a small number have been observed on rocks, and on the ground. Unlike the more perfect plants, many species of this order give out no oxygen when exposed to the rays of the sun under water. In such circumstances, however, there are a few which yield hydrogen gas.

This order is naturally divided into two tribes, according as the mucilaginous pulp issues from the receptacle in an obvious or insensible manner. The first of these approaches the fungi in appearance and consistence; the second intimates its relation to the lichens, by the pulverulent base which surrounds the receptacle. It is not our intention, in presenting our readers with an account of this order, to describe all the species which it embraces, but merely to enumerate the characters of the genera. Under each genus there will be found the description of one species at least, for the purpose of illustrating the characters upon which it is founded.

TRIBE I. *In this tribe the seed-bearing pulp obviously issues from the receptacle when the plant has arrived at maturity.*

Genus I. Rhizomorpha. This genus, which was instituted by Rothes, consists of plants having a receptacle nearly globular and persistent, opening at the summit by an indistinct orifice, attached in the form of tubercles, to a stem which is simple or branched, and spongy within.

Rhizomorpha fragilis. Clavaria phosphorea of Sowerby's British Fungi, tab. 100. The bark of this species is black, brittle, glabrous, and shining; the inside is white and spongy. The stem is cylindrical, when it grows exposed to the air; but compressed when it creeps in the crevices of wood. It pushes forth a number of branches, which frequently anastamose. The fructification, which is but rarely seen, consists of tubercles scattered or in groups, spherical, black, a little shagreened, ending in an orifice which can scarcely be perceived. These tubercles are filled with a black pulp containing the seeds. This plant grows in subterraneous places, in the hollows of trees, in the chinks of wood, and between the wood and the bark. In some instances it has been observed to emit a phosphoric light, when fresh, at the ends of the shoots.

Genus II. Sphæria. This genus consists of plants which present one or more osseous rounded receptacles, opening at the top by an orifice usually of a lengthened shape, solitary, clustered, or inserted upon a corklike stalk, filled with a mucilaginous substance, containing the seeds, and which issues by the orifice of the receptacle. Almost all the species of this genus are of a black colour, and of a compact consistence; a few are red and fleshy. Several species, previous to the opening of the cells, exhibit a white fugacious powder, which has been accurately observed by Hoffman, Todé, and Bulliard, and which many naturalists consider as the male organs of the plant. Almost all the species of this genus, especially those which have no stems, grow under the epidermis of living trees, or decaying leaves, which they pierce at the time of the dispersion of the seeds. The genus is divided into the following sections.

Sect. 1. *Capsules supported on a lengthened fleshy or cork-like base.* (*Hypoxylon* of Jussieu.) Sphæria digitata, Sower. tab. 69. This plant commences its growth very early in the spring, and continues through the summer, ripening its capsules in autumn annually. Though at first somewhat pointed, and covered with a whitish dust or farina, as it advances it assumes a more conical form, and the farina is more on the top. It finally becomes blunter, and the head is covered with spherules copiously discharging a black soot-like powder. The inner substance is very white and solid, the fibres diverging from the centre upwards, and in breaking form a diverging cone. This plant, when exposed to the action of the sun under water, gives out air which contains seventy per cent. of hydrogen gas.

Sect. II. *Capsules placed upon an exposed base more or less apparent. Sphæria concentrica*, Sower. tab. 160. The general shape of this curious parasite is hemispherical, though often very uneven. It forms whitish farinaceous threads, and black spherules in alternate order around the whole surface, which having fructified, remain in striæ, concentrating from the root or base. The white threads destitute of farina becoming greyer, and the appearance of capsules in the black striæ being totally lost, give it the exact resemblance of the grain of the wood in some charcoal. This plant is found on ash, hornbeam, willow, and other trees, and often grows to three inches diameter, in some situations continuing to grow many months.

Sect. 3. *Capsules not united by a common receptacle, but joined the one to the other in bundles or clusters. Sphæria coronata*, Hoffm. *Crypt.* i. p. 26. tab. 5. f. 2. This species presents five or six cells disposed in a circular ring, black, somewhat globular, of the size of a pin head; their openings are lengthened, cylindrical, and inclined in such a manner as to unite at the summit. These cells are placed in the bark; their orifices pierce the epidermis, and appear a little on the outside. This species grows upon the birch.

Sect. 4. *Capsules distinct, approaching, or solitary. Sphæria gnomon*, Sower. tab. 373. fig. 6. This species is found at the beginning of spring upon the leaves of the hazel tree, forming, in general, rounded or annular patches. The capsules are distinct from one another. On the upper part of the leaf, a black somewhat convex tubercle may be perceived, beneath are found lengthened blackened knobs; a concave orifice may be observed at their summit, furnished with a bristle resembling a style.

Genus III. Næmaspora. The plants of this genus differ from those of the preceding, in consequence of the fertile pulp containing the capsule issuing from the orifice of a semi-compact consistence, and lengthening out into a capillary appendage, soluble in water.

Næmaspora carpina, Sower. tab. 376. This is not uncommon on the hornbean; the spherules are lodged under the bark, and are compressed, irregular, and waxy, and throwing out black twisted tendrils; afterwards they become brittle, and like charcoal.

Genus IV. Xyloma. The capsules are hard, of various forms, filled with fleshy jelly; they remain firm, and burst in different places to allow the escape of the jelly. The plants of this genus grow upon dead or living leaves, where they form black and frequently bright spots. They prefer the upper surface of the leaves, while the greater number of the parasitical fungi which grow upon living leaves, prefer the under surface.

Xyloma punctatum. Every one is acquainted with the appearance of this plant. It grows upon the upper surface of the common sycamore, in the form of black patches, approaching to a circular form. It consists at first of rounded distinct wrinkled flat points.

Genus V. Hypoderma. The plants of this genus have an oblong receptacle opening by a longitudinal slit, and emitting a substance, which is nearly pulverulent, containing the seeds. They differ from the plants of the last genus in aspect, and by the oblong slit of the receptacle.

Hypoderma quercinum, Sower. tab. 373. 3. This plant is frequent on the dried branches of the oak in lengthened spots, waved, and for the most part transverse. When the seeds are about to be dispersed, the epidermis of the bark opens, and the capsule splits in the same direction, affording a passage to the seeds, and vanishing itself soon after: the seeds are black.

TRIBE II. *In this tribe, the seed bearing pulp remains in the receptacle, or escapes in a gradual and insensible manner.* The former tribe connects the hypoxyla with the fungi, and this tribe establishes their relation to the lichens.

Genus VI. Hysterium. The receptacle is oblong, and opens by a longitudinal slit. It encloses the seeds, which are enveloped in a gelatinous liquor, thus forming a capsule constituting the whole plant. The hysteria live on fallen trunks, and not under the epidermis.

Hysterium pulicare. Lichen marmoreus of English Bot. 739. This plant presents convex tubercles, which are black, compact, oblong or rounded, opening at the top by a longitudinal slit. It grows in groups on the bark of the oak, and various other trees.

Genus VII. Opegrapha. The receptacles of this genus are linear, sessile, simple or branched, marked above by a longitudinal slit containing the seeds. These are situated in an interrupted crust. This genus, named and characterised by Humboldt and Persoon, consists of numerous species, confounded under the names Lichen rugosus and scriptus of Linnæus. Some of the species grow upon trees, others upon stones. In all of them the receptacles are black.

Opegrapha denigrata, E. Bot. 1753. The crust is white, and sometimes so thin that one would be disposed to consider it a simple alteration of the colour of the epidermis of the bark. The receptacles are black, often shining, waved, simple or branched, prominent, marked by a distinct groove, clustered in rounded spots. Common on the oak and various other trees.

Genus VIII. Verrucaria. The plants of this genus have a thin crust, bearing the receptacles sometimes buried in it, sometimes prominent, somewhat globular, closed at first, afterwards pierced by a pore at the summit. They differ from the former genus in the receptacles opening by a rounded pore, and not by

Hypoxyla.

a longitudinal groove: These, in all the species of the genus, are of a black colour. Some grow on wood, or the bark of trees, while others prefer rocks or walls. They are arranged with the lichens by different authors.

Verrucaria sanguinularia, E. Bot. 155. The crust is ash-coloured, with a tinge of green, granular, wrinkled, thin, and irregular. The receptacles are scattered, hemispherical, black on the outisde, bright red within. When magnified, a small pore may be observed at the summit of the receptacles.

Genus IX. Pertusaria. The plants of this genus have an indistinct crust supporting their receptacles, which are pierced by many pores, corresponding to as many internal capsules; the pores sometimes unite, and form an irregular cup during the old age of the plant. They differ from the preceding genus in aspect, in the number of capsules, and in the receptacles being of the same colour with the crust.

Pertusaria communis. Lichen pertusus of En. Bot. 677. The crust is smooth, of a greenish ash colour when moist, cinereous when dry, and covered with numerous, crowded, smooth, angular warts, of the same colour as the crust. Upon the head of each wart are small black impressed punctures, from one to ten in number, as if made with the point of a pin, under each of which punctures, if the wart be cut transversely, will be found a hollow, spherical cell. In the old specimens, the punctures open of themselves, and discover the cell. It is found on the trunks of trees, and also upon rocks.

Fungus ‖ Furnace.

FUNGUS. See Surgery.

FUR. See Darfur.

FUR Trade. See Peltry.

FURNACE is the name given to an apparatus, which consists of a certain cavity containing combustible matter, with various means of supplying it with air to effect its combustion.

Furnaces may be divided into two general classes, viz. wind or air furnaces, and blast furnaces. In the first of these, the air is induced to pass through the fire by the draught of a funnel or chimney communicating with it. In the second, the air is supplied by the action of bellows, or other pneumatic apparatus. The term *furnace*, however, is more particularly applied to such as are used in the manufactures for the fusion and calcination of substances, and in the laboratory of the chemist.

The most simple and effective air furnace, would consist of a plain prismatic or cylindric column, the interior cavity of which is defended from the exterior air by some infusible substance, the least capable of conducting heat. That portion of the cavity which is occupied by the fuel, may be called the body of the furnace. This is separated from the lower portion, called the ash-pit, by a grate for the admission of air. The upper portion above the body is called the chimney. When the fire is kindled, all the air above the grate becomes specifically lighter than the outer air. This induces a current of air through the furnace, the velocity of which will be as the difference of temperature between the inner and outer air, and as the square root of height, reckoning from the grate to the summit of the column.

In a furnace so constructed, the air would meet with the least resistance from not being required to change its direction after it enters the grate, and its practical effect would come the nearest to the law above laid down. But for the sake of convenience, the body of the furnace is detached from the chimney, by a connecting cavity called the throat of the furnace. This will interrupt the free passage of the air, in proportion to the deviation of its direction from the perpendicular line, and inversely as the area of its section. The intensity of the heat of every furnace, will therefore be as the quantity of oxygen consumed in a given time, and inversely as the space in which the combustion is produced. This will therefore be as the velocity of the current and the density of the air, all other things being equal.

Furnace.

Let D = the density of the outer air,
d = the density of the air in the chimney,
h = the height of the chimney,
g = the velocity produced by gravity in a second of time,
i = the velocity of the ascending current;

then the velocity which the height h would give will be $= \sqrt{2hg}$, and the velocity of the current, or

$$i = \sqrt{2hg} \times \frac{D-d}{D}.$$

The practical effect, however, will fall short of this formula, from the interference of several causes, the principal of which is the interruption of the current, partly by the change of the direction of its motion, and partly by the roughness of the sides of the chimney.

The first of these may be in some measure obviated, by making the throat sufficiently wide, and as little out of the perpendicular as circumstances will admit. The friction upon the sides may be decreased considerably, by rubbing those sides of the bricks which have to form the interior surface, in order to make it as even as possible. It will also be advantageous that the walls of the chimney should conduct away the least possible quantity of heat. This will be effected, by first building an inner wall of one course of bricks, and then surrounding it with an outer wall, leaving a cavity between the two walls equal to the thickness of a brick, which cavity is to be closed firmly at the top. This will serve to keep the temperature of the air in the chimney hotter than it otherwise would be, and by that means increase the velocity of the current. The interior of the body of the furnace, the throat, and a small portion of the chimney, must be of fire brick.

It is difficult to give a maximum for the height of chimnies; although from the above theorem, the power of the furnace would increase as the square root of the height, to any extent. Yet in practice, it will be found to be limited by two causes. The one, the friction of the sides of the chimney; the other depends upon the gradual diminution of the temperature of the inner air as it ascends till it becomes equal to that of the external. This first will vary with the facility with which the heat is conducted away through the sides of the chimney. It will be obvious, however, under the most favourable circumstances, that the changes of power by altering the height will not be very conspicuous, from its being as the square root of the height.

Furnace.

For instance, if a chimney of one foot high produce an effect of 1, it will require the height to be 4 feet to produce twice, and one of 9 feet to produce three times the effect, and so on, increasing in the same ratio.

In reverberating furnaces, which are heated by the flame of pit coal, the maximum is much higher than in the melting furnace, which is heated with coak. This arises from the flame in the former heating the interior of the chimney. The melting furnace should have its chimney not less than 30 feet. The reverberatory furnace may with good effect be made much higher.

The chimney of a furnace should be perfectly distinct from every other, nor can it have any opening in its side without sustaining an injury proportionate to its size; but its effect will be less, as its height above the fire is greater.

Sound philosophy and experience will ever discard the practice of attempting to make one furnace perform two operations at the same time.

Melting furnace. Plate CCLXII. Figs. 1, 2.

Having given some account of the principles of furnaces, we shall now describe several at present used in the arts, and in the laboratory. Plate CCLXII. Fig. 1, is a section and side elevation of a melting furnace. B is the body of the furnace, containing a crucible upon its stand. The use of the stand is to raise the crucible above the grate *g*, so as to allow its bottom to receive the greatest heat of the fire. A is the ash-pit opening through the outer wall, or into a cellar below. This serves to prevent the cold air from annoying the operator. D is the damper, which when shut covers the under side of the grate. K is the cover, which is either formed by putting two fire bricks in an iron ring, or by moulding fire clay into proper form, and burning it afterwards. C is the chimney. Fig. 2. is a plan of the same furnace.

Furnace for heating a sand-bath. Figs. 3. 4.

Figures 3. and 4. are a section and plan of a furnace for heating a sand-bath. A is the ash-pit, B the body of the furnace, *d* the door for fuel, *g* the grate, W a wall, or one large fire-brick placed between the grate and the chimney, leaving no way for the smoke to pass but through the neck *n*. It then descends on the other side, and passes through the flue F into the chimney C. *p* is a plate of cast metal, formed of two plates ribbeting into each other, by which it is less liable to break by the heat than if the plate was in one. This plate covers the whole of the top of the furnace, so as not to allow the escape of smoke. I I is a frame of cast-iron lying loosely upon the plate, with as little touching surface as possible. Within this frame a wrought iron rim S is placed, for the purpose of enveloping the sand which constitutes the sand-bath. There are rims of different depths, according to the size of the vessels to be placed in the sand.

Reverberatory furnace, Plate CCLXII. Figs. 5, 6, 7.

Figs. 5, 6, and 7, are two sections and a plan of a reverberatory furnace. A is the ash-pit, B the fire place, *g* the grate; F, in the plan Fig. 7, is the opening for the introduction of fuel, which is pit-coal. The flame plays along the hearth H, and passes into the chimney C. O is an opening for the introduction of the substances to be entered or melted, which are placed upon the hearth. If the substance is to be melted, it runs down to the opening T, where it is taken out. D is the damper for regulating the fire. This furnace is more particularly adapted for melting than for calcining, on account of its inclining hearth, and the opening at T. The construction is a little varied for the latter purpose. The hearth is nearly horizontal, and there is generally but one opening, which is in the middle.

Enamelling furnace. Plate CCLXII. Figs. 8, 9.

Figs. 8 and 9, are two sections of an enamelling furnace. A is the ash-pit, *g* the grate, B the body-furnace, where the fuel is contained; M is the muffle, an earthen vessel, more plainly seen in Plate CXLIII. Fig. 9. It contains the substances to be operated upon, and is for the purpose of defending them from smoke or flame, and admitting a supply of fresh air; K is the cover, T the throat, and C the chimney. This furnace is also employed for assaying metals by cupellation.

Muffle furnace. Figs. 10, 11, 12.

Figs. 10, 11, and 12, contain a view and section of a muffle furnace, for producing very intense heats. The body of the furnace, shewn at AA, is in the form of an oblong coffer, swelling out in the middle. The grate is shewn at C, standing over the ash-pit F. The hole for the muffle is seen at E; and the dome, or upper part of the furnace, is seen at BB, having a very large door D, for the purpose of introducing the fuel. This furnace was employed by Pott, and afterwards by D'Arcet, in their experiments on the habitudes of earths and stones, when exposed to a violent and long continued heat. Figs. 13, 14, 15, 16. represent fire-tongs for various purposes.

Figs. 13, 14, 15,

A description of Dr Black's portable wind furnace will be found in our article on Chemistry, vol. vi. p. 189, and a perspective view and section of it in Plate CXLIII. Fig. 7. and 8.

A description of Mr Arthur Aikin's portable blast furnace is given in the article Chemistry, p. 160, and a perspective view and section of it in Plate CXLIII. Figs. 10, 11, 12, and 13.

Farther information on this subject will be found in our articles Glass-making, Iron, Stove, and in several other articles where furnaces are adapted to particular purposes in the arts. See also Lewis' *Philosophical Commerce of Arts*; Aikin's *Dictionary of Chemistry*, vol. ii.; Miche on Reverberatory Furnaces, in Rozier's *Journal*, vol. xxxii. p. 385. Perceval's Chamber Lamp Furnace, in the *Repertory of Arts*, vol. iii. p. 29; and in the *Transactions of the Royal Irish Academy*, vol. iv. p. 91; Watt's Patent Furnaces, in the *Repertory of Arts*, vol. iv. p. 226; Mr Edward Howard's Improved Air Furnace is described, in Tilloch's *Philosophical Magazine*, vol. v. p. 190—193, and represented in plate iv. of that work; Raley's Patent Furnaces, in the *Repertory of Arts*, vol. x. p. 155; Accum's Improved Universal Furnace of Dr Black, is described in his *System of Practical Chemistry*, vol. ii. p. 357, and in Nicholson's *Journal*, 8vo. vol. vi. p. 273; Curaudau's New Evaporating Furnace is described in the *Annales de Chimie*, No. 149. *An.* xii. and in Nicholson's *Journal*, 8vo. vol. ix. p. 204—207; and Lucas's furnace for cast-iron cutlery, in Parke's *Chemical Essays*, vol. iv. Ess. 15. A furnace for decomposing the sulphate of barytes, is described in the same work, vol. ii. Ess. 5. (c. s.)

Furneaux Islands.

FURNEAUX'S Islands. The great continent of New Holland is separated from Van Diemen's Land on the south, which was during centuries believed to be an integral part of it, by a considerable expanse of water lately discovered, called Bass Strait; and numerous islands, some towards the centre of the strait, and some on the respective coasts are interposed between the two territories. These have been classed into groups by successive navigators, though with little regard to order, and without any decided analogies. One of the principal and most comprehensive is Furneaux's Islands, divided by Bank's Strait 12 or 15 miles in width from the north-east extremity of Van Diemen's Land, stretching from about 40° 22′ to 41° 27′ of South Latitude, and situated, with respect to the centre of the group, in about 148° of East Longitude.

Furneaux Islands.

Neither the exact number of islands composing this group, nor their individual size, are completely ascertained: the principal are Great Island, Cape Barren Island, Clarke's, Preservation, Chappel, and Babel Islands, besides many rocks and islets. The first is not less than forty miles in length, and the second twenty. Almost all have good harbours for shipping; but the channels among some of them are narrow, and of dangerous navigation.

Mineralogy.

The basis of the greater part of these islands is a whitish granite, sometimes inclining to a reddish tinge, and full of small black specks, supposed to be tin, and communicating a deleterious quality to water, as several people died on drinking it. When exposed to heat, fumes escape strongly denoting the presence of arsenic. The hills rise to a considerable height; the highest is supposed to be 1200 feet. Those of Cape Barren Island are generally crowned with huge masses of granite; and immense detached blocks of the same substance are scattered about on the rest. The lower parts of the islands are commonly sandy, or they have swamps and pools, where the water is usually of a reddish hue; in other places, it is fresh and good, although transient visitors have denied its existence.

Trees.

The whole islands are overrun with brushwood, intermixed, in the more sheltered parts, with a few stunted trees, never exceeding twelve feet in height, and several low shrubs grow on the humid grounds, surrounding the margins of pools and swamps; but most of the brushwood assumes a depressed and creeping form, particularly on those sides of the islands exposed to the more prevalent winds. A very singular and unexampled feature is presented in some of the trees having undergone a partial petrifaction in Preservation Island. There, in a particular spot, none of them are thicker than a man's leg; all are decayed; but while the upper branches consist of wood, the roots at the surface, and the trunks to a certain height, are converted to a chalky substance. The interior central part is always circular, seldom of the same diameter or of the same composition; and rings of the brown wood sometimes appear, on breaking over the trunks, as if the petrifaction were still incomplete.

Vegetables.

The vegetable productions of Furneaux's Islands are scanty throughout; and it is to be observed, that although there are patches of rich and fertile soil, and the most luxuriant growth of numerous plants in the vast extent of New Holland and Van Diemen's Land, a very large proportion of the skirts, for the interior is yet unknown, consists of low sandy tracts, appearing as if recently reclaimed from the sea, and where nature is seen in her most barren aspect.

Animals.

Two species of seals, differing in structure and habits, frequent the shores of these islands, basking on steep declivities, from whence they can easily precipitate themselves into the sea; and they afford the three new genera of quadrupeds, the kanguroo, the wombat, and the duck-billed ant-eater, all strangers to the older naturalists, because none exist on the four great continents of the world. The first is of a reddish brown species, weighing 40 or 50 lib. now grown shy from incessant pursuit, and difficult to be caught on account of its impenetrable retreats of brushwood. The wombat, whose flesh is very acceptable food, where quadrupeds are so scarce, was first seen on Clarke's and Cape Barren Island. It has since been caught on the continent; but its instinct is visibly modified by the presence or absence of danger, for it here feeds at all times, often foraging among the refuse on the shore, while on the continent it never leaves the holes where it burrows like a badger until dark. The duck-billed ant-eater is esteemed a great delicacy. Speckled, yellow, and likewise black snakes, are seen on several islands on the confines of the brushwood; they have venomous fangs, but it is not reported that they have ever proved destructive. They frequently penetrate the burrows made by the sheer water or sooty petrel, amidst the sandy tufts of coarse grass, probably in quest of the young. These birds occur in surprising numbers, darkening the air at sun-set in their flight: they burrow exactly in the manner of rabbits, and breed in their holes, and, in spite of the disturbance and destruction which they experience, they pertinaciously resort to the same spot. Penguins and other birds burrow in the same manner, in places separate and distinct from the petrels; and as the latter always retire to the ground at night, the penguins, which have been sheltered there the whole day, then regularly leave it. It is extremely difficult, and sometimes dangerous, to walk amidst the excavations formed by them, as people suddenly sink knee deep. The most valuable birds are the goose and black swan; the former is numerous, it feeds on grass, and seldom takes to the water; the latter is rare, and frequents fresh water pools only, in the breeding season.

History.

Furneaux's islands were first explored by Mr Bass, surgeon of the Reliance, and Lieutenant, afterwards Captain Flinders, of the navy, in 1798. They were about the same time, and subsequently, resorted to by vessels from Botany Bay, in prosecuting the seal fishery, which was so profitable that a single ship captured 9000 seals. Some years later, the French expedition of discovery examined the principal islands, and their appearance and position have been further explained by the elegant charts of Captain Flinders, published in 1814. Previous to all these periods, however, one of them had afforded refuge to a shipwrecked crew, and it is not improbable that, during the frequent intercourse of the Dutch with their eastern possessions, the external islands may have been seen or visited. It must now be admitted, that an extensive portion of the coast of New Holland had, nearly two centuries ago, been surveyed by them, though all remembrance of the fact was lost. Yet the slight sketches, which only afforded scope for conjectures, are evidently the result of attentive investigation.

Furneaux's islands are probably of too little importance to become a permanent settlement. At present temporary establishments are formed upon them, by those engaged in the seal fishery, which is less productive than it was originally. Besides, fresh water is scarce in general, the navigation is intricate, and the shores are frequently covered with the wreck of vessels, which repeatedly perish in the neighbourhood. See Collin's *Account of New South Wales*, vol ii. Peron *Voyage aux Terres Australes*, p. 351. Flinders's *Voyage to Terra Australis*, vol. i. Introduct. p. 126. (c)

Furnes.

FURNES, *Furnæ*, a town of the Netherlands, situated about three miles from the sea, on the canal which leads from Bruges to Dunkirk. Its fortifications were demolished in the years 1792, 1793, and 1794. The town house, which is a good building, adorned with figures of kings and princes, has a handsome tower with musical chimes. The town carries on a considerable trade in corn, bees, cheese and butter. Its fairs are held on the 26th March, 5th May, and 3d October. Population of the town 3200. East Long. 2° 39′ 51″, and North Lat. 51° 4′ 23″, according to trigonometrical observations.

FURRUCKABAD, or the *Happy Abode*, is a town of Hindostan, in the district of the same name, and capital of the province of Agra. It is situated at a short distance from the west bank of the Ganges, and was built about 100 years ago by a Patan colony. The streets are wide, and the houses and open places are shaded with trees. In consequence of the vicinity of the British cantonments, the town is flourishing, and carries on a considerable trade. There is here a civil establishment for the administration of justice, and the collection of the revenue. Close to Furruckabad is the town of Futtygur, where a brigade of troops is usually cantoned. East Long. 79° 33′, and North Lat. 27° 23′. See Valentia's *Travels*, vol. i. p. 194.

FURNITURE STOP, on the organ, in music, is a double or triple, &c. range of pipes, sometimes called the mixture stop. The tune of these ranges of pipes are XXIV, XXVI, XXIX, &c. respectively, above the pitch of the diapasons. This stop is rarely used but with the sesquialtera and other compound stops; and this medley of sound to every note, is said by some to "enrich" the instrument: but whatever may prove to be their hitherto untried effect on a (Liston's) EUHARMONIC *Organ*, (see that article), the confusion of rattling loud *beats*, constantly heard on common organs using these stops, is not less offensive to good ears, than Dr Robert Smith has described in his *Harmonics*, 2d edit. pp. 80 and 227. (ϱ)

FURTH is a large and populous town of Germany, in the circle of Franconia, situated on the river Rednitz, some leagues from Nuremberg, on the road from that town to Franckfort. With the exception of the new parts of the town, Furth is very irregularly built, and is a mere mass of houses without order. Manufactures constitute the principal riches of this industrious town. Mirrors are made here to a great extent, and almost all those which bear the name of Nuremberg are manufactured at Furth. Each mirror, before it is finished, passes through the hands of more than twelve different workmen. Articles turned out of wood and metal, clocks, jewellery goods, chains of watches, needles, buckles, snuff-boxes, and a great many other similar articles, are manufactured here. There is here also a manufacture of tobacco, which is successfully cultivated in the neighbourhood. A considerable trade is carried on in wines, which are much esteemed, and which are made principally at Sommerhausen, Rundsuck, Sommerach, Westheim, &c. The commerce of this place is greatly facilitated by the junction of the Peignitz with the Rednitz, which are then navigable to Mein. The Jews, who form one half of the population, are permitted to have a synagogue, a school, and a printing-office. Population 16,000.

FURTHCOMING, or FORTHCOMING, in the law of Scotland, is that process by which an arrestment is followed up and made effectual. It is brought at the instance of the arresting creditor, who calls the common debtor before the judge to hear sentence given, ordering the debt to be paid, or the effects arrested to be delivered up.

The decree in an action of furthcoming operates as a legal assignation to the arrester, which cannot be defeated by the poinding of co-creditors. See ARRESTMENT. (z)

FUSEE. See TIMEKEEPER.

FUTTIPOOR, or FUTTEHPOOR, is a town or large village of Hindostan, in the province of Agra. It is encircled with a stone wall of great extent, built by the Emperor Akbar. The enclosed space does not seem to have been filled with buildings, and the inhabited part is an inconsiderable village. A hilly ridge of considerable height divides this space, and extends about 4 or 5 miles beyond the wall. The materials of which the houses are built comes from the neighbouring hills, which are composed of a greyish rock. On the highest part of the rock, near the centre of the enclosure, stands the tomb of Shah Selim Cheestee, in consequence of whose devotion the Empress of Akbar is supposed to have become pregnant after remaining several years barren. The approach to this mausoleum is extremely grand. An ancient palace of Akbar stands upon the same ridge. See Hunter in the *Asiatic Researches*, vol. vi. p. 75.

FUZE. See GUNNERY.

FYZABAD, or the *Beautiful Residence*, is a town of Hindostan, in the province of Oude, of which it was once the capital. It was founded by Sadalkhan, a Persian, who was forty years governor of the province. It is situated on the south side of the Goggra, or Dewals river. The town is of considerable extent, and contains many inhabitants, chiefly of the lower classes; the merchant-bankers, money-changers, and the great men, having removed to Lucknow when the son of Sujad ud Dowlah removed the seat of government to that town. The remains of a fortress and of Sujad ud Dowlah's palace, with its extensive gardens, are still to be seen. The ancient city of Oude, or Ayodha, the capital of the great Ram, adjoins Fyzabad. East Long. 82° 10′, and North Lat. 26° 46′. See Hodge's *Travels* and Foster's *Journey*.

G.

Gabres.

GABRES, GUEBRES, or GAURS, worshippers of fire, is the name of a religious sect which has subsisted in Asia from a very ancient period.

Mankind, in the most rude and barbarous state, are unavoidably sensible of the dissemination of light and heat by the sun. His presence announces the day, while his absence covers the earth with darkness. His emanations are a powerful source of vegetation; and summer, which enables them to provide alike for transient wants and future necessities, is denoted by his more protracted appearance. Hence it is not surprising, if, in gratitude for the benefits conferred by this luminary, some marks of adoration have followed. Men, in most ages and in most countries, have worshipped the sun; and fire, in his absence, has been substituted as a prototype, under different characters. Among the ancient nations following this practice, the Romans are most familiar to us, who preserved sacred fire, which was never to be extinguished, and which was guarded by the vestal virgins. But, anterior to their era, it appears that the worship of fire was widely spread over Persia, and reduced to an established form, acknowledged and received by a large proportion of the inhabitants long before the birth of Christ. A celebrated philosopher, Zoroaster, is reported to have either founded a sect distinguished from all others by the adoration of fire, or, which is more consonant with the customs of mankind, to have reduced the practice to systematic order. Miraculous events attended his origin; his life was, like that of all other lawgivers, a tissue of extraordinary occurrences; and, according to some of his followers, he was taken up into heaven, instead of dying a natural death. Zoroaster was born about 589 years before Christ, and his disciples subsisted in Persia until the overthrow of Jezdedjerd, king of that country, by the Mahometan Caliph Omar; whence historians date the era of the modern Gabres from the first year of the reign of this sovereign. Some months after the death of Jezdedjerd, the persecution of the Mahometans induced many of them to withdraw to Kohistan, a mountainous district in the present province of Khorassan, where they dwelt for an hundred years. They subsequently emigrated to the island of Ormuz, in the Persian Gulf, where they remained fifteen years stationary; and then, sailing for India, landed at Diu. But, on consulting certain oracular declarations in their sacred writings, they discovered that their residence was not auspicious here; and, again committing themselves to the sea, reached a fertile part of the coast, having experienced a frightful tempest on the voyage. The prince of this territory received them favourably; but observing them to be numerous and well armed, he engaged the observance of five separate conditions, before granting them permission to land; namely, that they should explain the mysteries of their faith, lay aside their arms, speak the language of India, and also that their women should appear unveiled, and that their nuptials, according to the custom of the country, should be performed at night. The Gabres, finding nothing in their books adverse to these conditions, gladly assented, and landed, professing their desire for peace and tranquillity.

[Or]igin of [th]e Gabres [in] Persia.

Gabres.

Account of their removal to India.

On the other hand, the Indians, discovering the analogy of some of their principles to their own, permitted them to settle where they chose; and a portion of ground being selected, they built a city on it, which was called Sanjan. Probably, in relation to the place from whence they had emigrated, they are more generally called Parsees, and have subsisted towards a thousand years in Guzerat and other parts of the coast of India. Soon after their arrival, they obtained a new grant of land, whereon they erected a temple dedicated to fire, in pursuance of a former vow, if they should escape the storm that had assailed them. Here they remained united for about three centuries after the death of Jezdedjerd, when they dispersed to Baroach, Surat, and other places, while, in the lapse of two more, their city was gradually depopulated. The sovereign of Guzerat, however, being threatened by an invasion of Mahometans, anxiously recalled them, on which occasion 1400 were found capable of bearing arms; but many of their number fell in an engagement with the enemy. Their city was pillaged, and the survivors fled, carrying the sacred fire along with them, in quest of another establishment, which they successively found and abandoned. The fire was conveyed from place to place during several centuries, and at last the Gabres found an asylum in Surat, Bombay, and various settlements on the coast of Malabar, where they enjoy the full and undisturbed exercise of their religion.

Account of the Gabres in Persia.

Part of the original stock remained in Persia, their native country, where they seem to have experienced even a harder fate than those who emigrated. In consequence of the oppressions of their conquerors, the arts known among them declined, they lost all knowledge of their own origin and history, and became a poor and degraded race. At present they are treated with the utmost rigour, and most of them have, in consequence, been compelled either to emigrate, or to abjure the religion of their ancestors. In addition to other oppressions, they are subjected to a capitation tax of twenty piastres by the Persian government. The greater proportion inhabit the shores of the Caspian; and the cities of Ispahan, no longer the capital of the empire, Yezd, and Kerman. The suburb of the first, which they occupy, is called Gaurabad, and in the same quarter is a bridge called the Gaurs Bridge. About a fourth part of the population of Yezd, which contains 20,000 houses, consists of Gabres. But the principal resort of old, though now exhibiting only a few scattered cottages, was a place in the neighbourhood of the city of Badku, on the peninsula Abscharon, on the Caspian Sea. Here a natural phenomenon has served to promote their faith, and rivet them in the adoration of fire. About 10 miles north-east of the city, is what is called Atash Kudda, or fire temple of the Gabres, a remarkable spot, something less than a mile in circumference, from the centre of which a bluish lambent flame is seen to arise. When the wind blows, it is elevated to about eight feet in height, but it is lower in still weather. All around this place an invisible vapour escapes on digging up two or three inches of the

Gabres.

Account of the fire temple of the Gabres.

earth, which is inflamed on the application of fire; nay, if a cane tube, or one of paper, be inserted so deep in the ground, and a light applied to the orifice, a flame resembling that of spirit of wine immediately bursts forth, which does not injure the tube, provided the edges be covered with clay. Several temples, apparently of simple construction, lately stood in this neighbourhood, and, among others, a small one, where a flame issued from a hollow cane near the altar. Devotees were to be seen, about forty or fifty in number at a time, who had made expiatory pilgrimages hither, and subsisted on wild celery, a kind of Jerusalem artichoke, and other roots, while they remained. They affirm that this fire has burned since the flood, and believe that it will last until the end of the world. So singular a phenomenon cannot but deeply impress the uncultivated minds of the Easterns, who would rather seek its origin in some supernatural cause, than endeavour to explain it by the combination and action of the different substances of inanimate matter.

According to the principles of the Gabres, their sacred fire should be found in every town or settlement, and ought never to be extinguished. If compelled by the pressure of circumstances to remove, it ought to be carried along with them; and it has thus been transferred from place to place in India, while preserved in vigour, during 800 or 900, or perhaps 1000 years. Some time ago, when from invasion, or another cause, the whole Gabres were obliged to fly, and their houses were burnt, the temple, or edifice containing the sacred fire, was preserved, which they ascribed to its innate powers of protection. Concerning this element they entertain the most extravagant ideas, though its worship be subservient to that of Hormusd, a divinity the source of all good. They maintain, that an original principle, analogous to eternity, (at least nothing more definite can be explained by it,) created light, water, fire, Hormusd the author of good, and Ariman the author of evil; but speech preceded all creation, for by its influence the formation of beings was effected: Hormusd is adored for his beneficence, and Ariman held in detestation on account of his malevolence. The sacred fire Behram, which is the guardian of the country, is the extract of 1001 fires, taken from 15 other fires. It must be preserved unextinguished in absolute purity; and many sacred offices are performed before it, either by priests in their temples, or by individuals in private. In the former it is kept up simply, we conceive, by a supply of wood. It is watched night and day by priests, and burns on a vase contained within a grating, which none other may approach. The light of the sun being brighter than fire, is excluded from their temples; and if any person of different tenets should approach, the priests consider themselves defiled, and have to undergo purification. Independent of this care of the sacred fire, they entertain a veneration for the element in general. When once kindled, they deem it sacrilege to extinguish it unless by a particular method: A candle must either burn to the end, or, if they wish to spare a portion, a small part next the wick is cut off, and, being carried to the hearth, is left to burn out. A light is blown out by the wind of a fan or the hand, but never with the breath, for that is impure; and should their houses take fire, instead of extinguishing the flame with water, the surrounding parts are pulled down, or removed, in order that it may go out of itself. In short, their general principle is, to allow it to come naturally to a close, and not abbreviate it by violence. The Gabres keep different festivals, continuing six days, as at the beginning of the year; six particular festivals afterwards, each of five days; and a festival the last ten days of the year, during which they believe that the souls of the virtuous descend to within three bow shots of the earth. They also observe the anniversaries of their own birth, and that of their children. But these festivals are different in different places, and some in Persia are unknown in India. Their prayers are numerous; they are offered up not only after natural operations, but on cutting their hair or nails, the fragments of which are preserved to be laid in their cemeteries.

Marriage ceremonies.

Marriage is a favourite condition among the Gabres, and sterility a reproach. A man is entitled to have only one wife, but should she have no offspring, he may, with her consent, take another, the first still continuing to dwell along with him. But the same privilege is not allowed to a wife. In Persia, it has been affirmed that a man might marry five wives, though only the first was to be considered the true and legitimate one, and hence a preference over the rest. The husband was entitled, however, to repudiate her at the end of seven years if she remained sterile; as also for adultery, or apostacy from her own religion. It is added, that if the wife repented of her offence within a year, and did penance during three years, the parties might be reunited. Perhaps these points are not sufficiently established, and the authors who have treated of some of them are not aware that marriage is considered to be of five different kinds. When a young female has attained maturity, she may demand that her parents shall provide a husband for her; and if they disregard her request, it is a culpable neglect; but if she, on her part, refuses marriage, and dies a virgin at eighteen, her soul is believed to remain in hell until the resurrection. The marriages of the Gabres are performed with great pomp and solemnity, 2000 guests being sometimes invited in India, while all the friends and relatives of the parties are clothed in their most splendid attire. A prodigious display of lighted torches appears, and a numerous procession is attended by noisy musical instruments. The ceremony is then performed by a priest, and the wedded pair occupy their own proper residence. By a special regulation, which has prevailed nearly 150 years, the Gabres of India never present any thing at the great entertainments which embellish their marriages that has had life in it, because there are always numbers of Indians invited to participate.

Mode of disposing of their dead.

But amidst the most singular customs which have ever been witnessed among mankind, is the conduct of these people in the disposal of their dead. They are neither interred nor burned, but exposed to be devoured by beasts of prey. Perhaps there is no custom of the present day, however extraordinary, that we cannot trace in the records of antiquity; and few which were practised in the most remote ages, are altogether extirpated among modern nations. Herodotus, and after him Strabo, acquaint us that the Magi, who were the original race now described in these pages, did not inter the bodies of their dead, but exposed them to beasts of prey. The Hyrcanians, or natives of Irak, as we denominate it, had dogs trained, if they could require any training, to devour the dead; and the Bactrians were so tenacious of this fashion, that when Nicanor, governor for Alexander, wished to abolish it, he was very nearly losing the whole province. According to Justin, the Parthians exposed the dead to be devoured by dogs and birds, and afterwards buried the naked bones. The ancient inhabitants of India left the bodies of their deceased relatives to be devoured by vultures, which were possibly viewed as sacred birds. Ælian speaks of a nation or tribe, the Barcæi, which burnt those who died by the course of nature, but others who fell in battle were exposed to be devoured by vultures, because these birds were held to be sacred. The modern Gabres, or Parsees, the worshippers of fire, expose their deceased relatives as a prey to vultures, whether in Persia or in India. When a person is about to expire, a prayer is whispered in his ear, and a dog presented before him; but it is important that the animal should look in his face, which is obtained by placing some meat in that direction. Two dogs must be brought for a pregant woman; or if no dogs can be procured, means should be used to attract the attention of the bird that is to prey on the body. It appears that this part of the ceremony may be postponed until carrying forth the body to be deposited in the sepulchre, which is either done in silence attended by a numerous assemblage, or while women chaunt a kind of requiem. The repository of the dead is a circular edifice, or low tower, open above, with a stone floor, elevated from the ground to receive the bodies, and inclining towards the centre. By the letter of the law, this sepulchre, which is called Dakhme, should stand only on a hill, and be demolished every 50 years, to expose the earth to the light of the sun; but probably neither of these conditions are fulfilled, and we only know that they are apart from towns. Several are seen at Bombay and Surat; the largest about 55 feet in diameter, and 25 feet in height, built up to within five feet of the top, and having a well or sink of 15 feet diameter in the center. There are three concentric grooves or compartments around the sink for receiving the bodies, which are loosely wrapped in cloth, the outer for the men, the next for women, and the interior compartment for the bodies of children, all with connecting channels to drain off the fluids, into which they are partly resolving by the progress of decay. Nothing can be more horrible than the spectacle presented here, whether in the various stages of putrefaction in its most unsightly form, in the disjointed and mangled fragments of the human frame, the overpowering fœtor emanating from the corpses, the presence of the vultures greedily devouring their prey, or glutted with human flesh scarcely able to take wing, altogether forming such a combination, as the strength of living man can with difficulty resist. But the natives have no such feelings; on the contrary, they look for auspicious omens in the very eye which shall be first torn from its socket. After a certain interval, the bones are collected towards the sink with iron rakes, and the communication of subterraneous channels prevent it from being choked up. The body first interred in a new-constructed Dakhme ought to be that of an infant, the child of a priest.

The Gabres nourish a strong predilection for some animals, and entertain a corresponding aversion for others. Cows and dogs are in great estimation. They have an antipathy to cats, insects, and reptiles, from believing them created by Ariman, the source of evil; and Tavernier says, that in Persia the women destroy all the frogs on a certain day, because a prophet whom they principally venerate, was once disturbed by these animals. But the zeal of this author for the Catholic faith has led him, according to his own acknowledgement, to expose only what is most absurd in the religion of the Gabres; hence his accounts, which in some things are manifestly erroneous, must be read with caution.

This sect seems to exist in much greater purity in India than in Persia. Their ceremonies, even some of the most important, are extremely different; and those of the Persian Gabres are compounded of the principles of the Christians and Mahometans along with their own. The earlier doctrines of Christianity, and many points of Jewish history, are especially to be recognized in the baptism of their children, the history of their prophets, the escape of the sacred fire in the semblance of a white dove, and the like. Probably these have been introduced by the decline of learning, and from the influence of their priests being unable to preserve their original faith in its purity. But the reverse has succeeded in India, where the Gabres practise their worship undisturbed, and have preserved some of their books of the law, written in a peculiar character, until the present era.

The moral character of these people is universally esteemed. They are qniet, inoffensive, and industrious. At Bombay and Surat, but especially the former, where they are best known, they are highly respected, and one of the most wealthy some years ago charitably maintained 2000 persons of all different tribes at his own expence, during a time of famine. They are among the richest inhabitants of the island, and are accustomed to give the most magnificent entertainments to Europeans, while no one of their own sect is left destitute, so much are they distinguished for munificence and liberality.

See Hyde *Religio Veterum Persarum. Zend-Avesta*, tom. ii. iii.; Moore's *Narrative of Little's Detachment*, p. 383; Ovington's *Voyage to Surat*; Hanway's *Travels*, vol. i. p. 263; Abu Taleb's *Travels*, vol. ii. p. 386; M'Donald Kinneir's *Geographical Memoir of Persia*; *Justin*, lib. xli.; *Ælian*, lib. x. cap. 22. (c)

GABS, the name of a town of Africa, situated on the south-east part of Tunis, in a bay of the Mediterranean. It was the *Epichus* of Scylax, and the *Tacape* of Ptolemy and Pliny. Dr Shaw informs us, that the ruins of this ancient city are still to be seen upon a rising ground, at the distance of half a mile from Gabs, having been formerly washed by the sea, which here formed a bay nearly half a mile in diameter. The greater part, however, of this bay is now filled up and gained from the sea. Among these ruins are some beautiful granite pillars, about twelve feet long, and all of them square: a form which Dr Shaw had never seen in any other part of Africa. There are several extensive plantations of palm trees at Gabs, but the dates are much inferior both in taste and size to those of Jireed. The principal trade of the place consists of the al-hennah, which is cultivated to a great extent in all the gardens. "This beautiful odoriferous plant," says Dr Shaw, "if it is not annually cut and kept low, as it is usually in other places, grows ten or twelve feet high, putting out its flowers in clusters, which yield a most grateful smell, like camphor. The leaves of this plant, after they are dried and powdered, are disposed of to good advantage in all the markets of this kingdom: For with this all the African ladies that can purchase it, tinge their lips, hair, hands, and feet, rendering them thereby of a tawny saffron colour, which, with them, is reckoned a great beauty. The al-hennah, no less than the palm, requires to be frequently watered; for which purpose, the river that runs through these plantations is cantoned out, as it seems to have been in the time of Pliny, into a number of channels. Distance from Tunis 57 leagues south, from Wood-riffe three leagues, and from Ellamaite 12 leagues. The baths of Gabs, or the *Aquas Tacapitanas*, are situated at Elhammah, about four leagues to the westward of Gabs, and are described by Shaw. East Long. 10° 2′, North Lat. 34°. See Scylax, *Perip.* p. 46; *Ptolemy*, lib. iv. cap. 3; *Pliny*, lib. v. cap. 4; lib. xviii. cap. 22; *Strabo*, lib. xvii. p. 1188; and Shaw's *Travels in Barbary and the Levant*, chap. iv. p. 213.

GADES. See CADIZ.

GADOLINITE. See MINERALOGY.

GADUS. See ICHTHYOLOGY.

GAEL. See CELTS.

GAERTNER. See *History of* BOTANY, p. 34.

GAETA, or GAIETA, the *Cajeta* of the ancients, is the name of a sea port town of Italy, in the kingdom of Naples, and province of Lavora. It is situated on a peninsula, which is joined to the mainland by a narrow isthmus. The fortress, which was erected by Ferdinand II. of Arragon, stands upon the rocky promontory; and when seen from Mola, it forms a very striking object, with its white ramparts presenting to the eye, one above the other, its stages of angles and batteries. The sea floats into its moats, which are both broad and deep. Its harbour, which is well described by Homer, still exhibits the same character. It was anciently repaired by Antoninus Pius. The streets of the town are neatly built and well paved; the houses are built on porticos; and the general appearance of the town is lively within, and picturesque without. "The cathedral," says Mr Eustace, "though not large, nor highly decorated, is well proportioned, well lighted, and, by the elevation of the choir, admirably calculated for public worship. The font is a fine antique vase of white marble, with basso relievos, representing Athamas, Ino with a child in her arms, and a group of Bacchantes. The sculptor was an Athenian; but such a vase is better calculated for a gallery of antiques than for the place where it now stands. Opposite the great portal of the cathedral rises an antique column, marked with the names of the winds in Greek and Latin.

The tomb of Munatius Plancus stands upon a bold eminence, on the neck of land which joins the peninsula to the continent. Like that of Adrian, it is round, stripped of its marble casing, and converted into a tower with battlements. The gulf abounds with fish, particularly sturgeon, from which caviar is made. Gaeta is the see of a bishop, suffragan of Capua. Distance from Naples 40 miles north west; from Mola four miles by land and two by water. East Long. 13° 28′, North Lat. 41° 15′. See Homer *Odyss.* x. 107; and Eustace's *Travels*, vol. i. p. 475.

GAGE. See PNEUMATICS.

GAINSBOROUGH, a town of England, in the county of Lincoln, is pleasantly situated on the eastern bank of the Trent, which here separates Lincolnshire from Nottinghamshire. The town is clean, well paved and lighted, and consists chiefly of one long street parallel to the river. The principal public buildings are the church, the town-hall, the old hall or palace, the theatre, and the bridge. The church, which is an irregular building, in a very bad style of architecture, was lately rebuilt at the expence of the inhabitants. The pulpit cloth and cushions are made of crimson brocade velvet, trimmed with gold; and they are made of materials which were taken in 1743 at the battle of Dettingen. The town-hall, which is situated in the market-place, is a brick edifice, with shops below it and the jail: it is used occasionally as an assembly room. The old hall or palace is a Gothic mansion, situated at the north-west end of the town. It consists principally of oak timber framing, and forms three sides of a quadrangle, open to the south. It has a tower 78 feet high, and the whole building was about 600 feet square. The moats with which it was once surrounded are still visible. It is now converted into apartments for families. The theatre is a small but very handsome modern building. The bridge, which is very elegant, consists of three elliptical arches. It was completed in 1791; and, being private property, a toll is exacted. There are several meeting-houses in the town, and some good charity schools. This town has a small share in the Baltic trade, and it carries on a considerable trade in corn and other commodities to and from the coast. Vessels of 150 tons burden can come to the town with the tide. The trade of Gainsborough is greatly facilitated by the Readley Canal, which opens a communication with Yorkshire; and by the Chesterfield Canal a communication is opened with the counties of Nottingham and Derby.

About five miles to the south-east of Gainsborough are vestiges of the city of Sidnacester. On a ridge along the banks of the Trent, about half a mile to the north of Gainsborough, are some embankments called the *Castle Hills*. The central encampment contains an area of 510 feet in circuit, and is surrounded by a double fosse and vallum. The circular part appears to have been a Roman work, and the rest is Danish. Horse races are annually held at Gainsborough.

The following is the statistical abstract for the town and parish in 1811:

Inhabited houses	1159
Number of families	1227
Families employed in agriculture	49
Ditto in trade and manufactures	628
Males	2446
Females	2726
Total population	5172

See the *Beauties of England and Wales*, vol. ix. p. 671.

GALANGAL is the name of a medicinal root, and the produce of a plant of the same name. There are two kinds of galangal, the great and the small; the last of which is generally held in the greatest estimation. The *great galangal* is a tough woody root, about $1\frac{1}{2}$ inch thick. It is whitish within and brown without, and has a thin bark, covered with rings or circles about one-fourth of an inch distant. It has a bitterish and a somewhat aromatic taste. The *small galangal*, which is superior in all its qualities to the great galangal, is a much shorter and smaller root, of an irregular form. It is commonly the size of the little finger, being seldom more than half an inch thick, and two inches long. It is of a pale red colour, with a small admixture of brown on the inside, and of a brownish-red colour on the outside, and is surrounded with many circular rings, that project a little beyond the rest of the surface. It is not heavy, but its texture is firm and compact. It cuts with difficulty with a knife, and leaves a polished surface. Small galangals must be chosen full and plump, of a bright colour, compact and sound, and leaving an acrid and unsupportably hot taste.

The permanent duty upon galangals is £1, 8s. per cwt. and the war duty 9s. 4d.; amounting in all to £1 : 17 : 4.

The following Table shews the quantity of this root imported and sold by the East India Company, from the years 1804 to 1806 inclusive:

Years.	March Sale.		September Sale.		Average Price per Cwt.
	Cwt.	Price.	Cwt.	Price.	£ s. d.
1804	896	£1810	..	....	2 0 5
1805	..	....	104	£264	2 10 9
1806	..	....	10	18	1 16 0

Twelve cwt. of galangal are allowed to a ton. See Lewis's *Materia Medica;* and Milburn's *Oriental Commerce.*

GALAPAGOS, or TORTOISE, or ENCHANTED ISLANDS, are the names which have been given to a cluster of desert islands situated in the Pacific Ocean, in East Long. 268° 18′, and South Lat. 1° 22′. They were first discovered by the Spaniards, and have been since visited by Dampier and Vancouver. The southernmost island is about 4 miles in circumference, and the northernmost about 1½ mile. Most of these islands are flat, and tolerably high. Four or five of the most eastern are rocky, hilly, and barren, producing nothing but some shrubs on the shore. Others of this cluster produce trees of different sorts; and in some of the most western of the group, which are 9 or 10 leagues long, and six or seven broad, large and tall trees, especially mammee trees, grow in extensive forests. In these large islands, the rivers are of a tolerable size. See Dampier's *Voyage round the World*, vol. i. and Vancouver's *Voyage.*

GALASHIELS. See ROXBURGHSHIRE.

GALAXY, or MILKY WAY. See ASTRONOMY.

GALBA. See ROME.

GALBANUM is the name of a gum which exudes naturally from the joints, or is obtained by incision from the stem of an evergreen plant, which is found in Persia, Arabia, and some parts of Africa. The following excellent account of this gum, as an article of commerce, is given by Mr Milburn.

"Galbanum is a gummy, resinous, rather unctuous substance, sometimes in the natural drops or tears, but more frequently in masses composed of a number of these blended together. The drops, when perfect, approach near to a roundish or oblong figure; but they commonly lose their form in the masses. These are pale coloured, semi-transparent, soft, and tenacious. In the best specimens, they appear composed of clear whitish tears, often intermixed with stalks and seeds of the plant. When fresh, the masses and tears are white, and with age change to yellow or brown.

"When the tears can be procured, they are to be preferred to the masses or cakes. These tears should be fattish, moderately viscous, and glossy on the surface; such as are too fat, of a dark brown colour, and mixed with sticks and other foreign substances, are to be rejected. The best cakes are those of a light yellow colour, of a strong, piercing, and, to most persons, a disagreeable smell, of a bitterish warm taste, not very humid, nor yet quite dry, being of a nature between a gum and a resin, flaming in the fire, and with difficulty dissolved in oil. The fewer chips, dirt, stalks, or other impurities, the better. A mixture of two parts of rectified spirits of wine, and one of water, will best shew its quality, by dissolving all the pure galbanum, and leaving the impurities. When its foulness renders it of little value, it is best purified by enclosing it in a bladder, and keeping it in boiling water till it melts or becomes soft enough to be strained by pressure through a hempen cloth. If this process be skilfully managed, the galbanum loses but little of the essential oil, some of which is generally carried off in evaporation."

The following is an account of the quantities imported and sold at the East India sales in the years 1804 to 1808 inclusive, with the sale amount and average price per cwt.

Years.	March Sale.		Sept. Sale.		Total.		Average per Cwt.
	Cwt.	Price.	Cwt.	Price.	Cwt.	Price.	£ s. d.
1804	..	..	15	£241	15	£241	16 1 4
1805	24	£199	42	399	66	598	9 1 2
1806	..	..	57	238	57	238	4 3 6
1807	..	..	..	..	..	..	.. .. ..
1808	..	..	..	..	..	..	.. .. ..

Sixteen cwt. of gum galbanum is allowed to the ton. The permanent duty is £2, 4s. per cwt. and the temporary or war duty £1, 8s. per cwt.; making in the whole £5, 12s. per cwt.

GALEN, one of the most celebrated physicians of antiquity, and singular for the unbounded sway which his opinions long maintained over the medical world. He was born in the 131st year of the Christian era, in Pergamos, a city of Asia Minor, of which Esculapius, the god of medicine, was considered as the protector. This circumstance, and the consequent attention which its priests paid to the medical art, probably rendered it a place well fitted to cherish in an ardent mind a zeal for medical pursuits. He flourished in the reigns of M. Aurelius, Commodus, Lucius, and Severus. He enjoyed great advantages from the literary and scientific attainments of his father Nico, a man of considerable wealth, and highly respected for his exemplary temper and virtue, as well as for his eminent knowledge in literature, geometry, astronomy, and architecture. His mother is described by him as a woman of strict virtue, and an excellent economist, but unhappy in her temper, often quarrelling with her husband, and even biting her domestics.

His preliminary education, consisting in grammar, arithmetic, geometry, and astronomy, was continued till he was fifteen years of age. In these branches he discovered a ready capacity and a retentive memory, and his attainments far exceeded those of his fellow scholars. He then turned his attention to logic and philosophy. He studied the system of the Stoics, by attending the prelections of Philopator, and reading the works of Chrysippus. On the latter he wrote a comment during his early studies. From the Stoical discipline he is considered as having greatly profited, by acquiring principles of rigid self-government, which armed him against the licentious manners of that age. He studied the Platonic philosophy under Caius, a fellow citizen, a man of singular worth and incorruptibility of character. To these studies he was probably indebted for the elegant direction which was given to the natural fervour of his mind. His father also gave him an opportunity of learning the Epicurean philosophy, under an Athenian who had settled in Pergamos. On the various systems of the day, he so far made up his mind, as to write dissertations on their merits. In these he gave a share of praise to each, with the exception of the Epicurean, which he rejected and opposed. His early studies were not undertaken with any view of rising in the world, but purely as conducive to the improvement of his own mind, and the rational enjoyment of life. But a resolution to cultivate a philosophy which excludes all exterior glory, very often proves unsteady, especially where prospects of utility to mankind seem to exact from an accomplished mind a devotedness to a public life. The destinies of Galen were widely different from these original views. In his seventeenth year, he was determined, by a superstitious regard to a dream of his father's, to apply to the study of medicine. His previous liberal education had so far enlarged his mind, as to impress him with the propriety of combining with his new pursuits the prosecution of his philosophical studies. Natural philosophy, in a particular manner, appeared necessary, for the purpose of cultivating a thorough knowledge of the physical qualities of those objects which medicine comprehends. He carefully weighed the merits of the various medical as well as philosophical systems, and made himself a complete master in the art of reasoning, as practised by the ancients. Possessed of judgment to guide in some measure his own studies, he changed his teachers whenever he perceived that no improvement was to be derived from them. Hence it was an honour to have him for a pupil, and to the sophists of the day he was not a little formidable. Some of his studies were prosecuted at Corinth, others at Smyrna. Afterwards he went to Rome, where he embraced an opportunity of studying with the teachers belonging to the three medical sects, the Rational or Dogmatic, the Methodic, and the Empiric. He maintained a uniform respect and attachment to all his teachers, but in none did he ever repose blind admiration or implicit confidence. Determined to take nothing on mere report, which it was possible for him to examine with his own eyes, he travelled for the express purpose of seeing the different articles of the materia medica in their native country. He went to Palestine to see the opobalsamum and bitumen, and to Lemnos to see the celebrated Lemnian earth. He reviewed the metallic productions of Cyprus, and brought home, for the use of his countrymen, quantities of the mineral substances which went under the names of Cadmia, Pompholyx, Diphryges, and Chalcanthus. He also examined the articles of diet used in different countries, and pointed out those which he considered as most proper for the sick.

After a long residence in Alexandria, and a course of travels which he had performed in Egypt, he returned at the age of 28 to practise medicine at Pergamos. He communicated to the medical men of that city the information which he had collected, and directed them in a variety of experiments on the virtues of medicinal plants. He was honoured with the medical charge of the gladiators, and gained no small credit by the success with which he treated their wounds.

A sedition arising in Pergamos, he repaired to Rome, where he soon acquired very high celebrity by his professional success in the diseases of some conspicuous individuals. He cured Eudemus the philosopher of an intermittent fever, which had been previously mismanaged. He gave remarkably accurate predictions of the future course of various cases of disease, and displayed great address in tracing some instances of indisposition to maladies of the mind. When called to the wife of Justus, he declared her illness to have originated in an amorous affection, and discovered the individual who was the object of her languishing attachment. He found that the disease of a servant to whom he was called, proceeded from the depressing influence of fear; and it appeared, on enquiry, that this person was unable to give a proper account of some property which had been committed to his charge. In short, Galen seems to have shone as an accurate student of the phenomena of disease, and to have applied to professional uses a general and ready knowledge of the human heart.

At Rome he was intimate with the first characters in the literary world, such as Eudemus and Alexander Damascenus, two celebrated Peripatetic teachers, and Sergius Paulus the prætor, a man of consular dignity, the most eminent man in Rome for intellectual accomplishments, and for ability in the management of state affairs. The great success of Galen, his growing character, and the high remunerations which he sometimes received, excited the hostility of his competitors, most particularly among the sect of the Methodics whom he opposed, and who at that time were in high credit. They represented his success in practice, and the accuracy of his predictions in disease, as entirely the effect of accident. The latter was sometimes ascribed by them to the art of magic. The annoyance which he sustained from this opposition, and the breaking out of a plague in the city of Rome, determined him, in the 37th year of his age, to leave that city, and return to his native country. But he had not remained long there, when he was invited to attend the Emperor M. Aurelius in Aquileia, and in the train of this emperor he returned to Rome. Aurelius gave him the charge of his two sons, Commodus and Sextus, during his absence in the German war. Galen ingratiated himself at court, by performing some successful cures on Commodus, and by showing the accuracy of his judgment in the prognosis which he pronounced of an acute disorder with which Sextus was affected. When the emperor himself was afterwards seized with sickness, Galen told him that it was entirely the effect of an overloaded stomach, and gave him relief by a suitable prescription. This benignant emperor was no less pleased with the philosophic spirit and the virtuous habits of Galen, than with his professional ability. On the death of Demetrius, Galen was appointed to succeed him as the sole compounder of the famous preparation called *theriaca*, a distinction which served to mark him as the first physician of his day. It does not appear that Galen continued stationary in Rome till his death. Several years of his life, though we know not how many, seem to have been again spent in his native city. Galen died at the age of 70. The place of his death is unknown. Some say that he lived to the age of 87, and a fabulous story was at one time circulated that he lived 140 years.

The biographers of this celebrated man have delighted to recount the virtues for which he was eminent, such as fortitude, inflexible justice, and piety. He appears to have held the creed of the unity of the Deity. A zealous writer has laboured to show that he died on his way to Judea, on a journey which he was led to undertake by the claims of the Christian miracles. From this a hope is suggested that he had submitted to the rite of Christian baptism, and died within the bosom of the Catholic church. These facts, however, Galen.

are but ill authenticated. His dutiful sentiments towards his father, his devotedness to his native country, (the interests of which he often cultivated to the neglect of his own fortunes at Rome,) the grateful veneration which he entertained for his teachers, the sedateness of his manners, the correctness of his conversation, which was equally remote from obscenity and ridicule, the mildness of his temper, his gentle behaviour towards his servants and all around him, and the cheerful animating tone of his discourse with the sick, are virtues which, though not uncommon, it is pleasant to find adorning the character of this great physician.

In his reasonings he was reckoned solid and close, in every argument confounding his adversaries, and coming off triumphant. The most unbecoming quality betrayed in his writings, is a disposition to boast of his own ability, and to treat other writers with contempt.

He wrote several treatises which have not reached our day, among which are his books on philosophy and grammar. Five hundred treatises on medicine are ascribed to him, and half that number on other subjects.

Galen, though possessed of a mind too independent to submit implicitly to any of his predecessors, unconsciously forged chains which enthralled the medical opinions of many succeeding ages. The contending errors of ancient systems, produced a very powerful effect on his inquiring mind. He entertained the plausible opinion, which was so universal among the ancients, that all particular truths in philosophy are to be deduced from general or first principles. The specimens of philosophical truth, however, which he found thus substantiated in the various schools, were so unsatisfactory, and so often at variance with the phenomena of nature, that at one time he was strongly disposed to embrace that philosophy, which declares the universal uncertainty of human knowledge, a system which, under the name of Pyrrhonism, was at that time very prevalent. From this he was preserved, by contemplating the satisfactory results which mathematical science afforded in the problems of geometry and astronomy, and, in a particular manner, the calculation of eclipses, and the undoubted utility of dials and other mathematical instruments. On comparing the proofs of the certainty of science, with the numerous specimens of its errors, he was not induced to abate his exclusive confidence in synthetic reasoning, but drew the inference, that the true data or first principles, which were the foundations of natural science, had not yet been discovered. He conceived that he himself was destined to lead the way in the investigation of medical truth. To this object accordingly all his efforts were powerfully directed. If he had not laboured under the error now mentioned, which was derived from Aristotle, an error common to him with other men of learning in that age, and which never indeed lost its dominion over science till the appearance of the *Novum Organon* of Bacon, Galen would have produced a work as conspicuous for solidity and minute information, as for genius and comprehensiveness of thought. Future ages would then have approved while they wondered. His system, though defective, and often rendered illusory by the intermixture of the subtile doctrines of Aristotle, was ingenious and well connected. His talents enabled him to stop the spirit of improvement for fifteen centuries; but now, when emancipated from his illegitimate dominion, we are enabled to profit by his labours, and to contemplate in his writings a mighty monument of genius and industry, fitted at once to animate exertion, and to repress presumption. For an account of his opinions, see the *History of* ANATOMY, and the *History of* MEDICINE.

Galen wrote with elegance in the ordinary dialect of the Greek language, inclining to the Attic.

The Greek editions of his works are those of Aldus and Aud. Asulanus, printed at Venice in 1525, in five folio volumes; and that of Hieron Gemusæus at Basle, in 1538, in the same form.

The editions of Latin translations of his works are more numerous, and were published at Paris, Venice, and Basle. René Chartrier published his works in Greek and Latin, along with those of Hippocrates at Paris. See Eloy's *Dict. Hist*; Le Clerc's *Hist. de Medicine*; and the prefatory dissertations to the different editions of Galen's works. (n. n.)

Galicia.

GALICIA, a province of Spain, situated in the north-west angle of that kingdom; is bounded on the south by Portugal, on the north and west by the Atlantic Ocean, and on the east by Asturias and Leon. It lies between 41° 50′ and 43° 46′ North Latitude, and between 6° 10′ and 9° 10′ West Longitude, forming a very irregular kind of square, extending about 40 leagues from east to west, and 46 from north to south. It takes its name from its ancient inhabitants the Callaici, or Gallæci, and formerly comprehended a part of Old Castile. In its mountainous districts, as well as in those of Asturias and Biscay, the Cantabrians resisted all the power of the Roman armies; and in 714, presented the strongest barriers to the invasion of the Moors. Galicia was constituted a kingdom in the year 1060, by Ferdinand the Great, king of Leon and Castile, and was assigned as a province to his son Don Garcias; but till the reign of Ferdinand and Isabellá, in 1474, the inhabitants maintained, amidst their mountains and rivers, much of their original independence. The nobility, without paying great regard to the royal authority, acted as sovereigns in their respective territories, and encouraged their vassals in their marauding practices. But, by the exertions of Ferdinand and Isabella, these disorders were repressed, the country civilized, and the inhabitants attached to the Castilian monarchy.

Boundaries.

History.

The country is in general covered with mountains, most of which are well wooded, and very abundant in game. An extensive mountainous chain, which proceeds from the Pyrenees near Roncevallos, traverses Galicia from Leon, till it terminates at Cape Finisterre, the most westerly point of land in the province. The most considerable part of this branch is occupied by the mountains of the Sierra de Mondonedo, which occupy the whole of the north-eastern extremity, and extends northwards as far as Cape Ortegal. The principal rivers in the province are, the Eo, Eu, or Rio de Miranda, which runs from south to north along the common boundaries of Galicia and Asturias, and falls into the Northern Ocean above Ribadeo; the Sil, which rises in the mountains to the west of Leon, and proceeding westwards in a very circuitous course of 33 leagues, joins the Mino a few leagues north of Orense; the Mino or Minho, (in Latin *Minius*, so named from the vermilion which is found in abundance in its vicinity,) which rises in the east of the Sierra Mondonedo, and, after a course of 52 leagues in a south-west direction, falls into the Atlantic near the port of Guardia; the Tambra or Tamaris, which gives the name of Tamaricians to the people on its banks, and runs for the space of 20 leagues from the north-east to the south-west; the Ulla, which originates in the interior of the country,

Aspect, mountains, and rivers.

Galicia.

and has a course of 23 leagues in a south-east direction; the Mandeo, the Eume, and a number of others to the amount of seventy, besides an immense number of small streams.

Minerals.

The province of Galicia is said to have been formerly celebrated for rich mines of gold and silver; but its metallic productions at present are chiefly copper, lead, and tin. Between Corunna and Betanzos, there are quarries of jasper and white marble; and in other places there are found also marcassite, vitriol, sulphur, &c. The country abounds in mineral waters, and especially in hot springs, many of which are well frequented for the purpose of bathing. One part of the town of Orense, in consequence of the number of these thermal waters, which warm the air by their vapours, enjoys all the mildness of spring, while the opposite part is experiencing all the rigours of winter. There is one wonderful spring called Lousana, at the source of the river Lours, on the mountain of Cebret, which, though 20 leagues distant from the sea, and raised considerably above its level, is obserevd to ebb and flow with the tide. Its waters also are at one time as cold as ice, and at another extremely warm, in which latter state they are always most copious. In the forests and mountainous districts are found a variety of wild animals, particularly roebucks, hinds, stags, boars, and a great quantity of game. In its numerous rivers and extensive coasts, immense quantities of fish are taken, particularly salmon, sardin herrings, shad, trout, lampreys, skate, eels of all kinds, and above all the hog-fish, which has no bones, and being caught in the months of November and December, are frequently sent quite fresh into the provinces of Castile and Leon.

Climate and productions.

There may be said to be three different temperatures in the different districts of the province; that of the coast, which is generally mild and gentle; that of the mountains toward the north-east, which is cold, damp, and rainy; and that of the valleys towards the south-west, which is warm, dry, and pleasant. It is indeed of all parts in Spain the most subject to frequent rains and a cloudy atmosphere; but it is every where salubrious, and generally productive. There are vast quantities of lofty trees, especially oak, walnut, chesnut, and hazel; and in many places are seen mulberry, orange, and lemon trees, vines, apples, and a great variety of other excellent fruits. Though in some parts the soil is not very fertile by nature, the industry of the inhabitants has done much for its improvement. The lands frequently bear wheat, barley, rye and oats; and great quantities of maize, millet, flax, hemp, pulse, and excellent vegetables. The farmers fatten great numbers of cattle, besides raising some good horses, mnles, and a fine breed of asses and hogs. Numerous flocks of sheep and goats are seen upon the ridges of the mountains; and in many places abundance of excellent poultry is reared.

Manufactures.

There are fewer manufactures in Galicia than in the other provinces of Spain; and, though the inhabitants are remarkably industrious, they seem to have little inclination for the more mechanical arts, or the occupations of commerce. There are at Corunna and Ferrol rope-works and manufactories of sail-cloth, chiefly for the use of the Spanish navy. In the province of Lugo, woollen stuffs, hosiery, and coarse cloths, are made. In the territory of Monforté, in the county of Lemos, there are manufactories of silk, which produce a considerable revenue. There are also made in the province leather, tapes, soap, some printed calicoes, tolerably good table linen, a considerable number of hats, and great quantities of knit stockings, of which last article it is calculated that 25,000 pairs are annually sent to the neighbouring provinces, and double that number to America. Its principal articles of commerce are cattle, mules, horses, fish, cloth, wool, and wine, which are sent into the other provinces; salt provisions, particularly salted fish, which goes to foreign countries; leather, skins, hides, hats, soap, table-cloths, napkins, stockings, to America. Its exportations are made from the port of Corunna, and its imports, excepting those from America, are received by Vigo.

Articles of commerce.

Cities.

Galicia contains seven cities, 74 towns, 3434 villages, and 3683 parishes. The principal inland towns are San Jago de Compostella, the capital of the province, and residence of the archbishop, Lugo, Orense, Mondonedo and Tuy, each the seat of a bishop, Porto-Marin, Portvelezar, Torbeo, Velezar, Salvatierra, Monforté de Lemos, Viana, Monterey, Ponte vedra, &c. On the coast are forty sea-ports, but the greater part are very small, and the most worthy of notice are Corunna, Finisterra, Bayona, Gondomar, Muroz, Rivaldeo, Ferrol, Betanzos, Vigo, &c. The population of the province, in proportion to its extent, is greater than that of any other in Spain; and is estimated at nearly one million and a half. The people are chiefly employed in agriculture and fishing; and are distinguished by their simplicity of manners, hospitality of disposition, and general disregard of the arts of luxury. They are large and robust in their persons, commonly barefooted, and capable of supporting every kind of fatigue. The women are fair and tolerably handsome, with fine teeth, and very regular, but not very expressive features. The Galicians are naturally of a martial spirit, and great numbers of the young men enter the army even at fifteen years of age. They pique themselves upon their descent from the old Christians, who have never intermarried with converted Jews or Moors; and they are equally noted for their regard to religion, and their loyalty to the king. They are serious, grave, sober, rather solitary and retired in their habits, but uniformly distinguished by probity and courage. Their language is a mixture of the ancient Castilian and of the Portuguese, with several expressions of the Latin. They are said to have been the first poets in Spain; and a few of their ancient verses are still retained by tradition. But the chief characteristic of the Galicians is their inclination to emigrate to other provinces in quest of employment, though they can neither be said to be very poor or in want of subsistence at home. It is supposed that not less than 100,000 annually leave the province in this view, many of whom never return. They are uniformly employed as labourers in the time of vintage and harvest, in the two Castiles, and Portugal; and, when they do not appear to assist in these countries, much of their valuable produce, from the slovenly manner in which it is gathered, is actually trodden under foot. The great proportion of servants in all the principal towns of Spain are either Galicians or Asturians, who are generally preferred on account of their fidelity and obedience. They are ready to perform any kind of occupation, however servile, sweeping chimneys, or cleaning shoes; and the porters and water carriers in Madrid, Cadiz, and even at Lisbon, are commonly Galicians: at the same time it must be observed, that the name Gallego, which properly signifies a Galician, is now applied to the occupation as well as to the country; and is given to a person from any other province, exercising the employment of a porter. These Galicians are everywhere remarkable for their submissive dispo-

Population.

Galicia.

sition, and are too often treated like slaves; but their patient endurance is said to proceed from a fear of displeasing rather than from any meanness of spirit; and, in their native country, their character is found to be sufficiently decided. As a proof of the general honesty of the Galicians, it is worthy of notice, that in many parts of the province, but particularly in the vicinity of Orense, where much excellent wine is made, every proprietor deposits the produce of his vintage in vaults, at a little distance from the villages; and, though these cellars are neither guarded by any watchmen, nor even in many cases secured by shut doors, there is no instance of a theft being committed upon the property, thus in a manner delivered over to the public faith. See Laborde's *View of Spain*, vol. ii. (*q*)

GALICIA, or GALLITZIA, is the name given to the southern part of the possessions which the House of Austria acquired at the partition of Poland in 1772. The northern part, called Lodemeria, was an ancient dependance of the kingdom of Hungary. Galicia is separated from Hungary by the Carpathian mountains; and, including Lodemeria, it contains 1280 square German miles, or nearly 3555 square leagues.

The following Table will shew the agricultural state of this province. It contains in metzens, a German measure equal to nearly 5½ French bushels, the annual produce of the province.

Rye	1,148,123	Metzens.
Wheat	415,001	
Barley	793,372	
Oats	1,656,155	
Pease	98,323	
Millet	76,370	
Lentils	76,370	
Forage	3,130,177	Cart loads.
Number of horses in 1780	35,079	
Number of horned cattle	1,556,276	
Draught cattle	38,234	
Farms	3,253	

The following Table will shew the state of its manufacturing industry at the same period of 1780.

Water-mills	4694
Wind-mills	57
Saw-mills	259
Oil-mills	472
Powder-mills	11
Paper-mills	41
Iron forges	40
Manufactories of potash	25
Glass-works	21
Salt-works of various kinds	232

The trade which Galicia carries on with Poland, Hungary, &c. consists principally of grain, cattle, hides, wax, honey, salt, and other productions of its territory.

The following is the number of towns and population of Galicia and Lodemeria in 1780, according to M. Schloetzer.

	Towns	199
	Bourgs	111
	Villages	5575
	Houses	408,447
Christians	Males	1,112,442
	Females	1,093,311
Jews	Males	68,601
	Females	70,472
Total population		2,344,826

Galicia is watered by the Dniester, the San, and several other rivers. Lemberg is the capital of the province.

Galileo.

GALILEO GALILEI, an eminent Italian astronomer and natural philosopher, was born at Pisa, in Italy, on the 15th February 1564, and was the son of Guilia Ammanati di Pescia, and Michelagnolo Vincenzio Galileo, a Florentine nobleman, who distinguished himself by his writings on musical subjects. The earlier years of Galileo were occupied with the study of music and, drawing, in both of which he made singular progress, but as the limited fortune of his father did not permit him to settle his son in a state of comfortable independence, he resolved to educate him as a physician, and after going through the usual course of instruction at Florence, he was entered in 1582, at the university of Pisa as a student of philosophy and medicine. The doctrines of Aristotle, which were then taught in the public schools of Italy, were not congenial to a mind like Galileo's, and he was equally disappointed in the pleasure which he anticipated from the study of physic. He therefore abandoned for ever the medical profession, and devoted himself with unremitting ardour and proportionate success to the study of mathematics. Without the aid of a master he studied the different books of Euclid, and made himself master of the writings of Archimedes, and the other ancient geometers. His fame as a mathematician was soon widely extended; and in the year 1589, before he had reached his 26th year, the Duke of Tuscany appointed him to the mathematical chair in the university of Pisa. In the discharge of his duties as a professor, he incurred the resentment of some of the more violent Aristotelians, whose doctrines he did not scruple to oppose; and his tranquillity and his studies were frequently disturbed by the hostility of his metaphysical enemies. He resolved therefore to change the place of his residence, and he gladly accepted of an invitation which he received to fill the mathematical chair in the university of Padua. He left Pisa in 1592, and continued in his new situation at Padua for 18 years, raising the reputation of the university by the brilliancy of his talents, and diffusing a taste for science through the whole of Tuscany. His affection for his own country, however, induced him to accept, in 1611, the mathematical chair at Pisa, from Cosmo II. Grand Duke of Tuscany, who annexed to it a very handsome pension. The same nobleman afterwards invited him to Florence, with the title of principal mathematician and philosopher to his highness, and continued his former pension, without any obligation to discharge the duties of the professorship.

In these various situations, Galileo's attention was particularly occupied with the subjects of optics and mechanics. During his first residence at Pisa, he was led to the idea of measuring time by the pendulum, by observing the motion of a lamp in the cathedral of Pisa. From reading the treatise of Archimedes, *De his quæ vehuntur in aqua*, he was led to the invention of his *Balance* for determining the proportion of the ingredients in mixed metals. He constructed a glass thermometer, which contained water or air; and in 1597 he invented his geometrical and military compass, of which he published a description at Padua in 1606. In April or May 1609, when he was on a visit to Venice, he was accidentally informed that a Dutchman, of the name of Jansens, had invented an instrument through which distant objects had the same appearance as if they were brought near the eye. Galileo reflected deeply on the subject of this contrivance, and, from his thorough knowledge of the properties of lenses, he was soon enabled not only to discover the principle of its construction, but to complete one of the instruments for his own use. He immediately applied his telescope to the heavens, and made those splendid discoveries of which we have already given a full account in our History of ASTRONOMY, vol. ii. p. 597, and p. 612, 613.

It was during these observations that he was invited to Florence, where he enjoyed the fullest leisure to pursue them with diligence, and to carry on a correspondence with the principal philosophers of Germany, respecting the discoveries which he had made, and the great truth of the earth's motion, which they tended to establish. Galileo had scarcely enjoyed four years of tranquillity at Florence, when the fame of his discoveries, and his sentiments respecting the stability of the sun, reached the ears of the holy inquisition. Formal complaints were laid before that vigilant body; and Galileo was summoned to appear at Rome, in 1615, to answer for the heretical doctrines which he had taught. He was accused of maintaining the motion of the earth, and the stability of the sun; of teaching the same doctrine to several of his disciples; of carrying on a correspondence on the subject with several German mathematicians; and of having published it, and attempted to reconcile it to Scripture in his epistles to Marc Velser, in 1612. A meeting of the inquisition was held on the 25th of February 1616, and they decreed that Galileo should be enjoined by Cardinal Bellarmine, to renounce the doctrines which he taught, and to promise neither to teach, nor defend, nor publish them; and that, if he refused to acquiesce in this sentence, he should be thrown into prison.* On the following day, the 26th of February, Galileo appeared before Cardinal Bellarmine; and having declared that he would abandon the doctrine of the earth's motion, and would neither defend it nor teach it, either in his conversation or in his writings, he was dismissed from the inquisition. The mildness of this sentence was no doubt owing to the interposition of the Grand Duke of Tuscany, and other persons of great rank and influence at the papal court, who took a warm interest in the fate of Galileo. The inquisition, however, was not satisfied with this abjuration. They issued a decree, declaring the new opinions to be heretical and contrary to scripture, and prohibited the sale of every book in which they should be taught.

Galileo returned to Florence, and prosecuted his studies with his usual ardour and success. The opinions which he had disavowed, acquired additional strength from every new discovery. He resolved, therefore, to publish them to the world, but in such an indirect manner as to prevent, if possible, any interference on the part of the inquisition. He accordingly published at Florence, in 1632, his great work, entitled, *Dialogo di Galileo Galilei delle duo massime Sisteme del Monde, Tolemaico e Copernicano.* The subject of the Ptolemaic and Copernican system is here discussed by three speakers, Sagredo, Salviatus, and Simplicius, a Peripatetic philosopher, who defends the Ptolemaic system with much ingenuity against the overwhelming arguments of the other speakers.†

The church of Rome again took alarm at the publication of this work, and Galileo was a second time summoned to appear before the holy inquisition in the year 1633. Although he had now entered the 70th year of his age, yet he was compelled to repair to Rome; and upon his arrival in that city, he was confined to the apartments of the fiscal of the inquisitorial tribunal. By the intercession of the Grand Duke, however, he was permitted to reside in the house of his ambassador during the trial, which lasted about two months. At the end of this period he was brought up to receive the sentence of the court, which was signed by seven cardinals. This sentence, which is one of the most remarkable documents which the history of superstition can present, begins by recounting the former heresies of Galileo, and reminding him of the gentle punishment which had been inflicted. It accuses him of having obtained dishonourably a license for printing his book at Florence, and ordains that he shall, in the most solemn manner, abjure the Copernican system, as contrary to the scriptures; and bind himself by oath never to maintain or support it, either in his conversation or his writings. In order that this great heresy should not pass altogether without punishment, the court also ordained that the sale of his Dialogues thould be prohibited by a public edict; that he should be detained in the prison of the inquisition; and that he should for three years recite once in the week the seven penitentiary psalms, the court reserving to itself the power of modifying or removing this sentence.

The abjuration of Galileo, a copy of which we have given below,‡ was signed on the 22d June 1633, and exhibits a mortifying picture of human imbecility. If

* On the authority of many distinguished writers, we have stated, in our history of ASTRONOMY, that Galileo was thrown into solitary confinement. This, however, is a mistake, as there is abundance of evidence to prove that he was merely threatened with confinement, if he should refuse to acquiesce in the sentence of the inquisition.

† Sagredo, a learned Venetian, and Salviatus, a learned Florentine, were two of Galileo's intimate friends, but were both dead when he published his Dialogues. They had often discussed the same subject with Galileo at Venice, and their names were introduced as a mark of respect to their memory.

‡ "Ego Galilæus Galilæi filius quondam Vincentii Galilæi Florentinus ætatis meæ annorum 70 constitutus personaliter in judicio, et genuflexus coram vobis Eminentissimus et Reverendissimus Dominis Cardinalibus universæ Christianæ Reipublicæ contra hæreticam pravitatem generalibus inquisitoribus, habens ante oculos meos Sacrosancta Evangelia, quæ tango propriis manibus, juro me semper credidisse et nunc credere, et Deo adjuvante in posterum crediturum omne id, quod tenet, prædicat et docet S. Catholica et Apostolica Romana Ecclesia. Sed quia ab hoc S. Officio, eo quod postquam mihi cum præcepto fuerat ab eodem juridici injunctum, ut omnino desererem falsam opinionem, quæ tenet solem esse centrum ac moveri, nec possem tenere, defendere aut docere quovis modo vel scripto prædictam falsam doctrinam et postquam mihi notificatum fueral prædictam doctrinam repugnantem esse Sacræ Scripturæ: Scripsi et typis mandavi librum in quo eandem doctrinam jam damnatam tracto et adduco rationes cum magna efficacia in favorem ipsius, non afferendo ullam solutionem; idcirco judicatus sum vehementer suspectus de hæresi, videlicet quod tenuerim et crediderim, solem esse centrum mundi et immobilem, et terram non esse centrum ac moveri.

"Idcirco volens ego eximere a mentibus Eminentiarum Vestrarum et cujuscunque Christiani Catholici vehementem hanc suspicionem adversum me jure conceptam, corde sincero et fide non ficta abjuro, maledico, et detestor supra dictos errores et hæreses, et generaliter quemcunque alium errorem et sectam contrariam supradictæ S. Ecclesiæ, et juro me in posterum nunquam amplius dicturum, aut asserturum voce aut scripto quidquam, propter quod possit haberi de me similis suspicio; sed si cognovero aliquem hæreticum aut suspectum de hæresi, denuntiaturum illum huic S. Officio aut Inquisitori et ordinario loci, in quo fuero. Juro insuper ac promitto me impleturum et observaturum integre omnes pœnitentias quæ mihi impositæ sunt, aut imponentur ab hoc S. Officio. Quod si contingat me aliquibus ex dictis meis promissionibus, protestationibus, et juramentis (quod Deus avertat) contrarie, subjicio me omnibus poenis ac suppliciis, quæ a Sacris Canonibus et aliis constitutionibus generalibus et particularibus contra hujusmodi delinquentes statuta et promulgata fuerant: sic me Deus adjuvet et Sancta ipsius Evangelia, quæ tango propriis manibus.

"Ego Galileus Galilæi supradictus abjuravi, juravi, promisi et me obligavi ut supra et in horam fidem mea propria manu subscripsi præsenti chirographo meæ abjurationis, et recitavl de verbo ad verbum Romæ in Conventu Minervæ hac die 22 Junii anni 1633.

"Ego Galilæus Galilæi abjuravi ut supra manu propria."

the ignorant zeal of the assembly of cardinals has met with universal condemnation, what must we think of the conduct of a philosopher, who, for the sake of a few years of freedom, could solemnly abjure and renounce opinions which he implicitly believed, and which he had himself established by years of incessant labour? He who has the boldness to maintain opinions in opposition to the vulgar prejudices of the age in which he lives, should have also the fortitude to bear the consequences to which they may expose him. The fame of discovering and defending truth, is in no small degree tarnished by the meanness of afterwards abjuring it; and yet the history of persecution affords more than one example of science having exposed herself to this worst of indignities.

Had Galileo maintained with firmness the truth of his doctrines, he might even have succeeded in disarming the bigotry of his enemies; and if he failed in this, he would have at least secured the approbation of future ages. The truth of the Copernican system was at that time admitted by numerous distinguished and pious individuals, and there were many members even of the Catholic church who found no difculty in reconciling it with the apparently opposite language of scripture. It is a curious fact, which has not been noticed in any of the lives of Galileo which we have seen, that, during the first persecution of Galileo in 1615, or rather before it, an illustrious Neapolitan nobleman, Vincenzio Caraffa, had requested the opinion of Paul Antony Foscarinus, a learned Carmelite, respecting the Pythagorean and Copernican doctrine of the mobility of the earth. In his letter upon this subject, he reconciles the various passages of scripture with the new system, which he considers as well founded. He notices, with praise, the opinions of Galileo and Kepler; and he dedicates his epistle to the chief of the order of the Carmelites. This learned epistle was dated at Naples on the 6th January 1615, and was printed by permission at Florence on the 11th September 1630, three years before the second persecution of Galileo.

When we consider, therefore, that the new system had been promulgated more than a century before the time of Galileo, by Copernicus, who was himself a Roman Catholic clergyman; that the book which contained it was dedicated to the Pope himself; that the Copernican doctrines were embraced by Roman Catholic bishops and cardinals; and that they were maintained with impunity in Italy by some pious Catholics, at the very time when Galileo defended them; we can scarcely hesitate to believe, that Galileo had been a habitual and marked enemy of the Catholic faith, and that the inquisition had seized the opportunity of punishing him for his astronomical opinions, when they were irritated only at his irreligious sentiments.*

Through the influence of some distinguished individuals at Rome, Pope Urban VIII. softened the rigour of the sentence, and confined him for a while to the palace of the Garden de Medici at Rome. On account of his state of health, Galileo was allowed to leave Rome; and as the plague then raged at Florence, he was sent to the archiepiscopal palace at Sienna, the residence of the Archbishop Piccolomini, where he continued the prosecution of his studies, and demonstrated the propositions respecting the resistance of solids. After remaining about five months at Sienna, when the plague at Florence had disappeared, he was allowed to retire to his villa at Bellosguardo, and afterwards to that at Arcetri, in the neighbourhood of Florence, where he spent the remainder of his life.

In this tranquil spot, he observed the phenomena of the moon's libration, he continued his observations on the motions of Jupiter's satellites, and he proposed a new method of finding the longitude at sea, by observing on different meridians the frequent eclipses of these secondary planets. This important subject had occupied his attention before the year 1615, and the secretary of state to Cosmo Grand Duke of Tuscany, had communicated the invention to the Tuscan Ambassador at Madrid, for the information of Philip king of Spain; † but no attempt seems to have been made by the Spanish government to adopt it in their navy. Galileo, however, persuaded of its practicability, offered the use of his discovery to the States General of Holland, through Grotius ambassador to the Queen of Sweden, at Paris. The negociation with the States of Holland was carried on by M. Diodatus, a celebrated French lawyer. The States General eagerly embraced the proposal, and returned a polite letter in answer to Galileo's offer, accompanied with a golden chain as a testimony of their gratitude. Four of the most distinguished Dutch navigators, astronomers, and geographers, were appointed as a committee to examine both the theory of the new method, and the proposal which Galileo had made of a method of diminishing the agitation of a ship, for the purpose of observing the eclipses of Jupiter's satellites. Martin Hortensius, a mathematician at Amsterdam, and William Bleau, a geographer, and both members of the committee, were appointed commissioners to visit Galileo, and receive instructions from him respecting the theory and practice of his discovery. When they arrived at Arcetri, they had the mortification to find that Galileo had recently been deprived of his sight. He communicated to them, however, his views respecting the determination of the longitude, and occupied his hours of study in computing tables of the motions of the satellites of Jupiter. We are not distinctly informed what was the result of this interview; but astronomical instruments were then in an imperfect state, and Galileo's method, though admirable in itself, could be of no practical use, till the eclipses of the satellites could be computed from accurate Tables of their motions.

In the year 1636, when the Count de Noailles, the French ambassador at Rome, was returning to Paris, he paid a visit to Galileo at Arcetri, with whom he had formerly corresponded. Galileo presented him with a manuscript copy of his great work, entitled, *Discursus et Demonstrationes Mathematicæ circa duas novas Scientias pertinentes ad Mechanicam et Motum Localem.* The Count de Noailles shewed this work to several of the philosophers at Paris, and actually sent it to be printed by the Elzivirs at Leyden. Galileo was just preparing to send manuscript copies of the work into Germany, Flanders, England, Spain, and perhaps into some parts of Italy, ‡ when he received a letter from the Elzivirs, stating that the Count de Noailles had put the MS. into their hands, and requesting him to transmit a dedica-

* See our Life of Copernicus, where we have stated some additional reasons for this opinion.

† This correspondence is published in the *Opere di Galileo*, vol. ii. p. 435.

‡ Galileo mentions this fact in the dedication of this work to the Count of Noailles. His hesitation about sending MS. copies into Italy is curious: "et forsan," says he, "in loca quædam Italiæ."

Galileo.

tion as soon as possible. Galileo was delighted with this plan, and drew up, in the most flattering terms, a dedication to the Count, which is dated at Arcetri, March 6th, 1638. This work contains some of his finest discoveries. The doctrine of motion is treated ably and geometrically. The theory of equable motions, and of motions uniformly accelerated and retarded, and of these two combined, is correctly explained. Galileo had the honour of first demonstrating, that the spaces described by heavy bodies are as the squares of the times, and that all projectiles move in a parabolic orbit. He also laid the foundation of the subject of the strength of materials, and treated with much perspicuity the doctrine of the force of percussion.

The last days of Galileo's life were spent in the investigation of the force of percussion, and some other mechanical subjects; and, in consequence of the intensity of his application, he brought on a slow fever, and a palpitation of the heart, which carried him off on the 8th of January 1641, in the 77th year of his age. The death of this great man was universally regretted, and the sciences were considered as having sustained an irreparable loss. His body was carried from Arcetri to Florence, and at the desire of the Grand Duke of Tuscany, he was buried in the church of the Holy Cross, in the ancient sepulchre of the noble family of Galilei.

The most complete edition of Galileo's works, was published at Padua in 1744, in 4 vols. folio. This edition contains numerous annotations, and long commentaries, by several of his disciples. The following is a list of its contents, excluding the commentaries which we have mentioned:

Tom. I. Le Operazione del compasso Geometrico, e militare di Galileo.

Difesa di Galileo contro alle calunnie ed imposture de Baldassar Capra Milanese.

Discorso intorno alle cose, che stanno in su l'Acqua, o che in quella si muovono, di Galileo.

Lettera di Galileo al Sig. Tolomeo Nozzolini.

Della Scienza Meccanica, opera del Galileo con un frammento sopra la forza della Percossa.

La Bilancetta di Galileo.

Trattato del modo di misurar colla vista di Galileo.

Tom. II. Sidereus Nuncius.

Comtinuazione del Nunzio Sidereo.

Istoria e dimostrazioni intorno alle macchie solari, e loro accidenti, comprese in tre lettere scritte al Marco Velseri da Galileo.

Il Saggiatore di Galileo..

Lettera di Galileo al serenissimo principe Leopoldo di Toscana in proposito di quanto discorre Fortunio Liceti del candor Lunare nel cap. 50 del suo Liteosfero.

Lettera di Galileo al (P. Cristoforo Griemberger della Compagnia di Gesu in materia) della montuosita della Luna.

Lettera di Galileo a Monsignor Dini sopra l'uso del Canochiale, e di Pianeti Medicei.

Risposta di Galileo ad un problema propostogli dall' illustrissimo Sig. Pietro Bardi de'Conti di Vernio, *onde avvenga, che l'acqua a chi v'entra appaja prima fredda, e poi calda più dell'aria temperata.*

Lettere di Galileo in proposito de trovare le longitudini per via de Pianeti Medicei, coll'aggiunta d'altre lettere scritte al Galileo intorno alla medesima materia.

Operazioni Astronomiche di Galileo.

Trattato della Sfera, o cosmographia di Galileo.

Lettere di Galileo a Paolo Gualdo, &c.

Tom. III. Dialoghi delle Scienze Nuove, o sia discorsi e dimostrazioni intorno a due nuove scienze attenenti alla Meccanica ed ai movimenti locali di Galileo.

Galileo || Galls.

Lettere di Galileo circa le materie trattate nei dialoghi delle scienze nuove.

Lettere di Galileo, e del P. Castelli del modo di misurare le gocciole d'acqua cadenti sopra una data superficie.

Lettere di Galileo a Curzio Picchena, nelle quali tratta della Calamita.

Lettera di Galileo sopra il Fiume Bisenzio.

Lettere di Galileo, del P. Castelli, e del Nozzolini in proposita della stima d'un Cavallo.

Frammenti di Galileo.

Parere di Galileo intorno all angolo del Contatto.

Postille di Galileo al libro intitolato *Esercitazioni Filosofiche di Antonio Rocco.*

Considerazione di Galileo sopra il Gioco de'Dadi.

Problemi Vari di Galileo.

Pensieri Vari di Galileo.

Tom. IV. Diologo de Galileo delli due massime Sisteme del Mondo, Tolemaico e Copernicano.

For a particular account of the discoveries of Galileo, we must refer our readers to the articles Astronomy, p. 59, 612, 613; Carpentry, p. 500; Dynamics, p. 285; Epicycloid, p. 179; Mechanics, Optics, and Pneumatics. (β)

GALILEO's Temperament of the musical scale. In the Overend MS. works in the library of the Royal Institution in London, vol. i. p. 135, the temperaments of the principal notes in the scale, in fractions of the major comma, as mentioned in the second column of the subjoined Table, are ascribed to the above author, viz.

1	2	3	1	2	3
C	VIII		F※	IV	$-\frac{5}{7}c$
B	VII $-\frac{10}{7}c$	$-\frac{1}{7}c$	F	4 $+\frac{2}{7}c$	$+\frac{2}{7}c$
B♭	7	$+\frac{4}{7}c$	E	III $-\frac{8}{7}c$	$-\frac{1}{7}c$
A	VI $-\frac{6}{7}c$	$+\frac{1}{7}c$	E♭	3 $+\frac{6}{7}c$	$-\frac{1}{7}c$
G※	6 $+\frac{8}{7}c$	$-\frac{16}{7}\Sigma$	D	II $-\frac{4}{7}c$	$-\frac{4}{7}c$
G	V $+\frac{2}{7}c$	$-\frac{2}{7}c$	C※	I	$-\frac{7}{7}c$

But these would produce an extremely irregular douzeave, as appears from the third column, containing the temperaments of a regular douzeave, calculated by Mr Farey's theorems, *Philosophical Magazine*, vol. xxxvi. p. 51, and agreeing very nearly with Dr R. Smith's system of equal harmony. (ϱ)

GALLS, is the name given to morbid excrescences growing on different plants, in consequence of the attacks chiefly of hymenopterous insects. The egg of the insect is deposited in a puncture made with a sharp sting; and when it is hatched, the maggot causes a great degree of luxuriance in this part of the plant, which appears in various excrescences. Galls are found in the two British species of oak. The astringent galls brought from the Levant, and used in dyeing and making ink, are also the produce of a particular species of oak. The best Aleppo galls have generally a bluish, and sometimes a greyish and blackish colour, inclining to bluish. They are of a close compact texture, are difficult to break, and are unequal and warty on the surface. The small, white, and broken galls are by no means good. About 2000 cwt. of galls are annually used in Great Britain, the value of which, at £6 per cwt., is £12,000. The permanent duty upon them is 7s. and the war duty 2s. 4d.

The following Table, given by Mr Milburn, shews the quantity of galls sold at the East India Company's sales, from 1804 to 1808, with their prices.

Years.	March Sale.		Sept. Sale.		Total.		Aver. Price per Cwt.		
	Cwt.	Price.	Cwt.	Price.	Cwt.	Price.	L.	s.	d.
1804	330	£2006	51	£362	381	£2368	6	3	9
1805	71	559	594	3666	665	4225	6	7	0
1806	137	805	186	1167	323	1972	6	2	1
1807	1036	6611	131	665	1170	7276	6	4	4
1808	655	3673	321	1721	976	5394	5	10	6

Twenty cwt. of galls are allowed to the ton. See Olivier's *Travels in Persia*, and the articles Dyeing, p. 243; Ink, and Vegetable Physiology; and Milburn's *Oriental Commerce*, vol. i. p. 137.

GALLE, Point de, is a town in the island of Ceylon, being the third in point of size, built upon a long rocky promontory. The fort is about a mile and a half in circuit, and is situated upon a neck of land, and almost surrounded by the sea. The works are extensive and strong, but it is overlooked by some adjacent eminences. The rooms are large and bricked, the walls are thick, and the ceilings boarded. The houses in the fort are spacious and comfortably furnished. That of the commandant is very extensive. The Europeans live chiefly in the fort, but there are some good large houses built about it, and extending along the shore to the southward. The Cingalese live in cottages and hamlets scattered about in all directions. The houses both in the town and at the harbour are better than those of Trincomalee. The fort is garrisoned by two or three companies of Europeans; half a company of artillery, and a native battalion. The numerous batteries completely command the approach by water. They are in the old fashioned style, elevated on walls. The harbour, particularly the outer road, is spacious, and, excepting in a south-west wind, the inner harbour is secure. The entrance to it is narrow. The part of the bason which is land-locked is very small, but it secures a landing free from surf, which, according to Lord Valentia, beats with prodigious violence on the rocks that form the extreme end of the peninsula. On one of these rocks is erected the flag-staff, which therefore stands without the fort. A canal has been dug between the bay and a small river, for the purpose of conveying timber from the interior. It is, however, now in ruins. "We had here," says Lord Valentia, "excellent yams, good sallading, and cucumbers. The fruits were bad, mangoes, guavas, custard apples, cocoa nuts, varieties of oranges, some of which were black on the outside, and others the true mandarin, shaddocks, &c. The mutton is indifferent; but the beef, the poultry, the bread, and the fish are excellent. At Galle is a neat manufacture of tortoise shell." The coast and the surrounding country is very mountainous. The greatest quantity of rain falls between November and February. Arrack, oil, pepper, cotton, and cardamoms, are among its exports. East Long. 80° 20′, and North Lat. 6° 4′. See Percival's *Account of Ceylon*, and Valentia's *Travels*, vol. i. p. 266.

GALL, St, is the name of a town in Switzerland, and the capital of a canton of the same name. It derives its name from the ancient abbey of St Gall, situated within the walls of the town. The town is situated between two mountains, upon the small brook of Steinach. The seat of the cantonal government is in the chateau of the abbey. The Catholic clergy inhabit the monastery, which contains the library of the convent, now the library of the canton. It contains very valuable manuscripts relative to the history of the middle ages. The town library, which contains that of Vadianus, is kept in the college, which was founded in 1598. The collection of Vadianus contains many precious manuscripts, among which is a chronicle comprehending 13 folio volumes of letters of the most celebrated Swiss and German reformers. This library also possesses a cabinet of petrifactions, collected in the neighbouring country. There is a good collection of paintings and prints in the house of M. de Gonzenbach, and a cabinet of natural history in that of Doctor Zollikofer.

St Gall has always been celebrated as a manufacturing town. In the 13th century, great quantities of linen cloth were manufactured here, and at the epoch of the Council of Constance, 1414—1418, such crowds of workmen from that city settled in St Gall, that it became necessary to enlarge the town. The principal articles of manufacture, are linen goods, muslin, and cotton cloth. The inhabitants of Swabia, and of the mountains of Breghentz, were employed in spinning and embroidery by the manufacturers of St Gall; and towards the end of the 18th century, the number of embroiderers amounted to 30,000 or 40,000. The price of a piece of muslin richly embroidered in gold or silver, sometimes amounted to 60 Louis. The muslins embroidered in white are generally fabricated out of the town in the cottages of the forest of Breghentz. About the beginning of the present century, spinning machines, like those used in this country, were erected in St Gall, and in a few years a great number of these machines were in full activity, in consequence of the exclusion of English manufactures from the continent. All the environs of St Gall are covered with bleachfields.

The most interesting promenades and prospects at St Gall, are near the convent of Notkerseck; at Vogliseck, about a league from the town; at the Chateau of Warteck, from which there is a view of almost all the lake of Constance; and at the Chateau of Dottenwyl. The bridge of St Martin is well worthy of attention. It is built over a wild gorge upon the Goldach. It is the work of Hungewerk, and is constructed upon the same principle as the famous bridges of Schauffhausen, Wettingen, and Reichenau. Population of the town 9,000.

GALL, St, *Canton of*, one of the largest cantons of Switzerland, extends from the lake of Constance to that of Zurich, and almost to Kunkelsberg on the confines of the Grisons. It contains forty square geographical miles, or nearly 111 square leagues. Independently of the capital, it has nine towns and 15 convents, of which 11 are female ones. In the districts of *Sargans*, *Utznach*, *Upper Tockenbourg*, and *Rhinthal*, which contain mountains from 7000 to 8000 feet high, the people are principally employed in rearing cattle. In the other districts, viz. that of *St Gall*, *Gossau*, *Lower Tockenbourg*, and *Roschach*, there are many fine hills and cultivated mountains, with vallies covered with corn fields, vineyards and orchards. The canton of St Gall contains a small portion of the lakes of Zurich and Constance, the greater part of that of Wallenstadt, and some small lakes situated in the Alps. It has 10 rivers, viz. the Rhine, the Tamin, the Saar, the Seez, the Linth, the Thour, the Necker, the Glatt, the Sitter, and the Steinach. Population in 1803, 130,301, of whom nearly one half are Catholics.

GALLEONS. See Acapulco and Spain.

GALLICIA. See Galicia.

GALLIC Acid. See Chemistry, p. 61.

GALLIPOLI, from καλλος *beautiful*, and πολις *a city*, a town of Italy, in the kingdom of Naples, and province of Otranto, is built upon a rock connected with the continent by a long bridge. It is situated at the heel of the boot, at the very extremity of the kingdom. The town, which is well built, is hollowed out below into subterraneous vaults for containing the oil, which forms the staple trade of this town. The country near Gallipoli furnishes enough of corn, wine and fruits, for the consumption of the inhabitants; and muslin and other articles are manufactured out of a species of cotton which is raised. The duty of export upon the oil is fully 40 per cent. as the king receives five carlins of oil out of every last, which consists of 12 or 13 carlins. The oil, when placed in the subterraneous vaults already mentioned, is purified and bettered in its quality by fermentation, which is occasioned during summer; but this produces in these vaults a heat which is almost unsupportable. In the year 1766, there was exported from Gallipoli to the other parts of the kingdom, 1395 lasts of oil, and out of the kingdom 17,323 lasts; besides 43 cantari of spun cotton, and 247 cantari of cotton wrought in different ways. Briganti reckons the average export of oil at 993,804 Neapolitan ducats. Population 8,000. East Long. 15° 58′, North Lat. 40° 29′.

GALLIPOLI, is the name of a seaport town of Turkey, in the province of Romania. It is situated on the Sea of Marmora, on a peninsula which has two harbours, one on the south and the other on the north. The Bazar is a fine edifice, with several domes covered with lead. The adjacent territory abounds in grain, wines, fruits, and particularly in excellent melons. There is plenty of deer, hares, patridges, and ducks. The cotton collected in the neighbourhood is inferior to that which comes from Smyrna and Salonica. Wool of different kinds, and excellent wax, brought from the different countries on the Black Sea, are shipped in the harbour of Gallipoli. Population about 10,000 Turks, 3,500 Christians, and a smaller number of Jews. East Long. 26° 37′ 30″, and North Lat. 40° 25′ 33″.

GALLON. See MEASURES.

GALLOWAY, the name of a district in Scotland, comprehending the shires of KIRKCUDBRIGHT and WIGTON, which see.

GALVANI, LEWIS, a physician and physiologist, whose name has obtained a very unusual degree of celebrity, in consequence of his having discovered the rudiments of a new branch of science, which was called after him, Galvanism. The history of this discovery will be detailed in the following article; at present we shall confine ourselves entirely to the biographical events of his life. He was born at Bologna in 1737, and was a member of a respectable family in that city, several of whom had distinguished themselves in the exercise of the professions of law and divinity. From his early youth he appears to have been of a serious and devout turn of mind, and it is said that he was so much attached to the discipline of the Romish church, as to have resolved to enter into one of the monastic orders. He was, however, dissuaded from this resolution, and he engaged in the study of medicine, and the collateral branches of natural philosophy. In the course of his education, he became a domestic pupil of Professor Galeazzi, and he so endeared himself to the family by his amiable disposition, that he formed a matrimonial connection with the professor's daughter. This lady seems, from all accounts, to have been distinguished both for her virtues and her talents; Galvani bore the tenderest regard for her; and when in the year 1790 she died, after a long series of ill health, it threw him into a state of melancholy from which he scarcely afterwards recovered. It appears that the discovery, which gave so much celebrity to his name, was, in some measure, due to the sagacity of Madam Galvani, for the original phenomena were noticed by her in the absence of the professor, and were reported to him as something that deserved his particular attention.

In the year 1762, he took his medical degree at Bologna, and wrote a thesis on the subject of the bones, shortly after which he was appointed a public lecturer both in the University and in the Institute of that city. He is said to have been particularly happy in his manner of lecturing, and to have acquired a high reputation as a diligent cultivator of the science of comparative anatomy. His reputation in these departments was, however, confined to his native country, and he was little known to the rest of Europe, when in the year 1792 he published a work which immediately brought him into general notice. It was entitled, *A Commentary on the Powers of Electricity in Muscular Motion*; it contained an account of his discoveries on the effects of electricity in producing the contraction of the muscular fibre, and the hypothesis which he adopted to explain its action. His opinion that the electricity in these cases was inherent in the animal body, and was excited without the aid of any external cause, is now generally thought to be incorrect, and indeed the discoveries that have been since made have so extended the science, that the original treatise can now be regarded as valuable, merely because it presents the first sketch of those facts, which have been since developed in so surprising a manner.

Galvani's philosophical pursuits do not appear to have engrossed all his time, for he continued to exercise his duties both as a public lecturer and a medical practitioner, with great assiduity; he also devoted a portion of his leisure to the society and correspondence of literary men, in which he appears to have taken much interest. His domestic happiness, as we have related above, received a very severe shock from the death of his wife, and he was afterwards called upon to exercise his fortitude in a different way, when he manifested a degree of firmness, which must be regarded as highly praiseworthy, even although we may conceive it to have been carried beyond the necessary limits. In the new division of Italy, which took place after the conquests of the French, the city of Bologna was included in the Cisalpine Republic; and all the public functionaries were required to take the oath of allegiance to the new government. This, however, he refused, as is supposed, in consequence of the irreligious character of the principal leaders in France at that time, and he was accordingly stripped of his offices and emoluments. In this emergency, much dejected in his spirits, and probably reduced to a state of pecuniary embarrassment, he was received into the house of a near relation, and fell into a state of extreme weakness. Upon these circumstances being made known to the government, they appear to have felt a degree of regret, for their harsh behaviour towards a man, who had so many claims to respect, both from his private virtues and his public labours, and a decree was passed for restoring him to his honours and emoluments. But his frame was too much exhausted to derive any benefit from this favourable change in his prospects, and he died towards the conclusion of the year 1798, in the 61st year of his age. See *Eloge de Galvani*, par Alibert. (α)

GALVANISM.

Introduction.

Galvanism is a branch of natural philosophy, which has originated within the last twenty-five years, and derives its name from Galvani, professor of anatomy at Bologna. He had the good fortune to make some observations on the electricity of the muscles of frogs, that appeared to him to depend upon a new power in the animal body; and although it is now generally admitted, that he drew an erroneous inference from his observations, yet they led to a train of experiments, which have associated his name with some of the most brilliant discoveries of modern science. To the supposed new power he gave the name of *animal electricity*; conceiving it to depend upon something inherent in the animal body itself; but we now regard these effects as produced by minute quantities of the electric fluid, set at liberty by a certain agency of substances upon each other.

Definition.

Galvanism may be defined, a series of electrical phenomena, in which the electricity is developed without the aid of friction, and where we perceive a chemical action to take place between some of the bodies employed.

Plan of the article.

In treating upon this subject, we shall arrange our materials into two divisions. We shall begin by an historical detail of the discoveries that have been successively made, from the time of Galvani's first observation, to the present period; and, in the second place, we shall give an account of the theories and hypotheses that have been formed to explain the phenomena of galvanism.

Part I. HISTORY.

History.

Sect. I. *Experiments before the Discovery of the Pile.*

Galvani's first discovery.

The original discovery, to which we have already alluded, took place from a singular accident. The wife of the philosopher, being in a declining state of health, employed as a restorative, according to the custom of the country, a soup made of frogs. A number of these animals, ready skinned for the purpose of cookery, chanced to lie in Galvani's laboratory, on a table near the electrical machine. While the machine was in action, an attendant happened to touch, with the point of a scalpel, the crural nerve of one of the frogs, that was not far from the prime conductor, when it was observed, that the muscles of the limb were instantly thrown into strong convulsions. This experiment was performed in the absence of the Professor, but it was noticed by his lady, who was much struck with the appearance, and communicated it to her husband. He repeated the experiment, varied it in different ways, and perceived that the convulsions only took place when a spark was drawn from the prime conductor, while the nerve was, at the same time, touched with a substance which was a conductor of electricity. At the time that this accidental discovery was made, Galvani was engaged in a set of experiments, the object of which was to prove, that muscular motion depends upon electricity; and it appeared, in a very remarkable manner, to confirm his hypothesis; so that he was induced to prosecute the inquiry with redoubled diligence. See *Eloge de Galvani*, par Alibert.

Prepared frog a very delicate electrometer.

When a frog was so placed as to form part of the electric circuit, it was found that an extremely minute quantity of electricity produced contractions in the muscles. If the hind legs were dissected from the body, the connection being kept up by the crural nerves only, and the electric fluid was passed through it in this state, a still more minute quantity was rendered visible; so that a frog, prepared in this manner, was capable of exhibiting very decisive marks of electricity, where none could be detected by Bennet's gold-leaf electrometer.

Discovery of proper galvanism.

After employing the electric fluid, as disengaged from the common machine, he next tried the atmospherical electricity; and it was in pursuance of this object, that he was first led to observe the effects of galvanism properly so called. Having suspended a number of frogs by metallic hooks to an iron railing, he found that the limbs were frequently thrown into convulsions, when it did not appear that there was any electricity in the atmosphere. Having duly considered this phenomenon, he discovered that it did not originate from an extraneous electricity, but that it depended upon the position of the animal, with respect to certain metallic bodies.

Action of two metals.

It appeared, that when the muscle and nerve of a frog were each in contact with metallic bodies, and these were also connected by a metal, the contractions were always produced. The effect was considerably increased by *arming* the nerve with a metallic coating, by which means a larger portion of it was brought into contact with the metal. But the most important of Galvani's discoveries was the effect produced by the combination of two metals. Of these combinations the most powerful was that of zinc and silver, and the most violent convulsions ensued when the nerve was coated with one of these metals, the muscle placed in contact with the other, and the two metals connected by a conductor of electricity.

Plate CCLXIII. Fig. 19.

General conclusions.

Galvani's general conclusion from his experiments was, that the animal body possesses an inherent electricity of a specific kind, which is connected with the nervous system, and conveyed by means of the metals into the muscles, so as to throw them into convulsions. He deduced a theory of muscular motion from his discoveries, according to which the body contains an apparatus analogous to the Leyden phial, the muscles and nerves being in different states of electricity, and the metals forming a connection between them, by which the electricity is equalized. In this application of the new phenomena, Galvani went beyond the limits of correct deduction; yet he deserves much commendation for the perseverance and ingenuity which he exhibited in prosecuting the inquiry. Although the discovery originated, in a considerable degree, from accident, still it must be remembered, that it is only men of ability who take advantage of such accidents. In the year 1792, he published an account of his discoveries and theories, under the title of *A Commentary on the Powers of Electricity in Muscular Motion.*

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Valli's letters, 1792.

Galvani had no sooner published an account of his discovery, than the philosophers, in different parts of Europe, entered with eagerness upon the examination of the new phenomena. The earliest writers on the subject were Valli, Fowler, and Volta. The principal object of Valli's letters, which appeared in the *Journal de Physique*, was to examine how far the opinion of Galvani was correct, respecting the dependence of the new influence upon the nervous fluid, and its identity with electricity. Although much of his reasoning must now be regarded as erroneous, yet still he displays considerable ingenuity and address in the contrivance of his experiments, and in the inferences which he deduced from them.

Fowler's Essay on Animal Electricity, 1793.

In the following year, Dr Fowler published an *Essay on Animal Electricity*, in which he displays an acute and sagacious mind, and may be considered, by his observations, to have paved the way for many of the discoveries of his successors. At the time when he wrote, the question was warmly agitated, whether the phenomena of galvanism could be referred to the electric fluid, or whether they do not depend upon some specific agent peculiar to the animal body. He commences by the inquiry, "Are the phenomena exhibited by the application of certain different metals to animals referable to electricity?" Although he conducts his train of reasoning with much ability, yet he drew the conclusion which we are now enabled to say is not correct. After examining minutely the circumstances which are necessary for the production of the galvanic influence, he finds that it is requisite that there should be two different metals, which are to communicate with each other and with the animal. He conceives it necessary that they should be in contact, one with the nerves, and the other with the muscles, and points out an error, into which Valli had fallen in his experiments, where he thought that the contact of the nerve only is sufficient to cause the contractions: he shews that, in this case, the moisture on the surface of the nerve acted as a conductor of the influence of one of the metals to the fibres of the muscle.

Are galvanism and electricity the same?

Dr Fowler concludes that the galvanic influence is not referrible to electricity, because for the production of the former, the presence of two different metals appears to be necessary, while electricity, as proceeding from the electrical machine, is excited by the action of an electric upon a conductor; an inference which was correct, according to the state of the science at the time when he wrote. He also endeavours to show that electricity and galvanism are not, in all cases, conducted by the same substances, and particularly adduces charcoal, which, although a conductor of electricity, is impervious to the galvanic influence. He afterwards made some curious observations upon the effect of galvanism on animals not furnished with distinct limbs, such as worms of various kinds. These animals could not be made to contract, yet by the nature of their motions, they seemed to be sensible to the impression of the two metals, when they were placed, partly on one, and partly on the other.

Effect on the voluntary and involuntary muscles.

Dr Fowler afterwards enters upon an interesting inquiry respecting the effect of galvanism on the different parts of the body. "What are the relations which subsist between the influence discovered by Galvani, and the muscles, the nervous, and the vascular systems of animals?" He found that the contractions were very readily excited in all the muscles which are subservient to the will, but that they were with great difficulty produced in the heart, and that they could not be rendered perceptible in the stomach and intestines. He observed that when a part is in a state of inflammation it acquires an additional sensibility to the galvanic stimulus, and he made the curious discovery of the flash of light, which is produced by placing the two metals in contact with the ball of the eye, and then causing them to communicate with each other. Sultzer, a German metaphysical writer, had mentioned several years before, the effect produced on the organ of taste, by applying two metals, one above and the other below the tongue, and then bringing them into contact; but the sensation was ascribed to a peculiar vibration excited by the metals, and conveyed to the tongue. The experiments with the two metals, upon the eye and the tongue, were varied in different ways by Professor Robison, an account of which is published at the end of Dr Fowler's *Essay*. Professor Robison mentions the sensation of taste which is excited, when the tongue is applied to the edges of a number of plates of zinc and silver, placed alternately upon each other; a construction which may be regarded as an approximation to the apparatus afterwards discovered by Volta.

Effect on the eye and tongue.

Robison's experiments.

Volta's letters, 1

In the same year in which Fowler's *Essay* was published, a very important communication appeared in the Philosophical Transactions of London, from the pen of Volta, in the form of letters to Cavallo. He gives a luminous account of Galvani's discovery, and adds many curious experiments and valuable remarks of his own. He attempted, and with complete success, to overthrow Galvani's opinion, that the animal body bears an analogy to the Leyden phial, the nerve and the muscle being in opposite states of electricity. He found that for the production of the effect it was essential to have two different metals, and hence he arrived at the important conclusion, which may be regarded as leading to all his future discoveries, that the muscular contractions are produced by small portions of electricity, that are liberated by the action of the metals upon each other. Another point which Volta established was, that the nerve is the organ on which the galvanic influence immediately acts; but he found that if a part of a muscle be laid upon two different metals, and these be made to communicate, a contraction is produced. This probably depends upon the nervous matter that is dispersed through the muscles, and also upon the moisture that is always present, and which serves to conduct the electricity to all parts of the body. Volta performed many experiments in order to discover, what circumstances are favourable to the excitation of the contractions, and upon the parts of the body which are the most easily called into action. His observations agree, in many respects, with Fowler's, although it is certain that their experiments must have been made without concert or communication. He found that snails and worms could not be made to contract, but that many of the insects, as butterflies and beetles, were subject to the influence of the metals. It appeared from his numerous trials, that those animals alone were sensible to galvanism, who are furnished with distinct limbs, having flexor and extensor muscles. In the animals of this description, it appeared that it was the voluntary muscles alone which are capable of being made to contract. Although the heart is a muscle which is easily thrown into powerful action, by chemical or mechanical stimuli, yet he could never produce any effect upon it by the action of the two metals. Volta made some of the same observations upon the effect of the two metals on the organs of sense, as have been mentioned in our abstract of Fowler's *Essay*.

History. Dr Wells's paper, 1795.

Dr Wells wrote an interesting paper on galvanism, which was also published in the Philosophical Transactions of London He proposed three distinct objects of inquiry, which, at the time when he wrote, embraced the points that were the most general subjects of discussion. He first inquires, whether the influence discovered by Galvani depends upon any property inherent in the animal body, or peculiar to it. In the second place, he inquires into the conditions that are necessary for its excitement: And lastly, he examines how far it ought to be considered as identical with electricity. Dr Wells coincides in opinion with Volta, that the contractions of the muscles depend upon electricity liberated by some cause, independent of the animal body, and that the moisture, which is present in all parts, is the immediate cause of the facility with which the effect is produced. He discovered the important fact, that charcoal may be employed, together with one of the metals, for exciting the influence; and also that the influence, when excited, may be conducted by charcoal. He argues at length against the hypothesis of Volta, respecting the production of the electricity by the contact of the two metals, and urges as a decisive objection to it, that the moisture which is attached to the animal, ought to serve as a conductor, and equalize their electrical condition, without their being absolutely brought into contact.

Dr Wells made some curious experiments upon the effects that were produced on the power of the metals and on charcoal by friction; after this operation he found that one of the substances alone was sufficient to produce the contractions. As it appeared that the friction did not immediately communicate electricity to the body that was rubbed, it must be supposed, that some change was brought about in its nature, by which its different parts were enabled to act upon each other, in the same manner with two distinct substances. He is decidedly of opinion, that galvanism is identical with electricity, because every substance which is a conductor of one of these principles, is also a conductor of the other.

Committee of the French Institute, 1798.

A very ample and elaborate memoir, on the subject of animal electricity, was drawn up by a committee of the French Institute, which, besides examining all the opinions and controversies that existed on the subject, contained an account of a great variety of original experiments. The committee was composed of some of the most celebrated chemists and natural philosophers of France; Guyton, Fourcroy, Vauquelin, Hallé, Coulomb, Sabbatier, Pelleton, and Charles. They arrange the materials of their report under six heads; 1. They examine the different circumstances which influence the nature of what they call the animal arc, by which they mean, that part of the galvanic circle which consists of the parts of the animal. They conceive that the animal arc may consist of nerve only, but in this opinion it is probable that they were mistaken. They found that cutting a nerve across did not prevent the passage of the influence, provided the cut ends were laid close together, and also that it was transmitted through different parts of the same animal, or even through parts of different animals, provided they were in perfect contact. They observe, that when a nerve is made part of the circle, those muscles are thrown into contractions to which the extremities of the nerve are distributed, not those which are contiguous to the trunk of the nerve. In the 2d place, they examine the nature and disposition of what is called the excitatory arc, or the metallic part of the circle. 3d, They inquire into the circumstances which enter into the action of the galvanic circle, and in any way influence its effect. The 4th head consists of the means which may be employed for varying, diminishing, or restoring the sensibility of the animal to the galvanic influence. In this part, they mention the effects of immersing the animal in a fluid, or in an unrespirable gas, so as to produce suffocation, when the susceptibility to the galvanic influence was either destroyed or much impaired; but the effects were very various, and difficult to account for in many cases. The 5th head consists of a comparison between electricity and galvanism; and the 6th contains a detail of some experiments which were performed by Humboldt, and subjected to the inspection of the committee. Many of Humboldt's experiments were curious and interesting; but they appear not to have been, in all cases, very accurate; for he concludes from them, that some substances, which were good conductors of electricity, would not conduct galvanism. See *Annales de Chimie*, xx. 51.

Humboldt's experiments.

Fabroni's paper, 1799.

An ingenious paper was about this time published by Fabroni, in which he discusses the question, whether the galvanic phenomena are immediately referrible to electricity, or whether they ought not rather to be attributed to chemical affinity? He relates many observations, that he made upon the chemical action of different metals on each other, when placed in contact, and shows, that they were then disposed to oxidate under the same circumstances, except that of being in contact, where, if separate, no effect would have been produced. He argues, that the facts stated by Galvani, Volta, and others, which were conceived by them to prove the electrical nature of the phenomena in question, only went so far as to shew, that electricity was concerned in the operation, but did not prove it to be the cause of them; and he is inclined to regard it rather as the effect.

Fabroni mentions among other facts, that mercury and tin when pure, and kept distinct from other metals, will remain a long time without tarnishing, but when alloyed, or kept in contact with other metals, they soon begin to exhibit signs of oxidation. He remarked, that coins composed of a pure metal were more durable than such as were composed of a mixture of metals. He mentions the corrosion which takes place, when copper roofs are soldered with another metal, and in the copper sheathing of ships when fastened with iron nails. These phenomena are supposed to depend upon a chemical affinity between the metals, by which their particles are individually attracted towards each other, while the separation of the particles of the solid metal, which is caused by their tendency to unite, permits the oxygen to act upon them. "These facts," he says, "as well as many others of the same nature, no less common than well known, ought to have proved to philosophers, that the metals, by exercising their mutual attractive force, must by the same energy diminish their respective powers of aggregation; that though neither of them separately may be able to attract oxygen from the atmosphere, or from water, they may acquire that power by simple mechanical touch as they pass to new combinations."

He then relates some experiments which he performed, in order to observe the comparative effect produced, by placing metals first in separate vessels of water, then in the same vessels, but not in contact; and lastly, in the same vessels, and also in contact. In the two former cases there was no change produced, while in the latter there was a considerable degree of oxidation. He afterwards entered upon some speculations

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on the source of the oxygen, and he found that, by covering the water with a stratum of oil, and thus excluding the atmosphere, the process of oxidation was retarded. This fact he adduces as a powerful argument in favour of the chemical hypothesis. He concludes, that the oxygen in these cases cannot be derived from the water, because were the water decomposed there would be a liberation of hydrogen. The effect that is produced on the senses of vision and of taste, he attributes to the formation of new chemical compounds, which act in a peculiar manner upon the organs; an opinion which may be true, to a certain extent, so far as respects the tongue, but it is not easy to conceive how it could cause the flash of light which is excited in the eye by the contact of the metals. See *Journal de Physique*, xlix. 348.

Fabroni's paper did not appear to excite much attention at the time when it was published, as it directly opposed the current of popular opinion. But many of the statements have been since verified by succeeding philosophers; and when we consider that it was written before the discovery of the pile, it must be regarded as displaying much sagacity and nice observation.

In this state, the science of galvanism remained until the year 1800. It was generally admitted, that the immediate agent in producing the phenomena was the electric fluid, and that the actions exhibited by the animal body depended merely upon its extreme sensibility to small quantities of this fluid. The experiments principally consisted in different combinations of conducting substances with parts of the animal body, composing what was called the galvanic arc or circle. The chemical effects had been little attended to, except by Fabroni; and his remarks, although truly ingenious, must be regarded rather as the first glance of a series of important facts, than as constituting their complete developement.

SECT. II. *Experiments from the Discovery of the Pile to the Decomposition of the Alkalies.*

Discovery of the pile by Volta, 1800.

The second period of the history of galvanism commences with the important discovery made by Volta, of the instrument which has been called the *galvanic* or *voltaic pile*. Volta, as we have seen above, adopted the idea, that the action excited by the two metals, depended upon an alteration in their respective states of electricity, or in a destruction of its equilibrium. The effect produced by one pair of plates could only be comparatively small; but he supposed that by interposing a conductor between several pairs of plates, it might be multiplied and concentrated in an indefinite degree.

Description.

PLATE CCLXIII. Fig. 1.

He accordingly provided a number of silver coins, and pieces of zinc of similar dimensions; these were disposed in pairs, and between each pair was placed a piece of card soaked in water; and thus a pile or column was formed, in which the three substances silver, zinc, and water, existed in regular rotation. The effect of the combination fully justified the expectations of the discoverer.

Effects.

All the phenomena that had been excited by a single pair of metals were far exceeded by those of the pile, while by touching the two ends of it at the same time, it was found that a distinct shock was felt in the arms. This fully established the opinion that had been formed, and was generally adopted, of the identity of electricity and galvanism; although there were still some circumstances connected with the latter, which appeared not to be completely analogous to the usual operations of the electric fluid.

Galvanic shock.

He found, that 40 pairs of the metallic discs, with the proper number of pieces of moistened card interposed, were sufficient to produce a shock, which was very distinctly felt in the hands and arms, and that by increasing the number of pairs, the power of the pile was proportionally augmented. In order to produce the full effect, it was found necessary that two pieces of metal, either composing the extremities of the instrument, or in contact with them, should be firmly grasped by the two hands; and the shock might, in this case, be repeated for any number of times, as long as the pasteboard between the two metals remained sufficiently moist. Volta conceived, that the newly invented apparatus was analogous in its action to the electrical organ of the torpedo. The experiments that he performed with it, were almost exclusively confined to the animal body; and he appears to have entertained no idea of the important use which would afterwards be made of the pile, as an instrument of chemical analysis. It is indeed a little remarkable, that after making so curious a discovery, he should have rested there, and not have proceeded with the farther prosecution of the subject. It would be unjust not to acknowledge, in the warmest terms, the obligation under which the scientific world was laid by the discovery of Volta; but, at the same time, it must be admitted, on the other hand, that the benefit of the discovery has been obtained by others. An account of the pile was written by Volta, in the form of two letters to Sir Joseph Banks, which were published in the Philosophical Transactions of London for the year 1800.

Nicholson and Carlisle's experiments.

No sooner was the discovery of the galvanic pile announced, than the English experimentalists began their operations with it, and almost at the first trial of its effects, made some important and interesting observations. Sir Joseph Banks, on the receipt of the letters, having communicated the information to his scientific friends, a pile was formed by Messrs Nicholson and Carlisle, with which they began to repeat the experiments of Volta. They arranged the substances in the order of silver, zinc, fluid; silver, zinc, fluid, &c.: an arrangement which it is necessary to attend to, in speaking of what have been called the silver and zinc ends of the apparatus. Volta, it appears, had satisfied himself that the action of the pile was electrical, because it produced the shock; but Messrs Nicholson and Carlisle applied to it the instrument called the revolving doubler, (See ELECTRICITY, p. 526), and by this means decidedly proved it to be the case: They found, that the silver end was in the minus, and the zinc end in the plus state of electricity.

Discover[y of] the + a[nd] — states

Decompo[si]tion of w[a]ter in th[e] interrupt[ed] circuit.

In the course of the experiments, a part of the circuit between the upper and lower ends of the pile was formed by water; and it was observed, that there was a disengagement of gas, at the part where the wire came in contact with the fluid. This gas was thought to have the odour of hydrogen; and it led them to notice, with more attention, the effect produced by causing the electricity to pass through a tube of water, into the two ends of which wires were inserted, which communicated with the extremities of the pile. We shall relate this very important experiment in Mr Nicholson's own words. "On the 2d of May we inserted a brass-wire through each of two cocks, inserted in a glass tube of half an inch internal diameter. The tube was filled with new river water, and the distance be-

History. tween the points of the wires in the water was one inch and three quarters. This compound discharger was applied, so that the external ends of its wire were in contact with the two extreme plates of a pile of 36 half-crowns, with the correspondent pieces of zinc and pasteboard. A fine stream of minute bubbles immediately began to flow from the point of the lower wire in the tube, which communicated with the silver, and the opposite point of the upper wire became tarnished, first deep orange, and then black. On reversing the tube, the gas came from the other point, which was now lowest, while the upper, in its turn, became tarnished and black."—"The product of gas, during 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."

[...]l the body [...] the pile. They observed, that the same process of the decomposition of water is carried on in the body of the pile, as between the two ends of the wire in the interrupted circuit; the side of the zinc next to the fluid being covered with oxide in two or three days, and the apparatus then ceasing to act. Mr Nicholson found, that, by using metallic plates of considerably more extensive surface, no greater effect was produced in the decomposition of water, or in the violence of the shock; so that he concludes, "the repetition of the series is of more consequence to this action than the enlargement of the surface." It was now clearly ascertained, that the electricity of the silver or minus end was negative, that of the zinc or plus end positive. Although it appeared evident that there had been a decomposition of water effected by the copper wire, yet Mr Nicholson determined to render the operation more decisive, by employing a metal which was not oxidable. Platina was therefore substituted for the copper, and now gas was disengaged from both sides, and neither of the wires were tarnished. In a subsequent experiment, the wires were so managed, that the gases extricated from each side were kept distinct, and it was found that they consisted, the one of oxygen, and the other of hydrogen, and that in the proportion necessary to produce water. In some of these experiments the spark was visible (Nicholson's *Journal*, 4to, iv. 179.) Our readers will at once perceive the important views that were disclosed by the experiments related in this paper, in connexion with those performed by Mr Cruickshanks of Woolwich, of which we shall next give an account. They must be regarded as leading directly to the wonderful discoveries that have been made by means of the galvanic apparatus, as well as the theoretical deductions to which it has given rise, and which have produced almost a complete revolution in our ideas of the action of bodies upon each other.

[...]atina [...]res pro[...]ced both [...]drogen [...]d oxygen. [...]LATE [...]CLXIII. [...]g. 6.

[...]uick[...]anks's experiments.

Mr Cruickshanks confirmed the observations of Messrs Nicholson and Carlisle, respecting the actual appearance of sparks and the decomposition of water. This last process he varied in different ways. By employing the interrupted circuit with silver wires, and passing the influence through water tinged with litmus, he found, that the wire connected with the zinc end of the pile communicated a red tinge to the fluid contiguous to it; and afterwards, by employing water tinged with Brazil wood, he found that the wire connected with the silver end of the pile produced a deeper shade of colour in the surrounding fluid. Hence it appeared, that an acid was formed in the former, and an alkali in the latter case. The galvanic influence was passed through the interrupted circuit, in which the tube was filled with the solution of acetate of lead, when it was observed that the lead was separated in the metallic state, and deposited at the end of the *silver wire*, or the wire connected with the silver end of the pile, in the form of fine needles. Experiments were afterwards made upon the solutions of sulphate of copper and nitrate of silver: in this last case, he observes, "the metal shot into fine needles, like crystals articulated or jointed to each other, as in the *Arbor Dianæ*." He also succeeded in decomposing some of the neutral salts. See Nicholson's *Journal*, 4to, iv. 187.

[...]cid and [...]kali pro[...]ced in the [...]ter.

Metals revived from metallic solutions.

In a second memoir, Mr Cruickshanks paid more particular attention to the nature of the gases emitted in the interrupted circuit—to the effects of different kinds of wires—and to the influence of the fluid medium upon the decomposition of the water. Some of his most important conclusions are, that from the wire connected with the silver or copper end of the pile, whatever be its composition, if it terminate in water, the gas emitted is chiefly hydrogen; if it terminate in a metallic solution, the metal is reduced, and is deposited at the end of the wire. When the wire connected with the zinc end is formed of a perfect metal, nearly pure oxygen is disengaged; when of an oxidable metal, it is partly oxidated and partly dissolved, and only a small quantity of oxygen is liberated. When fluids contain no oxygen, they appear to be incapable of transmitting the galvanic influence; while, on the contrary, it would seem that it may be transmitted by every one which contains this element, (Nicholson's *Journal*, 4to, iv. 258.) These views of Mr Cruickshanks respecting the action of the pile were confirmed by some experiments that were performed, about the same time, by Colonel Haldane. He found that the apparatus ceased to act when it was immersed in water, or if it was placed in the vacuum of an air-pump. He found, on the contrary, that it acted more powerfully in oxygen gas, than when confined in an equal bulk of atmospheric air, while azote had the same effect as a vacuum. These circumstances led him to conceive that its action depended essentially upon the combination of oxygen, which it derives from the atmosphere. See Nicholson's *Journal*, 4to. iv. 242. 313.

Concludes that hydrogen is always emitted from one wire, from the other oxygen, or the wire oxidated.

Fluids without oxygen will not act.

Haldane's experiments.

Pile will not act without oxygen.

In the early part of his experiments, Mr Cruickshanks invented a new manner of disposing the apparatus, which has proved scarcely less important to the interests of science, than its original discovery by Volta. We allude to the method of placing the metals horizontally in a frame or trough, with proper intervals for containing the fluid which is intended to act upon them.

Trough apparatus. PLATE CCLXIII. Fig. 4.

The power of the pile in decomposing chemical substances being now established, by the experiments of Nicholson and Cruickshanks, a new field of investigation was opened, which was ardently entered upon, by some of the most distinguished among the English chemists. Dr Henry decomposed the sulphuric and nitric acids, and ammonia, and he reduced the oxymuriatic to the state of muriatic acid; but as gases do not conduct the galvanic influence, its decomposing power could not be applied to this last body. See Nicholson's *Journal*, 4to. iv. 223. 245.

Henry's experiments.

Decomposes acids and ammonia.

Sir H. Davy commenced his discoveries in galvanism at an early period of the investigation. He proposed, as a subject of experimental research, whether the ends of the wire, in the interrupted circuit, would discharge the two gases, if they were made to terminate in different portions of water. The ends of the wires were therefore placed in separate glasses, while the glasses

Davy's experiments.

Disengages the gases from two portions of water.

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were made to communicate by means of the fingers, or a moist substance, and it was found that the oxygen and hydrogen were evolved as usual. He next inquired whether it was necessary for the effect that the wires should be in contact with the ends of the pile; and in order to prove this point, slips of muscular fibre were interposed between the wires and the ends of the pile. The result of this disposition was that the gases were disengaged, but in a reverse order; the hydrogen now proceeding from the wire connected with the zinc end of the pile, and the oxygen from the silver or copper wire.

New combinations.

These experiments, which at the time when they were performed seemed most extraordinary, and almost inexplicable, were succeeded by others equally curious, in which Sir H. Davy produced the galvanic effect, by a new combination of substances. He found that charcoal was capable of conducting the influence and of decomposing water, the copper end giving out hydrogen, holding a little carbon in solution; the zinc end did not produce any considerable quantity of gas, the carbonic acid which was produced being absorbed by the water, in which the charcoal was immersed. He formed a pile of zinc and charcoal, which acted with considerable energy, and he afterwards discovered that a pile may be constructed of only one metal, with different fluids applied to its two surfaces, one of them capable of oxidating the metal, the other of preventing the effect of oxidation, the two fluids being separated from each other by water. The series which he employed was metal, diluted nitric acid, water, sulphuret of potash, and then again metal. In a subsequent train of experiments, he proceeded still farther, and composed a pile without any metal, but consisting solely of pieces of charcoal, having their different surfaces exposed to the action of different fluids.

Pile of one metal.

Pile of charcoal, without metal.

Pile will not act with pure water.

Sir H. Davy also made some very important observations on the nature of the fluid interposed between the plates of the pile. If the water that is employed be perfectly pure, containing no acid, salt, or gas, the apparatus is incapable of acting. He found that its energy was in proportion to the rapidity with which the oxidation of the metal advances, and consequently was most energetic when nitric acid was made use of. In pursuance of this opinion, he discovered, that the pile can act *in vacuo*, if an acid be interposed between the plates. See Nicholson's *Journal*, 4to. iv. 275. 326. 337. 344.; and v. 78. 341.

Wollaston's experiments.

About this period, Dr Wollaston began to investigate the subject of galvanism, and read a paper to the Royal Society of London, which displays great marks of sagacity and penetration. He observes that the energy of the apparatus seems to be in proportion to the tendency which one of the metals has to be acted upon by the interposed fluid. An experiment is related, not very unlike some of those which had been previously performed by Fabroni. If a plate of zinc and a plate of silver be immersed in diluted sulphuric acid, and kept asunder, the silver is not affected, but the zinc begins to decompose the water, and to evolve hydrogen. If the plates be now placed in contact, the silver discharges hydrogen, and the zinc continues as before to be dissolved. From these, and other analogous facts, he concludes, that whenever a metal is dissolved by an acid, electricity is disengaged. He extends this principle to the action of the electrical machine, which he conceives has its power increased by applying an amalgam to the cushion, into the composition of which a metal enters which is readily oxidated. As a farther illustration of the same principle, he found, that the machine will not act when immersed in carbonic acid gas.

Electricity disengaged by metals dissolved in acid.

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Electricity of the pile in large quantity, and of litt[le] intensity.

Mr Nicholson had suggested the opinion, that the electricity of the pile differs from that of the machine, in consequence of the latter being in a state of higher intensity, but in less quantity; the former of course being in greater quantity, but of low intensity. Dr Wollaston coincided in this idea, and supposed that it might explain the difference between the operation of the two instruments. It had been long known that water might be decomposed by the electric shock, but the effect differs from that of the pile, the two gases being separated promiscuously from both ends of the wire, not as when the pile is employed, the oxygen from one end, and the hydrogen from the other. But Dr Wollaston succeeded in producing the galvanic effect on water by common electricity, so as to keep the gases separate. This he acccomplished by coating two silver wires, so that the ends of them only were exposed. He then connected these wires with the two conductors of the electrical machine, and passed the spark, from one to the other, through a solution of a salt of copper; the negative wire was found to be covered with a metallic coating, as if it had been connected with the copper or silver end of the pile. See *Phil. Trans.* 1801, p. 427.

Decompose[s] water by electricity.

Trommsdorff burn[s] metallic leaves.

Professor Trommsdorff, about this time, discovered that the pile possesses a very powerful effect in burning metallic leaves. He formed an instrument of large plates of zinc and copper, and fixed gold leaf to the zinc end; then by bringing it in contact with the silver end, the leaf was rapidly consumed, the process being attended by a beautiful emission of coloured light. Silver, tin, and copper leaves were burned in the same manner, each giving out a brilliant flame tinged by its appropriate colour. (Nicholson's *Journal*, vol. v. p. 238.) The repetition of these experiments on the combustion of metals, led Fourcroy to a curious discovery, that the energy of the shock is not increased by the size of the plates, but by the number of the repetitions; while the same extent of surface, arranged in the form of a few large plates, readily consumed the metallic leaves, but had only a comparatively small effect on the sensations. (*Ann. de Chim.* xxxix. 103.) As the action of the pile was generally admitted to depend upon electricity, various attempts were made, by different experimentalists, to charge the Leyden phial, and Mr Cruickshanks at length accomplished it. It was now also generally agreed, that the extremity of the pile which gave out oxygen, was in the state of positive electricity, and the end which disengaged hydrogen in the negative state.

Fourcroy discovers the effect of large plates.

Cruickshanks charges th[e] Leyden phial.

Van Marum compares electricity and galvanism.

It became a curious subject of investigation to ascertain what was the precise difference between the electric fluid, as generated by the pile, and as disengaged by the common machine; and Dr Van Marum entered upon a series of experiments, in which the action of the pile was compared with that of the great Teylerian machine at Haarlem. He succeeded in charging, not only single jars, but whole batteries, by the pile; and they were always charged to the same degree of intensity with that which the pile itself indicated to an electrometer placed upon it. He found that the zinc end of the pile communicated positive electricity to the side of the jar or battery with which it was in contact, and the copper end the reverse. No perceptible difference could be experienced between shocks of the same intensity given by a jar or by the battery; whether they were charged by the pile or by the machine. He found that the intensity of the pile was always the same from

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the same number of plates, whatever was their size; but he perceived Fourcroy's observation to be correct, that it was necessary to employ large plates to burn the metals. He formed a pile of large plates of zinc and copper, and succeeded in fusing iron wires of considerable thickness; he at last even fused a wire of platina. He found that a battery, consisting of 137½ square feet of coated glass, was charged by a galvanic apparatus to an intensity equal to itself, in 1-20th of a second; a circumstance which proves the amazing velocity of the fluid. He conceived that the energy of the pile was much augmented when it was kept in an insulated state, and likewise when a solution of the muriate of ammonia was interposed between the copper and zinc plates. See *Ann. de Chim.* xl. 289.

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We have already noticed the discovery of Mr Cruickshanks, that the pile acted more powerfully in oxygen gas than in the air of the atmosphere; and an observation the converse of this, was made by Biot and Cuvier, which confirmed the relation between the action of the apparatus and the chemical state of the fluid in which it is immersed. When the pile was inclosed in a limited quantity of air, they found that, after some time, the air was sensibly deoxidated. See *Ann. de Chim.* xxxix. 242.

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The discoveries that were made with the galvanic pile, especially by the English chemists, completely established some of the most important points which had previously been subjects of doubt or controversy. Animal electricity, as produced in the original experiments of Galvani, and afterwards in those of Valli, Fowler, Volta, and others, was now admitted to depend upon nothing adherent in, or attached to, the animal body, but upon an agent, called into action by external causes, and manifesting itself in consequence of the delicate sensibility of the nervous and muscular systems. This agent was now generally recognized as being identical with electricity, conducted by the same substances, possessing the same properties, and, in short, subject to the same physical laws. It was conjectured, that the apparent difference between electricity, as excited by the machine and by the pile, depended upon the different states of intensity in which they exist; the electricity of the machine being in a much higher state than that of the pile, although this latter is generally disengaged in greater quantity. This may be regarded as the state of the science in 1801; from this time, until the grand discovery of Sir H. Davy, which we have marked out as the third era, the attention of the different experimentalists, who devoted themselves to this department of natural philosophy, was partly directed to improving or modifying the apparatus, and partly to hypothetical discussions, respecting the nature of the action, and its connexion with chemical affinity. This latter topic, in conformity with the plan which we laid down, will be treated more at length in the Second Part of the Article. A number of new facts were, however, from time to time, discovered, which we shall proceed to detail; and in order to preserve the historical order, we shall also briefly touch upon those points of theory that are to be considered more fully hereafter.

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A memoir appeared about this time from M. Biot, which contains some important observations on the relative effects of the different kinds of apparatus, especially with regard to the size of the plates that enter into their composition. Electricity is known to be discharged by points, and to be retained by extensive surfaces; and from this circumstance he conceives, that the smaller the plates are, the more rapid will be the circulation of the fluid; large plates furnish a greater quantity of the fluid, but it is less rapid in its motion; smaller plates, on the contrary, furnish less fluid, but it passes with more rapidity through the different parts of the apparatus. Hence what was spoken of by Nicholson and others, as constituting the intensity of the fluid, is resolved by Biot into the velocity of its motion. The different operations of the pile are differently affected by these two properties. The taste, the flash, and the shock, exist nearly in the same degree, and all depend principally upon the velocity; while the combustion of the metals is more influenced by the quantity of the electricity. The electrical attractions also depend upon the quantity of fluid, and are therefore more perceptible when large plates are used. It is observed that a pile composed of small plates affords very pungent shocks, but is more quickly exhausted. It was before stated, that Biot had perceived the pile to deoxidate a portion of air in which it was confined; and he now informs us, that the effect was produced more rapidly when the ends of the pile were made to communicate by intervening wires. The general conclusions with which he sums up this interesting paper, are, that the galvanic fluid resembles the electric in the repulsive property of its particles, and that the different phenomena depend upon variations in the quantity and velocity of the fluid. See *Journ. de Phys.* lii. 264.

Different velocity of the electricity.

Lehot's observations on the direction of the current.

An elaborate set of experiments was published about this period by Lehot, on the direction of the galvanic current. This subject had also occupied the attention of Biot, and it was generally admitted that its course was from the zinc plate, across the fluid, to the silver or copper plate. See *Journ. de Phys.* li. 135.

Erman's remark on the names of the extremities.

A circumstance of some importance in our view of the action of the pile, was pointed out by Erman of Berlin; he remarks, that the action takes place, not between the metals, but between the metal and the fluid; therefore, in designating the end of the pile, we should say that the zinc end is the negative, and the copper the positive. Nicholson and Cruickshanks supposed the apparatus to be constructed copper, zinc, fluid; but we should say, zinc, fluid, copper, as in this arrangement we have the complete circle. (*Journ. Phys.* liii. 121.) A similar remark was made by Dr Priestley, who was at this time performing experiments on galvanism in America: He says, that no alteration is produced in the apparatus by whatever metal is placed at the ends beyond the reach of the fluid. Most of the phenomena of common electricity had been imitated by the electricity of the pile, except that of attraction; and Gautherot now succeeded in contriving an apparatus for producing this effect. It consisted of two delicate wires, which hung loose from the extremities of the pile; when they were brought near together, a sensible approximation was perceived, and they were found to adhere with a degree of force. See *Ann. de Chim.* xxxix. 203.

Priestley's.

Gautherot on galvanic attraction.

Volta defends the electrical hypothesis.

It does not appear that Volta himself participated, in any degree, in the various discoveries that were made by means of his apparatus, or that he employed any means for improving or altering its original form. He seems to have interested himself solely in defending the hypothesis, which he had proposed to account for its operation, and which indeed may be considered as having led to its construction. His opinion, that the primary action was electrical, and that it depended upon a change in the distribution of the electric fluid, was

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now called in question by Mr Nicholson, Dr Wollaston, and other English chemists, who were more disposed to refer the effects to the chemical action of the fluid interposed between the plates in oxidating the metals. Volta, however, still adhered to his first opinion; and, in a paper written about this time, he lays it down as his decided conviction, that the action of one of the metals upon the other is the sole cause of the excitation of the electricity, and that the only use of the interposed water is to convey the excited electricity from one pair of plates to the other. (Nich. *Journ.* 8vo. 1. 135.)—Some remarks were, about this time, published on Volta's hypothesis, by Mr Cuthbertson and Dr Bostock; the former objecting to some of Volta's experiments, on which the electric hypothesis of the pile was attempted to be established, and the latter giving a more detailed account of the chemical hypothesis.

Pepys's galvanometer.

By an ingenious alteration in Bennett's electrometer, it was converted by Mr Pepys into a galvanometer. Mr Pepys also confirmed the facts to which we have already alluded, that oxygen is absorbed by the pile, that it will not act in azote or in hydrogen, and that it may be excited *in vacuo*, provided acid be interposed between the plates. (*Philosoph. Mag.* x. 38.) About this time, Ritter of Jena entered upon his investigation of the galvanic phenomena, and both performed many new experiments, and entered very zealously into theoretical discussions. He conceived that he had observed a connexion between galvanism and magnetism: He says, that if an iron wire be placed in the magnetic meridian, the north pole of the wire is more disposed to become oxidated than the south pole; when the magnetized wire is placed in water, the south pole, on the contrary, is most affected. If similar wires be employed, but not placed in the magnetic meridian, no difference is to be observed in the oxidation of the two extremities. See *Journ. de Phys.* lv. 235.

Ritter's experiments.

Supposed connection with magnetism.

Experiments on animals with warm blood.

In the experiments that had been performed on animals, those with cold blood had been generally employed, both on account of their being more convenient for the operation, and from the greater tenacity with which they retain their vitality. It was, however, ascertained, that animals with warm blood were equally susceptible of the influence; and Creve of Wurtzburg had produced strong contractions in a human leg after amputation. Vassali, in conjunction with his friends, Giulio and Rossi, performed a more ample set of experiments upon the bodies of some criminals that were beheaded at Turin. (*Journ. de Phys.* lv. 286.) They paid particular attention to the effect of the galvanic electricity upon the heart and the other involuntary muscles, a point which had been the subject of much controversy. Volta supposed that the involuntary muscles could not be made to contract. Fowler however asserts, that contractions were excited in the heart, although with difficulty; and Vassali confirmed the observations of Fowler, and extended them to the stomach and intestines; the same opinion was also maintained by Nysten. (*Journ. Phys.* lv. 465). On the other hand, Aldini, the nephew of Galvani, who now came into notice as an assiduous experimentalist, asserted that he was unable to act upon the heart.

By Vassali.

Nysten.

Aldini.

Circaud's experiments on fibrine.

Circaud announced a discovery, which, if it were fully confirmed, would prove of great importance in physiology, that the fibrine of the blood, immediately after it leaves the vessels, may be made to contract by the galvanic apparatus. Delametherie confirms the statement of Circaud, from his own observations; but we have been informed that the experiment has not succeeded in this country; and when we consider the difficulty and delicacy of the process, we may be allowed, without impeaching the veracity of the narrators, to entertain some doubts on the subject. See *Journ. Phys.* lv. 468; and lv. 161.

Aldini's experiments. Contraction in the human body by the pile, 1803.

In the year 1803, Aldini published his *Treatise on Galvanism*, a work which contains many curious experiments, and also some new theoretical opinions. The experiments which were the most calculated to produce an impression upon the spectators, were performed on the body of a criminal, who was hanged at Newgate, and also on the head and limbs of some of the larger warm-blooded animals. A powerful battery being applied, very strong contractions were excited, the limbs were violently agitated, the eyes opened and shut, the mouth and jaws worked about, and the whole face was thrown into frightful convulsions. These experiments, however, were principally remarkable from the subjects made use of, and the magnitude of the effect: there were others performed, really more curious, in which very considerable muscular contractions were excited, without the intervention of any metal, or other substance which could be supposed capable of disengaging the electric fluid. In some cases the effect was produced by bringing into contact the nerve of one animal with the muscle of another, and at other times by employing the nerves and muscles of the same animal. In some of the experiments, there appears to have been the most powerful contractions excited, by bringing the parts of a warm and a cold blooded animal into contact with each other. It does not appear, from any expressions in this treatise, whether Aldini considered the animal electricity, as he calls it, to be of a specifically different kind from that excited by the pile, or whether he supposes that the different parts of the animal body have the power of generating the same kind of electricity, without the aid of any external agent. He, however, deduces from his experiments an inference in favour of Galvani's hypothesis, of a proper animal electricity inherent in the body, and not requiring the assistance of any external agent for its developement.

Contractions produced without metal.

Remarks on Aldini's experiments.

There are some points respecting these experiments that require farther explanation. The most obvious conclusion that we should draw from them, would be that which was formed by Aldini himself, in favour of a proper animal electricity. But if this be the case, they must be regarded as essentially different from those of Galvani, where an electricity of the usual kind was certainly excited. Perhaps the most probable supposition is, that the parts of the body, in these experiments, acted in a manner analogous to the pile which was constructed by Sir H. Davy, in which electricity was developed by the action of two different fluids upon carbon. There are, however, many circumstances wanting to render this analogy complete.

Lagrave's animal pile.

An important experiment was announced by Lagrave: he stated, that by placing upon each other alternate layers of muscular fibre and of brain, separated by a porous body, soaked in salt water, a pile was formed which produced the usual effects of the galvanic apparatus: (*Journ. Phys.* lvi. 235.) The experiment must be of difficult execution, and we do not know that any one has since attempted to repeat it. Should it be confirmed, it would throw some light upon the experiments of Aldini, and would assist in the explanation of those facts, where animal electricity seemed to be developed, without the intervention of metallic bodies.

About this time galvanic electricity began to be ex-

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tensively employed in medicine, especially in those diseases where common electricity had been previously found useful. It might have been expected that much benefit would have been derived from so powerful an agent, and one which is so easy of application to any part of the body. Our expectations of advantage have, however, been generally disappointed. Flattering accounts of success were indeed published, in different nervous disorders, in paralytic affections, in deafness, in some kinds of blindness, in the recovery of persons apparently drowned or suffocated, and even in hydrophobia and insanity. But we believe that the practice is now very generally relinquished, from a conviction of its inutility.

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Ritter published an account of a curious appendage to Volta's pile, which he called the *secondary pile*, and which has been frequently called the *pile of Ritter*. It is a kind of electric apparatus, which may be charged by the voltaic pile, or may be made to retain the electricity that is perpetually flying off from this instrument. He perceived that a body, which had formed part of the galvanic circle in the pile of Volta, when the pile was removed, became itself electrical; but it exhibited an electricity opposite to that which it had previously possessed. Thus, if two wires terminating in water, and connected with the pile, were discharging one oxygen and the other hydrogen, when they were removed from it, they would still continue to discharge the gases, but the operation would be reversed. These wires, in this state, may be considered as charged, and if a greater number of similar wires be placed between the ends of the pile, they will all become charged. The nature of the experiment will not be affected, if, instead of wires terminating in water, plates of metal be substituted, with wet cards interposed. An instrument will thus be formed, which of itself cannot produce any signs of electricity, but which may be rendered electrical, by being placed in contact with the primary pile. When the two piles are connected, the action of the ends of each are reversed to each other, and, as when they are separated, the ends of the secondary pile are again reversed, consequently the ends of both the piles will now act in the same manner. It is necessary for the pile of Ritter to remain for some time in contact with the pile of Volta, in order that it may be sufficiently charged. It is stated that the chemical effect of Ritter's pile, that is, its effect in decomposing water, does not bear a regular ratio to its physiological effect, that is, its effect in giving shocks. The author observes, with respect to the voltaic pile, that its tension is the greatest, and it produces the strongest effects on the sensations immediately after it is constructed, but that its chemical effects are the most powerful after it has been acting for some hours. See *Journ. de Phys.* lvii. 345.

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Shortly after the publication of the account of the secondary pile, Ritter made a number of experiments with the pile of Volta, which are original and curious. He observed that when a communication was formed between the positive end of the voltaic pile and the earth, the whole instrument became negatively electrified, and when the communication was made with the negative end, the instrument became positive. These changes do not, however, destroy the chemical action of the pile, which goes on in the same manner as before the communication was formed. He supposes that the decomposition of water is effected in consequence of the positive end disengaging oxygen, and the negative end hydrogen, and that the two ends have also a tendency to dispose metals to unite with oxygen and hydrogen respectively. He says, if the positive end be armed with gold leaf, and the negative with charcoal, and these substances be then brought into contact, the gold will be burned; but if the position of the substances be reversed, the charcoal will be burned. When the extremities of a pile do not communicate, it is said that the action exercised between the different plates is very unequal; the zinc, which is nearest the positive end, is the most oxidated. It is also asserted, that if a pile be broken into separate parts, by a number of wires inserted between every fifth pair of plates, those wires nearest the positive end will be the most oxidated; while, on the contrary, those wires near the negative end will be less oxidated than if they had been simply plunged in water. Hence he infers, that at the negative end an action has taken place, or a state has been induced, the reverse of oxidation. He goes so far as to say, that different sensations are excited by the two ends of the pile, the one expanding, and the other contracting, the muscular fibre; the positive end strengthens the pulse, and produces heat, the negative weakens it, and produces cold. See *Journ. de Phys.* lvii. 401.

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Different effects in different parts of the pile.

Remarks on Ritter's experiments.

So far as we have been able to learn, few, if any, of the experiments of Ritter have been repeated, either in England or in France; a circumstance which is not a little remarkable, when we consider that many of them are quite original, and would lead to important theoretical deductions. His language and manner of writing are, however, unfortunately obscure; and he abounds so much in hypothesis, that he has not obtained that degree of attention to which he would seem to be entitled, from his industry and ingenuity. It is scarcely to be supposed that he could have been mistaken respecting the effect of the secondary pile, or that he would have invented a series of facts, the fallacy of which might be so easily detected. With respect to the experiments on the voltaic pile, their authority is more doubtful; they seem to have been performed with a manifest view to a particular hypothesis; some of them are of an indeterminate nature, and we may imagine that many are exaggerated, or even inaccurately stated.

Biot's opinions respecting the nature of the galvanic action.

The attention of the different experimentalists was now much occupied with the comparative merits of the two hypotheses, the electrical and chemical; generally speaking, the English seemed to incline to the latter, and the continental writers to the former. Biot drew up a candid and judicious memoir, in which he compares the merits of the two opinions, and endeavours to shew how far either of them is supported by acknowledged facts. Electricity, he observes, is certainly excited, but it is not certain whether we ought to regard it as cause or effect. He proceeds to inquire, whether the action of the instrument depends entirely upon the oxidation of the water, entirely upon the influence of the metals, or whether it is not produced by the two in conjunction. This he decides to be the case; and yet, at the same time that he makes this decision, he appears to have a leaning towards the chemical hypothesis. See *Ann. de Chim.* xlvii. 1.

Hisinger and Berzelius on the transfer of substances. 1804.

In the year 1804, a very valuable memoir was written by Hisinger and Berzelius, which must be regarded as containing the fundamental principle of those doctrines, which have since been so extensively developed by Sir Humphry Davy. By passing the galvanic influence through solutions of the different neutral

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salts, they found that there was a transfer of the acid and alkali to different parts of the apparatus. They formed the general conclusion, that whenever electricity is sent across a fluid, it disposes its constituents to separate and pass to the two sides respectively; combustible substances, alkalies, and earths, are attracted to the negative; acids, oxides, &c. to the positive extremity of the pile. The force of the decomposition they suppose is in the ratio of the quantity of electricity, and that the electricity is in proportion to the surface of metal which is in contact with a moist conductor. The decomposition is also influenced by the affinity of the components of the substance, its power of conducting electricity, and other circumstances. See *Ann. de Chim.* li. 167.

Supposed production of muriatic acid. 1805.

Mr Cruickshanks, among his earliest discoveries, had observed, that an acid and an alkali were generated at the two ends of the wires in the interrupted circuit, and this fact had been confirmed by other experimentalists. The substances produced were supposed to be nitric acid and ammonia; the first originating from the union of oxygen with the azote of air dissolved in the water, the latter from hydrogen combining with the same element. But it was now announced that muriatic acid and soda were generated by passing the electric current through pure water, and where this salt could not be suspected to be present in any part of the apparatus, or in any of the materials employed. In the spring of 1805, the following letter was published, purporting to be written by Mr Peel of Cambridge: "I took about a pint of distilled water, and decomposed about one half of it by means of galvanism, the other half I evaporated, and found to remain at the bottom of the glass a small quantity of salt, which, upon examination, proved to be muriate of soda. The salt could not have been contained in the water before I made the experiment, because I used every precaution to have it free from impurities. I even took the trouble to repeat the experiment, though a tedious one, and I again obtained the same result. A friend of mine has just informed me that he has tried my experiment, and has succeeded in procuring the salt." See Tilloch's *Mag.* xxi. 279.

Peel's experiments.

Pacchioni's experiments.

Almost at the same time that this notice was published in London, Pacchioni, professor at Pisa, gave an account of some experiments upon the action of galvanism on water, in which he obtained results analogous to those stated above. He informs us, that when water had been for a long time subjected to the galvanic influence, and had been parting with its oxygen from the extremity of a gold wire, the fluid was found to contain a quantity of oxymuriatic acid. From this experiment he drew the following conclusions: Oxymuriatic acid is an oxide of hydrogen; it consists of water deprived of part of its oxygen; muriatic acid is water in a still lower degree of oxidation; and, of course, oxygen and hydrogen are susceptible of different degrees of oxidation. See *Edinburgh Med. Journ.* i. 393.

Not confirmed.

A great degree of attention was excited by these experiments, to which the more credit was attached, because they proceeded from sources entirely independent of each other. They were repeated by different experimentalists in this country, and in some cases with apparent success. Mr Sylvester in particular, obtained traces both of muriatic acid and soda, where proper precautions were supposed to have been taken, to exclude the muriate of soda from every part of the apparatus. But from facts which have been subsequently discovered, we may conclude, that the substances obtained in these cases were not derived from the decomposition of the water. Pacchioni's experiments are now universally admitted to have been incorrect; and it appears that no such individual as Mr Peel could be found in Cambridge, so that the letter bearing his name is a complete fabrication. It was not, however, entirely without its use; for the minute examination of the effects of galvanic electricity upon water, to which it gave rise, may probably be regarded, in some measure, as the immediate cause of Sir H. Davy's most important discoveries.

Erman's experiments. 1806.

An elaborate memoir was, about this time, written by Erman, on the conducting power of different bodies, which obtained the prize from the French Institute. His object was to remove some anomalies, which appeared to exist in the relation of the galvanic electricity to the different conducting substances.

Five species of bodies.

He divides all bodies into five classes: 1st, Perfect non-conductors; 2d, Perfect conductors; 3d, Imperfect conductors; 4th, Positive conductors; and 5th, Negative conductors. The nature of the three first classes requires no explanation; the fourth and fifth class of bodies act as perfect conductors, when applied to either of the two poles separately, but when placed between them, insulate either the positive or negative pole respectively, and do not form a communication between them. The flame of a spirit lamp is described as a positive conductor; if it be applied to each polo separately, it conducts the electricity; but if it be placed between the two poles, it will not form a communication between them, in consequence of its insulating the negative electricity. Although flame is a conductor of galvanism, it does not conduct it so perfectly as metals. No effect is produced, when flame is interposed between the extremities of the pile. Flame is, however, a very different substance according to the body from which it is procured: the above observation refers to the flame of a hydro-carbonous body. The flame of sulphur insulates both the poles; and that of phosphorus insulates the positive, and conducts the negative influence. Phosphorus must therefore be placed in the fifth class of bodies; and perfectly dry soap is also a negative conductor.

Flame a positive conductor.

Soap a negative conductor.

The author gives an account of a number of experiments that he performed on this latter substance, many of which are curious and original. Hard soap, when perfectly dry, if applied to either end of the galvanic pile, conducts all the electricity from that extremity into the ground, and there appears to be no perceptible difference in its action upon the two extremities. If wires be connected with each end, and be made to terminate in a prism of hard dry soap, which is kept insulated, the circuit will not be completed; but if this soap be uninsulated, by establishing a communication with the ground, an electrometer connected with the positive pole, manifests a great degree of divergence, while one on the negative pole loses all signs of it. "Consequently," M. Erman observes, "the soap which insulates the positive effect, is a perfect conductor for the negative." As a proof and illustration of this property, the author informs us, that "if one finger be applied to the wire of the positive pole, and another finger wetted to the soap, no shock is felt, and the electrometers do not show the least change in their respective divergencies. But if the experiment be repeated, by establishing a communication between the positive pole and the soap with both fingers wetted, a very perceptible shock will be felt, and the two electrometers will arrive at an equal, and a very weak degree of intensity." He proposes the

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Erman's nomenclature.

following nomenclature for these five classes of bodies: 1st, Insulators; 2d, Perfect conductors; 3d, Bipolar imperfect conductors; 4th, Positive unipolar; and 5th, Negative unipolar: (*Jour. Phys.* lxiv. 121.) Although, as we shall afterwards find, Mr Brande explains the facts upon rather a different principle, yet they are highly important, and M. Erman is entitled to much commendation for the skill with which he conducted his experiments.

Guyton's observations on metallic oxides.

Guyton suggested an idea, which appears sufficiently plausible, that the action of galvanism may affect the formation of metallic oxides, and even cause them to assume the particular forms which they occasionally exhibit: (*Ann. de Chim.* lxiii. 113.) Bucholtz detailed a series of experiments which he performed, where a metallic oxide, held in solution by an acid, was precipitated in the metallic state by the metal itself. The metallic solution was placed in the bottom of a cylindrical jar, and a stratum of water was carefully spread over it. A slip of the same kind of metal that formed the solution was then placed perpendicularly in both the fluids. The upper part of the metal which was in the water was oxidated, while the lower part in the metallic solution had particles of the reduced metal deposited upon it. The reduction of the oxide was always expedited by whatever promoted the oxidation of the upper part of the metal. Experiments of an analogous nature were performed by Grotthus, on what he calls the *arborization* of metals, which, like the circle of actions described by Bucholtz, he attributes to a galvanic operation. In these processes, however, there are two metals concerned; and he shews that the tree is formed by successive portions of the dissolved oxide being reduced and attached to the solid metal, which, in its turn, becomes oxidated: (*Ann. de Chim.* lxiii. 5.) We have a little anticipated the chronological order in the relation of these two last sets of experiments, in order that we might not be interrupted in narrating the account of the decomposition of the alkalies and earths, which composes the third period of the history of galvanism.

Bucholtz on reducing metallic oxides.

Grotthus's experiments on arborization.

Sect. III. *Decomposition of the Alkalies and Earths.*

Davy's electro-chemical researches. 1806.

About the conclusion of the year 1806, Sir H. Davy read to the Royal Society of London the first of his series of papers, on what has been styled the electro-chemical action of bodies, which have been so justly celebrated, no less for the brilliant discoveries of which they give an account, than for the acuteness and sagacity which the author displays in his researches into the most hidden operations of nature. He commences by some remarks on the action of galvanic electricity upon water. He notices the experiments in which acids and alkalies appear to have been formed in water subjected to the galvanic current; and he states, that when he employed separate portions of water, connected together by slips of bladder, and united by gold wires to the voltaic battery, he obtained nitro-muriatic acid at the positive, and soda at the negative wire. It was, however, conjectured, that the animal matter placed between the two portions of water might contain muriate of soda, and thus afford the substances procured in the experiment; he therefore, at the suggestion of Dr Wollaston, substituted asbestos for the slips of bladder. It was also conceived, that when glass vessels were used, the alkali might proceed from a partial decomposition of the glass; and after trying various other substances, at length conical vessels of gold were employed. With these precautions, and when the water was very carefully prepared, no acid or alkali were obtained; and consequently the author concludes, that in all those experiments which were attended with contrary results, the acid and alkali must have proceeded from some extraneous source, not having been generated, but evolved, either from something held in solution by the water, or from some of the materials employed in the apparatus. Perfectly pure water, when subjected to the action of electricity, affords nothing except oxygen and hydrogen.

Action of galvanic electricity upon water.

Plate CCLXIII. Fig. 9.

No acid and alkali generated.

The very powerful action of the galvanic electricity, in the decomposition of various earthy and saline compounds, as experienced by Sir H. Davy in the researches above mentioned, offered an extensive field for farther investigation. Hisinger and Berzelius, in the valuable memoir to which we have already referred, noticed the tendency which different bodies possess, to attach themselves to one of the wires exclusively; acids and analogous bodies being attracted to the positive, while alkalies, metals, and all inflammables, were attracted to the negative wire. Our author had observed similar phenomena in his own experiments, and was induced to make them the more immediate subject of his examination. Acids and alkalies were found uniformly to observe this order; and it was perceived, that when substances, not supposed to be soluble in water, formed part of the circuit, they were also decomposed, and their components carried to the positive and negative wires respectively. In this way was effected the decomposition of sulphate of lime, sulphate of strontites, fluate of lime, and sulphate of barytes. It was also perceived, that where small portions of acid and alkaline bodies entered into the composition of solid earths, they might be detected by the galvanic influence, and would be transmitted to their respective wires. In this way, lime and soda were obtained from basalt and from zeolite, potash from lepidolite, &c. In proportion to the solubility of a salt, its decomposition was the more readily accomplished; and when neutral salts were employed, the separation of the component parts seems to have been quite complete.

Decomposition of earthy and neutral salts.

The tendency which different substances possess to attach themselves to their appropriate wires, causes them to be transferred across a medium which may be interposed. Thus, if muriate of lime be at the positive wire, the lime will pass, for a considerable space, to gain the negative wire, and may be conveyed from one vessel to another along the conducting fibres of the asbestos. In the same manner, when nitrate of silver was on the positive side, and distilled water on the negative, the silver passed along the transmitting amianthus, so as to cover it with a thin metallic film. When a neutral salt was placed in a vessel, between two other vessels of water connected by asbestos, the alkali passed to the negative, and the acid to the positive side: the decomposition in this case is complete, and the substances produced quite pure. A small vessel of the infusion of litmus was interposed between pure water and the solution of sulphate of potash, and the latter was negatively electrified. The acid passed across to the positive wire, and reddened the litmus, but the change of colour did not extend beyond the centre; so that the negative side, although it was transmitting the acid, was not affected by it. An experiment of precisely an opposite kind was performed with the infusion of turmeric, with a similar result; and afterwards the two operations were combined in the same experiment, so that soda passed through turmeric, and muri-

Transfer of the constituents of compounds.

Plate CCLXIII. Figs. 10, 11.

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atic acid through litmus, each without changing their colour.

Passage of acids and alkalies through different media.

As it appeared that acids and alkalies could be conveyed through water, without affecting colouring substances dissolved in it, Sir H. Davy next tried whether this power might not extend to other bodies. He accordingly found, that acids could be transmitted through alkalies, and alkalies through acids, to their respective wires, without neutralizing each other; and, in short, that the electrical state which was induced upon a substance, by the contact of the galvanic apparatus, had the power of counteracting, or even changing, the effects of chemical affinity. The general principle was thus completely established, that hydrogen, alkalies, and metals, are attracted by the negative, and repelled by the positive end of the pile, while acids and oxygen are attracted by the positive, and repelled by the negative. For the production of this effect, it is necessary that there be a conducting chain of particles through the transmitting fluids; the transfer cannot take place where insoluble compounds are formed, because in this case the new compound is carried out of the sphere of action.

General principle.

Effect of electricity in producing chemical changes.

The establishment of the general principle mentioned above, suggested some views of the nature of the change produced by electricity, which led to a new train of experiments. Sir H. Davy observes, that many bodies, after being brought into contact, exhibit opposite states when they are separated. When a galvanic combination is formed from an acid, an alkali, and a metal, the alkali appears to acquire, and the acid to part with, a quantity of electricity; the alkali is therefore rendered positive, and the acid negative, and they will of course have an attraction for each other. He found, that when such acids as were capable of being employed in the dry state were touched by metals, and then separated, the acids were rendered negative, and the metals positive; but when the metals were touched by the alkaline earths, the metals became negative. Hence it may be concluded, that acids and alkalies not only exhibit opposite electricities, when they have been in contact with metals, but also when they have been in contact with each other. The attraction of oxygen and acid for the positive, and of hydrogen and alkalies for the negative electricity, is so powerful, as to counteract their usual chemical affinities.

Relation between the electricity and affinity of bodies.

These considerations induced the author to enter into some farther speculations respecting the relation between the electricity of bodies and their chemical affinities. We have seen that chemical affinity is destroyed by giving a body an electricity different from its natural one, and is, on the contrary, increased by giving it a greater share of its natural electricity. It would farther appear, that all those bodies which possess a chemical affinity for each other are naturally in opposite states of electricity, and hence we conclude, that by inducing a state of electricity upon any body, contrary to its natural one, its chemical relations may be changed, and that thus we have in our possession an agent of indefinite power for affecting the decomposition of substances which had hitherto withstood all our attempts.

Action of the voltaic pile.

With respect to the action of the voltaic pile, Sir H. Davy conceives, that the first step in the process is the destruction of the electrical equilibrium, and that the chemical changes tend to restore it to its original state. The saline solution, which is interposed between each pair of plates, is decomposed, the acid is transferred to the zinc, and the alkali to the copper surface. This tends to restore the equilibrium, which is destroyed by the contact of the metallic elements of the pile; but the solution of the zinc, which then takes place, again alters the electrical condition of the bodies, and maintains the energy of the apparatus. Upon the whole, although it may be supposed that the chemical changes are an essential part of the process, they are considered by the author as only of secondary importance; the first step in the process, and that which immediately gives rise to all the rest, being an electrical effect arising from the action of bodies placed in contact.

Primary effects electrical.

Importance of this paper.

The uncommon merit of this paper has induced us to give a copious abstract of its contents. It may be regarded, not only as giving rise to some of the most important experiments and discoveries that have occurred in the history of modern science; but as leading to the establishment of a new train of reasoning, and to a new theory, respecting the action of bodies upon each other, and the connexion which subsists between the different branches of natural philosophy. The general principle being clearly established, the consequences were comparatively obvious, and the skill and ingenuity, which Sir H. Davy afterwards manifested, in the contrivance and execution of the experiments, which are next to be related, although attended by such brilliant results, are really less meritorious, than that profound insight into the operations of nature, by which they were suggested. Highly, however, as we appreciate the merit of Sir H. Davy, we think it proper to remark, that the views suggested by Hisinger and Berzelius must be regarded as leading to the theory that was so amply detailed and so firmly established by our illustrious countryman. See *Phil. Trans.* for 1807, 1.

Decomposition of the fixed alkalies. 1807.

About a year after the reading of the above paper, Sir H. Davy presented a second to the Royal Society, in which he most happily applied his hypothesis to practice, and succeeded in solving the problem, which had so long remained involved in obscurity, respecting the composition of the fixed alkalies. After encountering some difficulties in the arrangements of the operation, the grand object was at length accomplished in the following manner. "A small piece of pure potash, which had been exposed for a few seconds to the atmosphere, so as to give conducting power to the surface, was placed upon an insulated disc of platina, connected with the negative side of the battery, of the power of 250 of 6 and 4, in a state of intense activity; and a platina wire, communicating with the positive side, was brought into contact with the upper surface of the alkali. The whole apparatus was in the open atmosphere. Under these circumstances, a vivid action was soon observed to take place. The potash began to fuse at both its points of electrization. There was a violent effervescence at the upper surface; at the lower, or negative surface, there was no liberation of elastic fluid; but small globules, having a high metallic lustre, and being precisely similar in visible characters to quicksilver, appeared, some of which burst with explosion and bright flame, as soon as they were formed, and others remained, and were merely tarnished, and finally covered by a white film, which formed on their surfaces."

Relation of the experiment.

Base of potash and soda.

These globules proved to be the substance of which the author was in search, and were found to be a peculiar inflammable body, possessed of very singular properties, which constituted the base of potash. By employing a similar kind of process, a substance was procured from soda, which exhibited properties of an analogous nature, and which was the basis of the mineral, as the former was that of the vegetable alkali.

Proved to be metals.

The author then proceeded to examine the properties

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of these bodies, and by a masterly train of experiments, simple yet conclusive, he demonstrated that they are metals; that they have every quality which is deemed essential to characterise this class of substances, and that the alkalies are oxides of these metals. The theory of the decomposition of the alkalies, by means of the galvanic apparatus, is sufficiently obvious, and follows as the direct consequence of the facts that had been previously established. In all the decompositions that had been effected by the electrical influence, combustible substances were developed at the negative wire, while oxygen was produced or evolved at the positive termination. That this was the case with the alkalies, was not only rendered probable by the result of the process, but was afterwards proved by subsequent experiments. "When solid potash or soda, in its conducting state, was included in glass tubes, furnished with electrified platina wires, the new substances were generated at the negative surfaces; the gas given out at the other surface, proved by the most delicate examination, to be pure oxygen; and unless an excess of water was present, no gas was evolved from the negative surface."

Theory of the process.

Recomposition of the alkalies.

The experiments by synthesis confirmed the results of those by analysis. The new metallic bodies were converted into potash, by exposure to the air, and it was found that this depended upon the oxygenous part of it. When the globules were placed in contact with oxygen, they combined with it, and were covered with an alkaline crust. Sir H. Davy observes very justly, "that in these facts there is the same evidence for the decomposition of potash and soda into oxygen and two peculiar substances, as there is for the decomposition of sulphuric and phosphoric acids and the metallic oxides, into oxygen and their respective combustible bases." The two components of the alkalies obey the general law which was laid down in the former paper; the metallic or combustible base is attracted by the negative extremity of the apparatus, and perhaps repelled by the positive; while the oxygen, which reduces it to the state of an oxide, follows the contrary order. In the recomposition of the alkalies, the substances exert their natural affinities; according to circumstances, either simple oxidation is produced, or a more rapid combination, attended with the extrication of heat and light.

Properties of new metals.

Sir H. Davy next proceeded, in an elaborate train of experiments, to ascertain the physical properties of these metals, to which he gave the names of potassium and sodium, and their chemical relations to other bodies. He examined their fusibility, the power which they possess of conducting electricity and caloric, and their specific gravity. He afterwards observed their action on water, the acids, sulphur, phosphorus, the metals, oils, and metallic oxides. It is scarcely necessary to remark, that the examination was conducted with the address and dexterity which characterizes all the operations of this distinguished experimentalist. A minute detail of the particulars would be foreign to the object of this article, and strictly belongs to the science of chemistry; galvanism being no farther connected with these bodies, than as the instrument by which they are produced. On this account it will not fall under our province to notice the discussions which ensued respecting the nature of these new metals; for although it was generally admitted that the substances were the bases of the fixed alkalies, and were metallic, yet there were some circumstances in the mode of their formation, which led to the supposition, that they were a compound of a metal and hydrogen; but this opinion is now abandoned.

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Attempts to decompose ammonia.

The analogy which exists between the properties of the fixed and the volatile alkalies, led Sir H. Davy to apply his powerful means of decomposition to ammonia. The analogy of properties, however, which causes them to be placed in the same class of bodies, seemed to be counteracted by the experiments of Berthollet, who, as is well known, had resolved this latter substance entirely into hydrogen and azote. Accordingly the metallic nature of ammonia has not yet been proved, and although Sir H. Davy, in his earlier experiments, conceived that he had procured oxygen from it, and Berzelius obtained a species of amalgam, by exposing it in contact with mercury to the galvanic influence, yet subsequent experiments by Henry, and Gay-Lussac and Thenard, appear to explain these appearances on other principles, and to restore the original conclusion, that ammonia is a compound of azote and hydrogen alone. See *Phil. Trans. for* 1808, p. 1.

Decomposition of the earths.

Sir H. Davy next turned his attention to the earths. He found them more difficult to decompose than the alkalies, and many arrangements were employed without success. The object was, however, at length, to a certain degree, accomplished by mixing the earth with a metallic oxide, and placing this in contact with a globule of mercury negatively electrified, when an amalgam was formed, consisting of the mercury and the metal of the earth employed. In this way it appeared, that a metallic basis had certainly been obtained from the four alkaline earths, to which the names of barium, calcium, strontium, and magnium, were respectively applied. The remaining earths, silex, alumine, zircon, and glucine, were still more refractory, probably in consequence of their more powerful affinity for oxygen. No decomposition could be effected by the same means which had been found successful with the alkaline earths; but it was at length partially accomplished, by keeping the earth in fusion with potash, inducing upon it positive electricity, and touching it with a negative wire. In this case an amalgam was produced, which probably consisted of the metal of the earth employed and potassium. See *Phil. Trans. for* 1808, p. 333.

Confirmation of Davy's experiments.

The brilliant discoveries of Sir H. Davy, and still more the new and powerful agent which he had introduced into chemistry, could not fail to engage the attention of all those who were interested in the progress of the science. Among these, Gay-Lussac and Thenard in France, and Berzelius in Sweden, immediately commenced their operations in the application of galvanic electricity to the decomposition of bodies, made many important experiments, and brought to light many new facts. The general result was, to afford an ample confirmation of the statements of our illustrious countryman in their most important parts, although in some particulars they regarded the subject in a different point of view, both as to the mode of accounting for the effects, and the consequences which they deduced from them. These discussions, as well as the many new and interesting experiments connected with them, which have completely changed the aspect of many branches of chemistry, and have enlarged our knowledge of the nature of bodies far beyond its former limits, it does not belong to our department to detail. It will be proper, however, to lay before our readers some of the observations that were made by Gay-Lussac and Thenard, on what strictly belongs to galvan-

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ism, reserving the consideration of the hypothetical opinions to the second division of the article.

Gay-Lussac and Thenard's researches. 1811.

These sagacious experimentalists remark, that, next to the construction of the pile itself, the most important discovery was made by Hisinger and Berzelius, who found that when the electric current decomposed a neutral salt or an oxide, the oxygen and acid were carried to the positive end, and the base to the negative. The application of this principle enabled Sir H. Davy to effect the decomposition of the alkalies. The authors point out the distinction between the electrical and the chemical energy of the pile; actions which are essentially dissimilar, and which do not exist in the same ratio. They state, that a comparatively few plates, with acid interposed between them, will decompose the alkalies; while a greater number, with water instead of acid, will not produce this effect, and will yet exhibit a higher electrical tension. The power of the apparatus was found to be nearly in proportion to the strength of the acid employed; and some comparative experiments were instituted, for the purpose of comparing the effects of acids, alkalies, and neutral salts. The test which they employed to judge of the quantity of effect produced by the pile, was the amount of gas evolved from a fluid, subjected to the action of the wires connected with its two extremities: this they conceived was a more exact measure of its energy than the different lengths of wire which it was capable of consuming.

Difference between the electrical and chemical action.

Shock produced by a large battery.

When they employed a very powerful battery, it was observed that considerable shocks were given by it to an individual; but that in a chain of four or five persons, it was not felt in the centre; and in the extremities of the chain, that part of the body received the greatest impression which was nearest to the apparatus. This fact is supposed to prove, that the electric fluid cannot circulate through the whole circuit, according to the Franklinean hypothesis. When the battery is put into strong action, its chemical effect, *i. e.* its power of decomposing water, soon declines, or altogether ceases, while its electrical tension remains for some time longer unimpaired.

An interesting train of experiments is next detailed, in which mercury was interposed between the wires, and formed an amalgam with the substance which was intended to be decomposed: an arrangement which we have already pointed out as having been employed by Sir H. Davy in his decomposition of the proper earths. They repeated the experiments of this philosopher on ammonia, and they formed the amalgam with mercury, which he conceived was composed of this substance with the metallic basis of ammonia; but they differ from him in their idea of its constitution, and suppose that there is no evidence of the existence of the metal of the volatile alkali, although the analogy of the fixed alkalies offers so powerful an argument in its favour.

De Luc's analysis of the pile. 1810.

While Sir H. Davy was pursuing, with so much success, his interesting researches into the electro-chemical action of bodies upon each other, M. De Luc undertook to investigate the nature of the galvanic pile, and to examine the mode of its operation. After some animadversions upon the hypothesis of the inherent electric energies of bodies, which constitute the origin of the train of phenomena that are connected with the pile, he proceeds to dissect this instrument into three parts. He divides it into three separate groups, corresponding to what he regards as the three elements of the pile. These elements are the two metals and a fluid. They were first placed with the fluid between the two metals; then with the fluid in contact with one, and afterwards in contact with the other metal, the different groups being kept distinct from each other by small wire stands, so as to confine the action to that part alone. When the piles were fitted up in these three different ways, a delicate electrometer was attached to each extremity, and they were also connected by the interrupted wire passing through water. His first set of experiments were made upon the pile in which the groups were arranged with the fluid between the two metals. By means of the electrometer, he observed which ends of the apparatus were in the positive and negative states respectively; and he likewise made some new observations on the direction which the electric current takes in its passage across the water—in the interrupted circuit—and in the body of the pile itself. His observations agreed with those originally made by Nicholson, that the extremity of the pile which is connected with the wire emitting oxygen, is positive, and that the current is directed from this to the wire which emits the hydrogen. He informs us, however, that although electrometers placed at the extremities, when they are affected, indicate the electricity to be in the state mentioned above; yet they are not always both of them affected, sometimes only the positive electricity is visible, sometimes only the negative, while at other times both of them are perceptible. He conceives that, from various causes, the electric fluid passes through the apparatus with different velocity at different times, or through its different parts at the same time, so as to produce a partial accumulation or deficiency: It seems to be always retarded when it passes from the point of the wire into water. He observes, that the expressions positive and negative, as applied to the ends of the pile, or to the wires in the interrupted circuit, can only be regarded as comparative terms, because the chemical action of the pile goes on as usual in the decomposition of water, although the whole instrument be rendered positive or negative, by attaching it to the prime conductor, or to the rubber of the electrical machine. This experiment is adduced to prove, that the action of the pile is not necessarily connected with the electric energy of the substances that enter into its composition. The pile, when dissected in the first way, with the fluid interposed between the two metals, acts in the same manner as if the parts were continuous, except that the effect is rather less powerful.

Dissection of the pile.

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Plate CCLXII Figs. 14–18.

Fig. 19.

First dissection of the pile.

Observations on the direction of the current, and on the positive and negative states.

Second dissection.

M. De Luc then examined the action of the pile, when dissected according to the second arrangement, where the metals were placed together, and the wet cloth in contact with the zinc, or the most oxidable of the metals; the ternary groups being separated from each other by the wire frames. The extremities of the pile indicated to the electrometer the same states of positive and negative, as in the former instance, but no shock was experienced; when the wires of the interrupted circuit were placed in water, although it appeared that there was a communication established through the fluid, yet no decomposition took place, nor did there appear to be the retardation of the electric current upon its entering the fluid, as in the former case. Hence the author concludes, that the electrical and chemical effects originate from different causes, because in this state of the instrument the electrical effects continue, although the chemical effects are suspended. The third dissection of the pile was now made, *i. e.* it was divided into ternary groups, consisting of the metals contiguous to each other, and the wet cloths in contact

Third dissection.

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with the silver; the groups being separated as before, by wire supports. Here there was no effect perceptible, either electrical or chemical.

Muriate of soda employed between the plates.

In the above experiments, the cloths which were employed to retain the fluid were moistened with water: A second set of experiments was now performed, in which a strong solution of muriate of soda was employed. The pile, whether moistened with water or the saline solution, had the same effect upon the electrometers, both as to quality and quantity; but when the salt was used, there was a more powerful effect upon the sensations. He observed, that a new shock was experienced every time either of the hands was brought into contact with the apparatus, or removed from it; but that no effect took place as long as they remained in contact. When the interrupted circuit was applied between the extremities of the pile, the shock might be felt, but it was rendered less violent; and the chemical effects were diminished, but not suspended, while the contact of the body was preserved: hence it may be inferred, that the body is about an equally good conductor with water. The retardation of the current appeared to be rather greater in this case, than where the apparatus was supplied with pure water.

The pile was now dissected in the same three ways as before, muriate of soda in solution being employed instead of water. In the first dissection, *i. e.* with the moistened cloths between the plates, the same electric effects were exhibited by the electrometers, the same shock was felt, and the same chemical effects were produced, only in rather a less degree than in the continuous pile, with muriate of soda. The second and third dissections of the pile produced exactly the same effect, as when the same dissections were employed with pure water.

Hypothesis of the different cause of the electrical and chemical effects.

The author afterwards enters upon a number of speculations respecting the manner in which the electric fluid circulates through the apparatus, and upon the immediate cause of the electrical and chemical phenomena. He conceives, that when no cause of retardation exists, the electric fluid circulates so rapidly through the pile, as not to exhibit any of its effects, or indeed not to indicate its presence; and that when these are manifested, it always depends upon some retarding cause. The electrical and chemical effects are supposed to originate from different parts of the pile, or from different groups, considered in their relation to the parts contiguous to them. The electrical effects consist simply in the combination of the two metals, each pair being separated by a non-metallic conductor; while for the chemical effects, ternary groups are necessary, the two metals with a fluid between them. This distinction between the two sets of properties, or the two modes of action, is supposed to be proved by the different effects which are produced by the pile in its three states of dissection. In the pile dissected in the first manner, which indeed may be regarded as equivalent to the instrument in the continuous state, both the electrical and chemical action takes place: for here are the two metals, either in contact, or connected by the wire frames, for the electrical effects; and for the chemical effects, there are the two metals with the wet cloth interposed. In the pile as dissected in the second manner, there are the binary groups, *i. e.* the metals in contact, and accordingly they produce the electrical effects; but we have no chemical effects, because they have no fluid between them. In the third dissection, no effects are produced; we have not the chemical effects, because the metals have not the wet cloth between them, and we have no electrical effects, because the zinc has the copper plate on one side, and the wire frame on the other, which have the same electrical relation to the zinc, and therefore counteract each other.

Pile of silver and pewter.

The different effects which seemed to ensue, between the pile when furnished with pure water, and with the solution of a neutral salt, induced M. De Luc to examine what connexion existed between the oxidation of the zinc, and the chemical action of the instrument. For this purpose he formed a pile of silver and pewter, the pewter being selected for the experiment, because it has an electrical relation with silver, and is oxidable by muriatic acid, at the same time that it is not much affected by pure water. In the first instance, water was interposed between the plates; the extremities of the pile, as indicated by the electrometer, became electric, the pewter side negative, and the silver positive; but there was no shock, nor any decomposition of the water in the interrupted circuit. A pile was then formed of such a number of zinc and silver plates, that its electrical energy might be the same with the pewter pile; but here there was both the shock produced, and the decomposition of water. The pile of pewter and silver was then fitted up with muriatic acid; and in this case, when the pewter plates became oxidated, the shock and the decomposition of water were both produced. From these experiments, the author deduces the following conclusions. When the metal is not oxidated, no chemical effect is produced on the water in the interrupted circuit. When the oxidation is produced by means of pure water, there is no shock, although the chemical effects take place; and lastly, when either of these effects are produced, the current of electricity is retarded in its passage across the water in the interrupted circuit.

General conclusions.

Discovery of the electric column.

It was in the prosecution of these experiments, while he was examining the effect of different conducting substances placed between the plates, that M. De Luc was led to the discovery of the curious instrument, called the Electric column; a pile consisting of a number of discs of zinc and gilt paper, placed alternately upon each other, and included in a glass tube. This has already been described under the article ELECTRICITY, p. 469, and as it must be regarded as a stricly *electrical* apparatus, we shall not enter into any details respecting its effects or its mode of action. See Nicholson's *Journal*, xxvi. 39.

Children's large battery. 1809.

While Sir H. Davy and M. De Luc were thus enlarging our knowledge of the powers of galvanism as a chemical agent, and of the means by which its wonderful effects are accomplished, Mr Children was advantageously employing himself in improving the apparatus. He formed a battery, constructed upon a principle, originally suggested by Volta, according to which the plates are not cemented together, but are connected only at the top by a metallic conductor, and are then immersed in the cells of a trough. He employed 20 pair of plates, of four feet by two, making in all a surface of 92,160 square inches. The fluid that he used was a diluted mixture of nitric and sulphuric acids, the whole quantity being no less than 120 gallons. The effect of these large plates was to fuse entirely, in about 20 seconds, 18 inches of platina wire, of one-thirtieth of an inch in diameter, and to render three feet of the same wire red hot. Charcoal was burned with intense brilliancy. It seemed not a little remarkable, considering the powerful effect on platina wires, that the action of this battery on iron wires was comparatively trifling. Of iron wire, 1-70th of an inch in diameter, it barely fused ten inches, and had not power

PLATE CCLXIII. Fig. 5.

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to ignite three feet. It had not the power of decomposing barytes and other similar substances; it did not affect Bennet's electrometer; and it seemed scarcely able to produce a perceptible shock.

Comparative effects of smaller plates.

Mr Children next formed a battery of 200 pairs of plates of two inches square, affording a surface of 3200 inches. With this the alkalies and alkaline earths were readily decomposed, and a considerable divergence was produced in the gold leaves of the electrometer. From this comparison of the effects of the two batteries, we are led to the conclusion which has been already referred to, that the *intensity* of the electricity is increased with the number. and the *quantity* of it with the extent of the metallic plates. Upon this principle, we may explain why the platina wire was acted upon more readily than the iron wire, the more perfect conducting quality of the former presenting no obstacle to the passage of the electricity through it; while the tendency of the iron to oxidation required a greater intensity of the fluid to effect its transmission through the wire. In this paper, the author states, that he has removed one of the objections that have been urged against the identity of the galvanic and the common electricity, that the former has no striking distance; by employing a proper apparatus, he ascertained that the galvanic spark was capable of passing through a certain space between the extremities of two platina wires.

Striking distance of galvanic electricity.

General conclusion.

Mr Children's general conclusion is, that "the absolute effect of a voltaic apparatus is in the compound ratio of the number and size of the plates; the intensity of the electricity being as the former, the quantity given out as the latter; consequently, regard must be had in its construction, to the purposes for which it is designed. For experiments on perfect conductors, very large plates are to be preferred, a small number of which will probably be sufficient; but where the resistence of imperfect conductors is to be overcome, the combination must be great, but the size of the plates must be small. But if quantity and intensity be both required, then a great number of large plates will be necessary. For general purposes, four inches square will be found to be the most convenient size." See *Phil. Trans.* for 1809, p. 32.

More powerful battery. 1813.

Mr Children has since constructed a still larger and more powerful battery, consisting of 20 pairs of copper and zinc plates, each plate being six feet by two feet eight inches. It ignited six feet of thick platina wire, and melted platina with great facility; it also melted iridium and osmium. At the suggestion of Dr Wollaston, a singular fact was ascertained, that a greater length of thick platina wire was ignited, than of platina wire of a much smaller size. See Thomson's *Annals*, ii. 147.

Brande's remarks on Erman. 1814.

We have given some account of a paper of Erman's, in which he endeavours to show, that certain bodies are what he calls Unipolar, that is, that they are conductors of one kind of electricity only. Mr Brande conceived, that the facts brought forward by Erman, might admit of a better explanation upon a different principle, viz. that some chemical bodies, being naturally positive, and others naturally negative, they would be attracted to the surface of the pile in a contrary state to their own, the positive to the negative, and the negative to the positive surface.

Experiments.

In order to submit his opinion to the test of experiment, Mr Brande procured two insulated metallic balls, one connected with the prime conductor, and the other with the rubber of an electrical machine; and placing between them the different substances under examination, he observed to which of the balls they were attracted. He found that the flame of a candle, which principally consists of carbon and hydrogen, was attracted to the negative ball; while the flame of phosphorus, which would contain a quantity of phosphoric acid, was attracted to the positive side. Here the bodies seemed to follow the known laws of electro-chemical attraction, according to the idea of their inherent electrical states; and the other experiments which he performed of a similar nature generally tended to the same conclusion. The facts stated in this paper are conceived to be favourable to the hypothesis of Sir H. Davy, respecting the natural electricities of bodies, and also, when viewed in connexion with Erman's observations, to afford an additional proof of the identity of electricity and galvanism. See *Phil. Trans.* for 1814.

Wollaston's elementary battery. 1815.

Dr Wollaston has constructed an apparatus, which he calls an elementary galvanic battery, the object of which is to exhibit the most minute arrangement of electrical substances, by which visible ignition can be produced. The smallest that he has constructed consists of a thimble, without its top, flattened until its sides were about one-fifth of an inch asunder; a small plate of zinc was then contrived to be fixed within the thimble, but without touching it, and a proper appendage of platina wires was added. The zinc plate was less than three-fourths of an inch square, and even when a very diluted acid was employed, a platina wire of $\frac{1}{3000}$ of an inch in diameter was readily fused. See Thomson's *Annals*, vi. 309.

These experiments of Dr Wollaston's are the latest that have been made on the subject of galvanism, and will bring down the history of the science to the present period.

PART II. THEORY OF GALVANISM.

Theory. General remarks.

According to the plan which was laid down, we must now proceed to give an account of the theories and hypotheses that have been formed to explain the phenomena of galvanism. We have had occasion to allude to many of these in the course of our historical sketch; and the reader will, in some degree, have anticipated our opinion respecting them. The subject divides itself into several branches, partly corresponding with the progress of our knowledge of the facts that were gradually developed, and partly depending upon the supposed relation of galvanism to the other departments of natural philosophy.

Galvani's hypothesis.

In this concise view of the science, we shall not think it necessary to enter into the merits of the earlier speculations, that have been superseded by later discoveries. Of this nature is the original hypothesis of Galvani himself, that the convulsions which he observed in the muscles of frogs, were produced by a new and peculiar agent, residing in the body, to which he gave the name of Animal Electricity. Although there are some few cases which seem to militate against the supposition, it must, upon the whole, be regarded as being decisively proved, that all the phenomena which we stile galvanic, depend merely upon the action of electricity, modified by the manner in which it is produced or excited.

What is galvanism?

Hence arises an interesting question, and one which lies at the very foundation of all our future inquiries, heory.

Remarks on the defini-

How does galvanism differ from common electricity? This question may refer both to the nature of the phenomena themselves, and to the means employed for their production. We may define galvanism, either by enumerating the specific characteristics of those events which we class together under this title; or we may show how they have all a reference to each other, from the similarity of the processes that are employed for their developement. The definition that we have given at the commencement of the article, may be regarded as sufficiently correct and comprehensive, without exceeding the limits to which a definition ought to be restricted. It appears to include every action of bodies upon each other, which is usually considered as belonging to this particular branch of natural philosophy; while it excludes those that are, by common consent, referred to a different department. It is, however, in some cases, difficult to draw the exact line of distinction between electricity and galvanism, and indeed we may doubt, whether any precise distinction actually exists. For as it is conceived, that they both depend upon the same agent, having merely experienced some modification in its nature, or mode of action, we must conclude, that there may be some intermediate or indeterminate state, which might be referred to one or the other with almost equal propriety.

finition.

To recur then to the former definition: "Galvanism is a series of electrical phenomena, in which the electricity is developed without the aid of friction, and where we perceive a chemical action to take place between some of the bodies employed." This definition may perhaps be thought to limit the science too much, and to remove from it many facts, which have always been regarded as galvanic. For example, a great number of the original experiments of Galvani himself, and his immediate contemporaries, where contractions were excited in the muscles of animals, by the application of the two metals, many of those of Fowler, and the first set of Volta's experiments, would, according to this definition, be reduced to the effects of common electricity. To this objection we may reply, that wherever moisture comes in contact with the zinc, or more oxidable metal, it is not improbable that some chemical action is produced, but that it is very slight, and has therefore not been noticed. If, however, upon a strict examination, it is found not to be the case, and that there is actually no change in the chemical condition of any part of the apparatus, it must be admitted, that, according to our present ideas, the phenomena are not to be referred to galvanism. The first unequivocal experiments where the chemical effects were observed, and were connected with the electrical condition of the substances, are those of Fabroni's; and it was not until Volta's discovery of the pile, that we were put in possession of a method by which we were enabled to examine, with any degree of accuracy, the relation between these two actions. Even if we find it necessary to conclude that Galvani, although he had the good fortune to have his name associated with a new department of science, did not witness any of the facts to which we now apply the term, the contradiction will be more apparent than real; and we must not permit the mere circumstance of *names* to influence our opinion respecting the essential nature of *things*. The present state of our knowledge seems, however, to warrant the conjecture, that the action of the two metals on the parts of animals, is strictly galvanic, *i. e.* accompanied by a chemical action on the metals and the fluids, so as to reduce it within the limits of the proposed definition.

i: proper ga nic experiments.

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Difference between electricity and galvanism.

Waving, however, the farther discussion of this point, which indeed can only be decided by experiment, we must recur to the question already stated, respecting the essential difference between galvanism and common electricity; and, conceiving it to be ascertained, that in the production of the former, a chemical action takes place, which is not necessary in the latter, we must next inquire, in what way this chemical change of the substances imparts to the electricity that particular state or modification which we style galvanic. With respect to the nature of this chemical change, experimentalists are generally agreed: as to the metals, it consists in the oxidation of that metal which possesses the strongest attraction for oxygen; and with respect to the fluid interposed between the metals, it consists in its decomposition, the oxygenous part being attracted to the most oxidable metal, and the alkaline to that which is the least oxidable. Although, as we have already had occasion to remark, there are various galvanic combinations, into which only one metal enters, or even some entirely without metals, yet, as the most powerful and complete circle is that which consists of two metals with a fluid interposed, we shall confine our illustrations to this form of the apparatus.

What is the chemical change?

Galvanic electricity of low intensity.

We may consider it as proved by a number of experiments, which have been stated in the first part of this article, that the electricity, as it is evolved by the different galvanic combinations, always exists in what has been styled a state of low intensity; and that, to whatever extent we increase the apparatus, and however powerfully it acts, still the intensity is but little augmented. Unfortunately it is still a doubtful point of theory, upon what the intensity of electricity depends, or in what it precisely consists. Some writers have ascribed it to a greater or less concentration of the fluid; some to a difference in the velocity of its motion, or in the strength of its affinity for the surrounding bodies; and others to its containing a greater or less portion of caloric. For the present, we must rest satisfied with admitting the fact of the low intensity, as manifested by the phenomena, without being able to explain its cause; and we may next proceed to inquire, whether there be any circumstances in the different methods of exciting or producing electricity, by the machine or the pile respectively, which should cause the first to develope the fluid in a higher, and the latter in a lower state of intensity.

Remarks on electrical intensity.

Electricity as excited by the machine.

And here, it must be confessed, we have little to direct our inquiries but conjecture and uncertain analogy. Of these, however, as being our only guides, we must make the best use that lies in our power. It is generally agreed, that all bodies possess a certain quantity of electricity, which is said to be natural to them, and which, while it remains undisturbed, manifests no indications of its existence. There are many processes which alter the state of this natural electricity, by which it is extricated from one body, and may be transferred to others in the neighbourhood. But this additional portion, being more than their natural share, seems to be retained by them with difficulty, and is ready to fly off in all directions, in order to restore the equilibrium. This may be considered as descriptive of what occurs in the operation of the common electrical machine, where, by the friction of the rubber against the cylinder, a portion of the electric fluid is carried off from one or both of them, and is transferred to the conductor. From the conductor it may be communicated to a variety of other bodies that are placed within the sphere of its influence; but, in all

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these cases, it is retained by them for a certain space of time only, and is continually passing off, more or less rapidly, to all the surrounding bodies.

Electricity of the pile.

But besides this temporary transfer from one body to another, without their undergoing any farther alteration, they occasionally experience a more permanent change in their electrical state, when, in consequence of their acquiring different physical and chemical properties, their capacity for electricity is entirely altered. When their capacity is diminished, a more gradual, but more continued discharge of the electric fluid takes place; and in this appears to consist the essential action of the pile, as contrasted with that of the machine. In the action of the machine, by which the electric fluid is set at liberty, and transferred from one body to another, no change appears to take place in the substances employed, except the alteration in their respective quantities of electricity. Their attraction for it is neither increased nor diminished; and, consequently, they have a tendency, the one to lose, and the other to acquire, the electricity which has been thus, as it were, forced into the one, and out of the other. According to the nature of the action by which the electricity is evolved, whether the substances experience any permanent change in their capacity, or whether their equilibrium is merely disturbed in a temporary manner, the state of the fluid appears to be affected, so as to cause a difference in its intensity.

The two electricities compared.

When we employ the machine, the electricity that we procure appears to be in a highly elastic state, its particles strongly repulsive of each other, and at the same time not disposed to enter into a permanent union with other bodies. The galvanic electricity which we procure from the pile, is more readily united to other bodies, and has a tendency to form new combinations with them, which is so powerful as to counteract some of the strongest chemical affinities. At the same time, it exhibits less of what may be called mechanical action: its particles are less repulsive of each other; its motions appear less rapid; it causes less commotion in its passage from one body to another; and although its ultimate effects are more powerful, it seems to act with less violence. The one may be compared to a small quantity of an agent highly concentrated; the other to a larger quantity, but in a state of greater dilution. The phenomena of electricity, as excited by the common machine, depend upon the attraction and repulsion of the electric fluid, and its passage from one body to another; while the most important actions of galvanic electricity result from the chemical changes that it produces in the composition of bodies. The excitation of common electricity is not necessarily attended with any permanent alteration in the state of the substances that are employed in producing it. It is usually developed by the mechanical aid of friction, and the same apparatus may continue to be employed for an indefinite length of time. Friction, on the contrary, has no effect in the production of galvanic electricity; it requires a chemical change in some part of the apparatus; and the individual parts which have been employed in generating it acquire new properties, and are incapable of any farther galvanic action.

Action of the pile.

After these general observations, which, scanty and inconclusive as they are, appear to be all that our present knowledge upon the subject will warrant, we must proceed to examine more minutely into the nature of the action that is exercised by the galvanic apparatus. From the remarks that have been already made, it will be obvious, that in the operation of the pile, there are both electrical and chemical phenomena produced; and it has been a point very warmly contended, which of these is the most essential, or rather which of them is the primary effect, and, consequently, is to be considered as the cause of the other, and of the whole train of actions. Volta, and most of the continental philosophers, support the electrical hypothesis; while there are several distinguished experimentalists in this country who maintain, that the chemical action is the one which gives rise to all the changes that are produced, and therefore constitutes the primary action of the instrument.

Volta s[upports the] electric [hy]pothesis.

In all the experiments that were performed with the two metals, previous to the discovery of the pile, with the exception of those of Fabroni, which seem to have been but little attended to, the only point in discussion was, whether the effects were to be referred to the electric fluid, or to a new agent inherent in the animal body. Volta strenuously adopted the opinion, that they depended simply upon common electricity, and accounted for them by supposing, that the contact of the two metals had the power of altering the quantity of electricity which was natural to them, adding a portion of it to the one, and subtracting it from the other respectively. To this power he gave the title of *electro-motion;* and he spoke of it as a new property, which had not been before noticed, and distinctly claimed to himself the merit of its discovery.

Forms pile.

He conceived that he might increase the power of the instrument, or rather concentrate the effect of a number of separate pairs of metal, by interposing between each pair a conducting substance, which, without altering the electric state of the metals, might increase the effect, by transmitting it through a number of successive stages. Whatever we may think of the hypothesis, the experiment to which it gave rise was most fortunate; for it led to the construction of the pile; an apparatus by means of which the most curious and important discoveries have been made in the different departments of natural philosophy.

Did n[ot no]tice its [che]mical [ef]fects.

Although Volta completed the discovery of the pile, and fully ascertained its action on the animal body, yet it is not a little remarkable, that he limited his inquiries to this object, and seems to have been totally ignorant of the farther powers of the instrument of which he was possessed. This circumstance must appear the more remarkable, when we recollect that upon the very first employment of it by Messrs Nicholson and Carlisle, they perceived its chemical action, and became aware of its importance as an agent in the decomposition of bodies. Cruickshanks, Davy, Wollaston, Henry, and the other English philosophers, farther developed its powers in this respect, which had so completely escaped the notice of Volta, and they were consequently led to form a different idea of the mode of its operation. Dr Wollaston seems to have been the first who decidedly adopted the opinion, that the chemical action of the pile is the primary origin of all the changes which it experiences, and is the cause of the electrical effects; and the same idea was embraced by Sir H. Davy, although he has since abandoned it for the hypothesis of electric energies.

An ac[count] of the [elec]tric h[ypo]thesis [of] the pi[le].

We must now proceed to examine the two leading theories of the galvanic action, as exhibited in the pile, with more minuteness; and we shall begin with that of Volta's, or the one which supposes a change in the electrical condition of the metals to be the primary cause of its operation. This philosopher has given a statement of his opinions on the subject, in several letters which he wrote to his friends, and which have been

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published in different scientific journals. His first communication was in a letter to Cavallo; the second to Gren, (*Phil. Trans.* 1793; *Ann. de Chim.* xxiii. 276.): both written before his discovery of the pile. His original account of this apparatus is contained in a letter to Sir Joseph Banks, in which he explains his ideas respecting its action; and he afterwards farther developed them in letters to Delametherie and to Van Marum, (*Phil. Trans.* 1800; Nicholson's *Journal*, 8vo, i. 135; *Ann. de Chim.* xl. 225.) In some of these papers, Volta details his hypothesis at considerable length; yet, after an attentive examination of them, it appears to us that they are not altogether consistent with each other; and that, without any intimation of the circumstance, he has, in fact, given to the world two distinct hypotheses.

The letter written to Cavallo, of which we have already given some account, is Volta's first essay on the subject of galvanism, and contains an account of Galvani's original discovery, and of the additional experiments which he had himself performed by the combination of the two metals. He accounts for all the facts on the principle, that when metals are placed in certain circumstances with respect to each other, there is "a destruction of the equilibrium" of the electricity. This action is stated to consist essentially in two metals, when placed in contact, giving the one to the other a portion of its natural electricity, so that the one becomes positive and the other negative. Some combinations of metals possess this electro-motive faculty much more powerfully than others; those that Galvani and Volta originally employed were zinc and silver; and in this case the zinc acquired the electricity and became positive, while the silver lost electricity or became negative. In this paper no other principle is referred to, and the action is not spoken of as belonging to any class of bodies except the metals. Volta speaks of the principle as a new law of electricity, which had not been before noticed, and decidedly claims to himself the discovery of it.

In the letter to Delametherie, written after the discovery of the pile, Volta still farther developes his hypothesis, but without altering the ground on which it rests. He describes each pair of metals as the efficient part of the apparatus, and speaks of the fluid that is interposed between them, as merely carrying the electricity from one pair to another, without producing any change in it. In his letter to Van Marum, he relates the following fundamental experiment, as it is called: A plate of copper and a plate of zinc are placed in contact with each other, but so that a part of each plate projects beyond the other; and he finds, that of the parts which thus project, one becomes positive and the other negative. So far all these opinions appear to be consistent with each other; but in the letter written to Gren, an idea is brought forward, which is not noticed in the other essays, and which seems to be essentially different from them. All conductors of electricity are divided into two classes, the dry and the moist; and electricity is supposed to be always excited, when two conductors of either of these classes are placed in contact with one conductor of the other class. In this way one metal only would appear to be sufficient for a galvanic combination, provided there be two moist conductors in contact with it. How the fluids act in this case, or what relation they bear to each other and to the metal, we are not exactly informed; but we may conclude, that it is not from any chemical operation, because in the letter to Delametherie, written four years after that to Gren, it is expressly said, that the fluids have no effect but in transferring the electricity from one metal to another.

General view of the electric hypothesis.

Upon the whole we may conclude, that Volta conceives the electricity to be excited by the metals producing a degree of electro-motion, or by destroying the natural equilibrium of the electricity; one metal thus becoming positive and the other negative, they each of them exhibit signs of electricity to an electrometer or other similar instrument. The only use of the fluid is to transfer the electricity which is excited by one pair of metals to the next pair; and although a chemical action may take place between the fluid and the metal, this action is merely incidental, and is not essential to the production of the galvanic effects.

Objections to it.

The objections to Volta's hypothesis are very forcible; in the first place, it does not appear that the chemical effects of the pile are, as he supposes, merely incidental. They seem, indeed, absolutely essential to its action, for when perfectly pure water is interposed between the metals, or when the apparatus is placed in any situation, where it is excluded from obtaining a supply of oxygen, it ceases to act. The same thing happens when the acid, or other oxidating fluid, is all expended; and in short it may be stated, that whatever promotes the action of the fluid upon one of the metals increases the energy of the instrument, and whatever tends to prevent or destroy this action suspends the energy. It has been urged as an objection to Volta's hypothesis, that it does not provide for any absolute increase of the electric power. The two metals, by their contact, become one positive and the other negative, and this is equally the case with each pair; but the fluid that is interposed between the metals is conceived to restore the equilibrium of the electricity, which has been disturbed by the metals. This is the whole effect of the apparatus, and we are not informed how any electricity can be actually produced or generated, as it would appear that the nature of the instrument is to cause an electric action in one part, which must be immediately counteracted by another part. Whatever deficiency of electricity there was in any copper-plate would be instantly supplied by the water communicating the superabundant electricity of the opposite zinc plate, so that the effect of the whole would be reduced simply to the difference between the two extreme plates of copper and zinc. A third, and perhaps a still stronger argument against the electric hypothesis, is, that the fundamental position on which it rests, is itself objectionable. Volta supposes that two metals, as for example, a plate of zinc and one of copper, when placed in extensive contact with each other, may become respectively positive and negative. This he endeavours to prove by direct experiment; but it will be found that in none of the cases is the experiment precisely in point. He adduces some facts, where metals were found respectively positive and negative, that *had been* in contact, but were afterwards separated: in one of his experiments the metals never actually touched, but were connected by a moist conductor; and in the experiment which we have related above, it was only the projecting parts of the plates that could be made to exhibit the opposite electric states. And here we may be allowed to entertain some doubt respecting the accuracy of the fact; it is evidently an experiment of a most delicate nature, and Mr Cuthbertson, who attempted to repeat it, obtained results contrary to those

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stated by Volta: (Nicholson's *Journ.* 8vo. ii. 281.) In the experiments of Bennet and Cavallo, where electricity was induced upon metallic bodies by contact, it is to be observed, that they were no longer in contact when they manifested signs of electricity, and it appears not easy to conceive how two metals can be in extensive contact, without communicating their electricity to each other, so as to acquire precisely the same state. The experiments of De Luc, on the dissection of the pile, seem to be strongly adverse to the electric hypothesis. In the second distribution of the ternary groups, the two metals are in contact, and therefore any electrical effect might be produced, which would arise from this circumstance; there was also the fluid between them, which would serve as a conductor of electricity, yet because the apparatus was so arranged that this fluid could not act upon the zinc and oxidate it, no proper galvanic effect ensued.

Chemical hypothesis.

As we have already remarked, Dr Wollaston was the first who decidedly pronounced the chemical action of the pile to be the primary cause of its effects; but in establishing this point, he did not proceed to explain the nature of the operation, or show what was the train of events which contributed to the final result. This was attempted by Mr Cuthbertson, who, in the essay to which we referred above, after pointing out the inaccuracy of the experiments that were brought forward by Volta in favour of the electric hypothesis, offers some observations in support of the contrary opinion. He conceives that the chemical action of the interposed fluid upon the zinc, alters the electric properties of the metal, and disposes it to part with electricity; that this evolved electricity cannot enter into the remainder of the zinc which has not been acted upon, because it retains its former electric state, but that it is "propelled forwards from the zinc, through the menstruum, to the next adjoining copper in the pile or trough. This effect, however, can only happen in a progressive manner, because the fluid is but an imperfect conductor; and to this he ascribes many of the peculiar phenomena of the apparatus. Dr Henry, in a judicious essay "*On the Theorics of the Excitement of Galvanic Electricity,*" (*Manchester Mem.* ii. 293, 2d Series), observes, that "the explanation of Mr Cuthbertson is unequivocally a valuable supplement to the theory of Volta, inasmuch as it takes into account the efficiency of chemical menstrua." But, as he farther remarks, it is defective, because it does not explain why "the action of the menstruum is chiefly, if not entirely, exerted in oxidizing and dissolving the zinc plates, and why the evolution of hydrogen gas, or of nitrous gas, occurs chiefly at the copper surface." This deficiency was attempted to be supplied by Dr Bostock, who, about the same time, published an essay on the action of the galvanic pile, which he has since considerably extended and modified in such a manner, as to accord with the recent discoveries. (Nich. *Journ.* iii. 8vo. 9. and 69. Thomson's *Annals*, iii. 32.)—He proceeds upon the principle which was laid down by Dr Wollaston, that electricity is evolved by the oxidation of metals; and generalizes it so far as to conclude, that the electric fluid is always liberated when an oxidable substance is united to oxygen. In addition to this principle, he proposes to admit the two following postulates, that the electric fluid has a strong attraction for hydrogen, and that when in passing through a chain of conductors, it leaves the oxidable substance to be conveyed through water, it combines with the hydrogen, and is again disengaged from it, whenever it again enters into an oxidable substance.

Cuthbertson's opinion.

Bostock's hypothesis.

We shall quote the account which Dr Henry gives of this hypothesis, as it appears to afford a correct, and at the same time a concise view of it.

Henry's account of it. PLATE CCLXIII Fig. 21.

"To the efficiency of the pile, two circumstances are essential; that the electric fluid should be disengaged, and that it be confined and carried forward in one direction, so as to be concentrated at the end of the apparatus. The first object is fulfilled by the oxidizement of the zinc; the second, as Dr Bostock supposes, is effected by the union of the evolved electricity with nascent hydrogen, and by the attraction of the next copperplate for electricity. At the surface of this plate, the hydrogen and electricity are supposed to separate; the hydrogen to be disengaged in the state of gas, and the electricity to be conveyed onwards to the next zinc plate. Here, being in some degree accumulated, it is extricated in larger quantity, and in a more concentrated form, than before. By a repetition of the same train of operations, the electric fluid continues to accumulate in each successive pair; until, by a sufficient extension of the arrangement, it may be made to exist at the zinc end of the pile, in any assignable degree of force." For a farther account of this hypothesis, we must refer our readers to the original essay, and more especially to that part of it where the author explains the action of the interrupted circuit in the decomposition of water, and the evolution of the gases at the extremities of the two wires: (Thomson's *Ann.* iii. 88.) It must be admitted that it satisfactorily explains the phenomena, and that it accords with all the facts that have hitherto been discovered, but it labours under the great objection of being founded upon a gratuitous supposition, of which there is no proof, except the facility with which it explains the appearances.

The pile both an electrical and galvanic instrument.

We think that part of the difficulty which has occurred in forming a theory of the pile, has arisen from our not clearly discriminating between its effects in exciting common electricity, and that modification of it which is called galvanism. We have endeavoured to point out in what respect these two actions differ from each other; and, imperfect as our knowledge is concerning the cause, we conceive that there is an obvious difference in the effect. Now, it appears to us, that the pile, as it is usually constructed, is both an electrical and a galvanic instrument; and that when we attempt to form a theory of its action, we have two distinct sets of phenomena to explain. The power of producing muscular contraction is an electrical effect, that of decomposing chemical bodies a galvanic effect; while that of burning metallic leaves, or igniting wires, probably partakes of both these actions. That the electric and galvanic effects of the pile bear no proportion to each other, that one may exist in a great degree while the other is scarcely apparent, is rendered evident from the experiments of Mr Singer. In examining the power of different kinds of fluids interposed between the plates, he observed, that although some of the effects were rendered more powerful by employing a solution of salt, yet the electrometer was not more effected than with simple water. He even asserts, that in many trials on a very extensive scale, for example, with 1000 pairs of metals, he has "found the electrical effects greatest when the chemical effects have been least." He relates other facts of a similar kind, which appear to place this matter beyond all doubt, and to establish a decisive difference between these two operations of the instrument. See Singer's *Elem.* p. 330.

Singer's experiments.

De Luc's experiments.

M. De Luc's experiments confirm and illustrate this view of the subject; for they not only show this want

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of proportion between the two effects, but they enable us to separate them from each other. In his second dissection of the pile, we have a powerful electrical instrument, but one which does not produce galvanic effects; and the same may be said of his electric column, which exhibits none of the phenomena that we exclusively refer to galvanism. On the contrary, some of those combinations which have been made by Mr Children, and other experimentalists, where a few large plates were employed, and where a diluted acid was interposed between them, may be considered as precisely the reverse of De Luc's column. Here very slight marks of common electricity were manifested, while the most powerful galvanic effects were produced.

Proper electrical action of the pile.

Our general conclusion on the subject is, that part of the effects, usually proceeding from the pile, are purely electrical, and do not, in any degree, depend upon a chemical change in the state of the metals. We conceive it to be a doubtful point in what way this electrical action is induced, because, for the reasons which we have already given, we do not think that the experiments of Volta, and the others that have been supposed to coincide with them, are applicable to the state of things as they exist in the pile; nor do we think that if we were to admit them, they would account for the continued evolution of fresh portions of electricity; or that they would explain, why the disturbance of the electric fluid, or the electro-motion, as it is stiled, is not counteracted by the conductors that are connected with the metals. As to the proper galvanic effects of the pile, we consider them to be always immediately caused by the chemical action of the fluid upon the metals; and that, in proportion to the extent of this action, as depending upon the quantity of surface exposed, or the nature of the fluid employed, we obtain the evolution of electricity in greater or less quantity, and in a more or less intense state. Our readers will perceive, from these observations, that we are, upon the whole, advocates for the chemical hypothesis; but at the same time that we attach ourselves to this doctrine, we do it with the restriction already referred to. If we conceive that the proper galvanic phenomena depend upon the chemical changes, we also admit, that there are electrical effects produced by the pile, independent of the others, and unconnected with them.

Galvanic effects.

Davy's hypothesis.

The great discoveries that have been made by Sir H. Davy, in his application of galvanism to chemical decomposition, and the importance which must attach to all his opinions upon the subject, induce us to inquire, what view he takes of the question that we have now been discussing. We have already related the experiments which he performed on the chemical action of the pile; and it appears that he formerly considered it as the primary cause of the phenomena. This opinion, however, he afterwards retracted, and adopted an hypothesis which he conceived might reconcile the doctrine of Volta with the experiments of the English chemists. He supposes, that both electrical and chemical actions are necessarily concerned in the production of the effect; that the former are the first in order of time, and that their tendency is to disturb the electric equilibrium of the different parts of the apparatus, while the chemical changes operate in restoring this equilibrium. In the farther detail of the hypothesis we shall employ the author's own words. "In the voltaic pile of zinc, copper, and solution of muriate of soda, in what has been called its condition of electrical tension, the communicating plates of copper and zinc are in opposite electrical states. And with regard to electricities of such very low intensity, water is an insulating body; every copper plate, consequently, produces by induction an increase of positive electricity upon the opposite zinc plate, and every zinc plate an increase of negative electricity on the opposite copper plate; and the intensity increases with the number, and the quantity with the extent of the series."

"When a communication is made between the two extreme points, the opposite electricities tend to annihilate each other; and if the fluid medium could be a substance incapable of decomposition, the equilibrium, there is every reason to believe, would be restored, and the motion of the electricity cease. But solution of muriate of soda being composed of two series of elements, possessing opposite electrical energies, the oxygen and acid are attracted by the zinc, and the hydrogen and alkali by the copper. The balance of power is momentary only; for solution of zinc is formed, and the hydrogen is disengaged. The negative energy of the copper, and the positive energy of the zinc, are consequently again exerted, enfeebled only by the opposing energy of the soda in contact with the copper; and the process of electro-motion continues, as long as the chemical changes are capable of being carried on." See *Phil. Trans. for* 1807, vol. xlv.

This hypothesis agrees with that of Volta, in ascribing the train of actions to the electric condition of the metals, yet it differs from it in many essential points. It supposes the chemical decomposition of the interposed fluid to be a necessary, although not the first step in the process. The conducting power of the fluid is, in both cases, taken into account, yet it is regarded in an opposite point of view. According to Volta, the better is the conducting fluid, the more energetic is the action of the pile; while the hypothesis of Sir H. Davy seems to require the fluid to possess almost a non-conducting property.

Electric energies.

Some of the late speculations of this illustrious chemist have led him to deviate still farther from the ordinary hypothesis, not only as it respects galvanism, but electricity in general. Those effects, which were formerly attributed to a material agent, capable of being added to, or subtracted from a body at pleasure, are now conceived, like gravitation, to be inherent qualities of matter. To these, which are called electric energies, all chemical decompositions are to be ultimately referred; for it is supposed, that chemical attraction, in all cases, results from the circumstance of two bodies possessing opposite electric energies, and consequently having a strong tendency to unite. By means of the galvanic combinations, we have it in our power to excite the electric state of a body to an indefinite degree, and to induce an electricity contrary to that which is natural to it. But the farther consideration of the merits of this theory, belong rather to electricity than to galvanism strictly so called. To whatever cause we ascribe the electric state of bodies, whether to a material agent distributed through them in different quantities, or to some affection of their primary qualities, the states of positive and negative electricity actually exist, and our present business is merely to inquire, what relation they bear to the phenomena of the galvanic pile.

De Luc's objections.

M. De Luc advances an argument, which he conceives to be quite decisive, against the hypothesis of the natural electric energies of bodies producing the phenomena of the pile, that the whole instrument may be rendered either positive or negative, by connecting

Theory.

it with the conductor or rubber of the electrical machine; and yet its operation is not in any degree affected. He also contrived an apparatus, in which there were three wires placed between the extremities of the pile, two of them connected with the ends of the pile, and the third in the centre; the wires having water interposed between them, and electrometers so situated, as to ascertain the electric condition of the wires. In the ordinary state of the apparatus, the terminating wires were one positive and the other negative, corresponding to the ends of the pile to which they were attached, while the central wire was neutral; yet the ends of this neutral wire produced opposite electrical effects, one separating oxygen, and the other hydrogen. By altering the apparatus, the electrical state of the wires were altered; the central wire was rendered at one time positive, and afterwards negative, and the state of the terminating wires was reversed; yet no change took place in the chemical action of the wires, each of them continuing to evolve oxygen and hydrogen as at first, and the two ends of the central wire separating oxygen and hydrogen respectively at its extremities, in the same manner, whether the wire itself was positive, negative, or neutral. See Nicholson's *Journ.* xxvi.

Singer's objections. PLATE CCLXIII. Fig. 22.

Mr Singer has proposed an objection to Sir H. Davy's hypothesis, very similar to this of M. De Luc's. If a number of metallic wires are placed in a line, with their extremities immersed in a fluid, and the whole connected with the pile, each wire will evolve oxygen at one end, and hydrogen at the other. Now, he conceives it impossible that every wire can have an opposite electricity at its two extremities, when it is surrounded by a conducting fluid; for no metallic body can be made polar, *i. e.* one end positive and the other negative, but by the temporary disturbance of the equilibrium of its natural electricity; an event which can only happen when they are separated by a non-conducting substance. But he observes, "No one can maintain, that water, or any saline fluid or acid mixture, is a non-conductor, either of the chemical or electrical effects of the voltaic apparatus; yet the usual chemical changes produced by voltaic electricity occur at every interruption of the metallic circuit in such fluids." See Singer's *Elem.* p. 376.

There appears to us to be considerable weight in these objections; and we confess, that the ideas of Sir H. Davy produce a shock to our usual associations on the subject of electricity, which it is not easy to overcome. However, as we have already remarked, it would be foreign to the object of this article to pursue the discussion any farther; nor do we conceive, that we are at present in possession of sufficient facts to warrant us in coming to any definite conclusion respecting it.

Concluding remarks.

We shall here conclude our account of the theory of galvanism. Our readers will perceive, that much discordance of opinion still exists upon the subject, and that some strong objections attach to every hypothesis which has yet been proposed. The most important points to ascertain are, the difference between electricity, as excited by the friction of the common machine, and that modification of it which is strictly called galvanism. For this purpose, the nature of electric intensity should be farther investigated; for it would appear that if we were able to attach a more precise idea to this term, a considerable insight would be gained into the cause of this difference. Experiments somewhat similar to those of M. De Luc should be prosecuted, in which the electrical and chemical effects of the pile are separated from each other, and a more accurate measure of the proper galvanic power should, if possible, be obtained, than any of which we are now possessed. The conducting power of the fluids concerned in the galvanic apparatus should be carefully examined, and the relation of their chemical action to their conducting power should be ascertained. But it is unnecessary for us to enlarge upon these topics: the rapid succession of discoveries which have been made in this department of science, and the very general attention which it has obtained from the first philosophers of the age, afford every reason to expect, that the farther investigation of it will be followed by no less success, than that which has hitherto attended its progress.

Description of the Figures in Plate CCLXIII.

PLATE CCLXIII. Fig. 1.

Fig. 1. The galvanic pile, as originally constructed by Volta, where the letters C, Z, and F denote the plates of copper and zinc, and the pieces of cloth or pasteboard soaked in fluid. The pile has four rods placed round it, to keep it in the perpendicular direction. The lower end was called the *copper*, and the upper the *zinc end.*

Fig. 2. When the number of plates is very considerable, Volta divides it into two or more parts, each being connected by slips of metal. In this case, it is essential that the same order of parts be observed from one end to the other, up the first pile, down the second, up the third, and, lastly, down the fourth.

Fig. 3. This was a modification of the galvanic apparatus that was formed by Volta, which he called *couronne des tasses,* where the zinc plates Z and copper plates C are not in contact, but are connected by metallic rods, and then immersed in a fluid.

Fig. 4. represents the trough apparatus invented by Mr Cruickshanks; the plates of zinc and copper are soldered together, and are then cemented into a wooden frame, leaving intervals between the double plates, to receive the fluid which is intended to act upon the zinc. It is provided with wires at each end, which are in opposite states of electricity, and may be applied to any substance which it is proposed to subject to its influence.

Fig. 5. represents the battery of Mr Children, which is a combination of the *couronne des tasses* of Volta and the trough of Cruickshanks. The plates are not in contact, but each pair is connected by slips of metal, and the whole is attached to a beam, so as to be lifted out of the cells at pleasure. The trough and partitions may be formed of either wood or earthen ware, and contain the fluid that is to act on the zinc plates.

Fig. 6. is the apparatus for receiving in separate vessels the gases which are evolved by the action of galvanism upon water. The two small jars have metallic wires inserted at their upper end, one of which is connected with the positive, and the other with the negative extremity of the pile. They are filled with water and inverted in the same fluid; and the ends of the wires are so situated, that the gas disengaged from them rises to the top of the jar.

Fig. 7. represents the apparatus in which the gases disengaged from water may be reconverted into water by the electric spark.

Fig. 8. are the agate cups, connected by amianthus,

Description of the Figures.

employed by Sir H. Davy in the decomposition of water; and Fig. 9. are the gold cones employed in the same set of experiments.

Plate CCLXIII. Figs. 9, 10, 11.

Fig. 10. represents the apparatus which Sir H. Davy employed for the decomposition of salts, and the transfer of their constituents. In Fig. 11. we have the combination of three vessels, in which the transfer is exhibited in a more striking manner.

Fig. 12. Fig. 12. represents the apparatus for taking the galvanic spark in gases: it consists of a graduated glass tube, into which two wires are introduced, the one which enters at the side being moveable, and capable of being approached to the other; according to circumstances, they may be tipped with pieces of charcoal, or the wire may be bare.

Fig. 13. Fig. 13. is a variation in the form, which may be employed over mercury. These instruments were invented by Sir H. Davy.

Figs. 15, 16, 17, 18. Figs. 15, 16, 17, 18. The dissected pile employed by De Luc, to illustrate the mode of its action. The shaded part represents the moistened cloths, and the letters C and Z the copper and zinc plates respectively. In Fig. 15. the pile is continuous, in its usual form; Fig. 16. is the first dissection, Fig. 17. the second, and Fig. 18. the third. Fig. 14. is one of the wire stands that are interposed between the plates.

Fig. 19. Fig. 19. represents the apparatus of M. De Luc: it consists of two piles connected by a metallic rod at the bottom; between the upper ends is interposed the interrupted wires terminating in water, and to each extremity one of Bennet's electrometers is applied.

Fig. 20. Fig. 20. represents the lower limbs of a frog, lying on a plate of metal, while another kind of metal is placed in contact with the spinal marrow; these two metals are then connected by a conducting body, and the muscles of the legs are thrown into convulsions.

Fig. 21. is Dr Bostock's numerical illustration of the effect of the pile; the letters point out the nature of the substances, and the figures indicate the increase of power which the electricity acquires by passing along the instrument. See Thomson's *Annals*, iii. 86. Description of the Figures. Plate CCLXIII. Fig. 21.

Fig. 22. is an experiment of Mr Singer's, which is supposed to disprove the hypothesis of electric energies. In this apparatus, each wire will have its ends in the opposite states of electricity, one positive and the other negative. Fig. 22.

Besides the references that we have made in the course of the article, the following works and papers deserve to be noticed, either as presenting an interesting view of the gradual progress of the science, or as containing an abstract of the hypotheses that have prevailed at different times.

Pfaff's *Dissertation on Animal Electricity*, 1793.

Monro *On Animal Electricity*, 1793.

Cavallo *On Electricity*, vol. iii. 1795.

Halle's report to the French Institute, *Journ. Phys.* t. 47. 1798.

Cuvier's report, *Journ. Phys.* 52. 1801.

Hachette's report, *Journ. Polytechnique*, 4. 1801.

Report to the French Institute, *Ann. de Chim.* 41. 1802.

Reports made by Delamatherie in several volumes of his *Journ.* 41, 46, 48, 50.

Sue's *History of Galvanism*, 1803.

Cuthbertson's *Practical Electricity*, 1807.

Carpue's *Introduction to Electricity and Galvanism*, 1807.

Conversations on Chemistry, 5th conversation.

Some good remarks on galvanism occur in Thomson's *History of the Royal Society*, in Murray's *System*, and in his *Elements of Chemistry*. (*x*)

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Galway.

GALWAY, a maritime county of Ireland, in the province of Connaught. It is bounded on the north by Mayo and Roscommon; on the east by Tipperary and King's County; on the south by Clare; and on the west by the Atlantic ocean. Its aspect is various, some parts of it being almost in a state of nature, and other parts of it fertile and cultivated. The western district is rocky and mountainous; the eastern district is flat with the exception of some low mountains on the borders of Clare. The soil here is warm and fertile, and capable of considerable improvement. The substratum being limestone, the verdure is almost every where exceedingly luxuriant. The best land in the county is situated between Mount Talbot and Portumna, and along by Ballyroan and Kilconneltenagh. That which stands next in quality, extends from Athenry to the town of Galway. It is not arable on account of its rocky nature, but produces excellent pasturage for sheep. The third division in point of quality, lies in the neighbourhood of Monaltee, affording very coarse grass, mixed with heath. The fourth comprehends Conamara and Joyce's land, and is quite destitute of cultivation.

Agriculture is in a very backward state. Indeed, almost the whole country is appropriated to grass. In some places, however, they raise wheat, barley, oats, and flax. Potatoes, of course, they have in abundance. There are scarcely any ditches or hedges; their fences consisting mostly of dry stone walls. They have an excellent breed of long horned cattle, and the finest flocks of sheep that are any where to be seen. To this last branch of rural economy they pay great attention; those who engage in it have both enterprise and capital; and accordingly it is in a very flourishing condition. The principal market for stock is that of Ballinasloe, situated on the east border of the county. Labour is generally paid by rent or price of corn acres, meadow or grass of a cow. In 1811, the average price of various articles were calculated as follows: A man the year round, £11, 10s. 9d.; a woman ditto £6, 10s.; carpenter per day 2s. 2d.; mason ditto 2s. 5½d.; slater ditto 2s. 3¼d.; quarryman 1s. 1d.; thrasher 9d.; saddle-horse ditto 4s. 4d.; plough ditto 5s. 5d.; grazing a cow per week 2s. 3d.; oak per foot 4s.; ash ditto 3s. 3d.; bricks per 1000 £1.; a car mounted £4, 11s.; potatoes per stone 3½d.; salt butter per cwt. £3, 14s. 8d.; fresh ditto per lib. 1s. 2¼d.; hay per ton £2, 17s. 6d.; whiskey per gallon 9s.; ale per quart 3d.; porter per gallon 1s. 6d.; beef per lib. 5½d.; mutton ditto 6d.; veal ditto 8d.; pork ditto 3½d.; lambs per score £19, 10s.; cheese per lib. 1s. 4d.; shoeing a horse 4s. 4d.; shoes per pair 9s. 9d.; salt per stone 1s. 1d.; Swedish iron per cwt. £1, 8s. 6d.; undressed flax per cwt. £3, 14s. 8d.; wool per stone £1.; fowls per couple 1s. 8d.; wheat per barrel £1, 18s. 5¼d.; barley ditto 15s. 6d.; oats ditto 10s. 1d.; malt ditto £1, 15s. 6d.; flour, 1st, per cwt. £1, 9s. 4d.; ditto, 2d, ditto £1, 4s.; ditto, 3d, ditto 17s.; oatmeal per cwt 14s.; labour in hay or corn harvest per day 1s. 1d.; mowing grass per acre 4s. 6½d.; rabbits per couple 1s. 1d.; milk per quart 2d.; herrings per 100, 5s. 3d.; corn acres of oats per acre £5, 6s. 10½d.; ditto meadow

Galway. ditto £6, 13s. 11¼; ditto potatoe land ditto £7, 7s. 6¾d.; flax per rood £1, 18s.

Large as this county is, there is not of property belonging to absentees above £50,000 per annum. Perhaps one-third of the whole land is let in partnership leases; and in some places leases are granted for three lives, or thirty-one years, to an indefinite number of tenants, who are not only joint in occupying the ground, but have the benefit of survivorship. The average rent is £1, 10s. per green acre. A man of large property is here termed a *statesman*, but he who has only a few acres is called a *patchman*. The Earl of Clanricarde, Lord Clancarty, Mr Eyre, and Mr Ross Mahon, have each estates in this county of about £10,000 per annum, Christoper D. Baleu, Esq. has £6000, John Burke, Esq. £7000, Lord French £3500, Malachy Doneyland £5000. Mr Martin has about 70 miles along the coast, and is reckoned the most extensive landed proprietor in the three kingdoms.

There is a good deal of fishing on the coast of Galway; but the fishermen are destitute of sufficient enterprise. The fish-market of Galway town is excellent, being supplied with turbot, salmon, &c. at a cheap rate. Trade is at a low ebb. Galway, though enjoying many local advantages in this respect, has declined very much of late years. Besides Galway, there are the well sheltered havens of Killkerran, Birturby, Roundstone, and Ballynakill. The manufactures of the county are not worth mentioning.

Galway abounds in rivers and lakes. The lake of Lough Corrib covers above 31,000 acres. It is twenty miles in length, and eleven acres at the broadest part. It resembles Lough Earne. Lough Reagh and Lough Coutra are said to be beautiful pieces of water. Several of the rivers have the peculiarity of being subterraneous in a part of their course. These are the Black River, the Clare, the Moyne, and the Gustnamakin. Almost every river and brook in the neighbourhood of Gort has a great number of these *swallows*.—The principal town in the county is that of Galway, which, indeed, is the largest in the province of Connaught. It is resorted to as a bathing-place in summer; and a place of residence in the winter for those families that are fond of society. The houses stand with their gables to the street, and a door in the end, like that of a coach-house.

Galway sends three members to parliament—two from the county and one from the town. There is no overbearing territorial influence. The Roman Catholic property is very extensive, and always supports that interest. The number of freeholders amounts to 4000. The freeholders within the borough, along with the members of the corporation, who are chosen at will, elect its representative.—The inhabitants of this county are mostly Catholics, the Catholics being as forty or fifty to one; in landed property they are about one to three; and in personal property as three to one. In the western parts, there are districts of fifty miles in extent, without a single church or a single Protestant. The militia, consisting of 1000 men, were all Catholics except the band and petty officers, amounting to sixty or seventy. The Catholics are increasing. There are ten Catholics called on the grand jury.

This county contains 1546 square miles, 989,950 acres, 16 baronies, 116 parishes, 28,212 houses, 142,000 inhabitants, 35 acres to a house, and 18.24 souls to a square mile. See Beaufort's *Memoir of a Map of Ireland*. Wakefield's *Statistical Account of Ireland*. (T)

Gama. GAMA, Vasco de, the discoverer of the passage to the East Indies by the Cape of Good Hope, was descended of a noble Portuguese family; and in early life distinguished himself as a naval commander in a war with the French. In 1497, he was selected by Emmanuel, King of Portugal, to command the squadron which had been equipped for the voyage to India. His courage, penetration, prudence, and enterprising spirit, rendered him worthy of the important charge, and were signally displayed in the course of the expedition. His squadron consisted only of three vessels and a store-ship, all of them of a burden and force very inadequate for such a service. On the 8th of July, the shore was covered with the inhabitants of Lisbon, and the adventurous band set sail amidst the tears and prayers of their countrymen and friends. It was the 4th day of November before they touched land on the western coast of Africa, where, in an accidental scuffle with the natives, Gama was wounded in his foot by a dart. From this period all his heroism was called forth in contending with the most tempestuous seas, and combating the mutinous opposition of his crew, till the 20th of the same month, when the storm suddenly ceased, and the Cape of Good Hope appeared in view. Having taken in provisions, and destroyed their store-sloop, they proceeded to sea on the 8th of December, and reached the shores of Mozambique about the beginning of March, where they first experienced the hostile dispositions of the Moors, and Gama narrowly escaped their treacherous attempts upon his life. After various adventures, in which his coolness and intrepidity were equally displayed, he came to anchor before the city of Melinda, where he found several merchant vessels from India, commanded by Christians; and, having procured a skilful pilot, arrived at Calicut on the 22d of May 1498. The sovereign of the country, or Zamorim, at first welcomed the strangers with every demonstration of friendship; but was soon influenced by the Moors to depart from his promises of alliance. On this occasion, Gama gave a noble proof of the most determined resolution and heroic self-devotion to the cause in which he had engaged. In order to complete the object of his voyage, an interview with the Zamorim was absolutely necessary; and, while he boldly committed himself into the hands of strangers, with all his experience of their treacherous dispositions, his whole arrangements and commands were directed, not to his own safety, but to the success of the expedition. He left the most peremptory orders with his officers, that if he were detained a prisoner, or any attempt made upon his life, they should take no step to save him; that they should give ear to no message, which might come in his name; that they should enter into no negotiation in his behalf; that they should not risk the loss of a single man, or endanger in any respect the homeward voyage for his sake; but, the moment they perceived his escape to be impracticable, they should set sail for Europe, and carry to the king of Portugal the tidings of the discovery of India. He escaped the snares of the Zamorim, defeated the Indian fleet, and pursued his homeward course. He reached St Jago in safety; but his brother, Paulus de Gama, sinking under the fatigues of the voyage, was unable to proceed. The generous and affectionate Gama, less elated with the triumphs which awaited his return, than afflicted by the sickness of his brother, sent forward his ship under the command of one of his officers, and remained at Tercera, to soothe the death-bed, and to close the eyes of Paulus. Having fulfilled this melancholy office, he landed at Lisbon on

Gamboge.

the 14th of September 1499, after performing the longest and most difficult voyage that had ever been made since the first discovery of navigation. Honoured with the title of nobility, appointed admiral of the Eastern seas, rewarded with a suitable salary, loaded with the compliments of the court, and followed by the shouts of the populace, he remained inconsolable for the loss of his brother, the companion of his toils; and, shutting himself up in a lonely house on the sea-side at Belem, could not be persuaded till after a long interval, to mingle again in public life. He was appointed, in 1503, to the command of a powerful fleet of 20 ships, destined for India, where he had frequent engagements with the fleets of the Zamorim; and, having secured a friendly commerce with the ports of Cochin and Cananore, he returned home with 12 ships, loaded with the riches of the East. The mal-administration of future commanders in India requiring the presence of some distinguished character, he set sail a third time, in the year 1524, in the office of Viceroy, and with the title of Count de Vidigueyra. Having remedied the errors of his predecessors by his exalted and liberal policy, he was interrupted in the prosecution of his enlightened plans, and died at Cochin three months after his arrival. See Robertson's *History of America*; Abbé Raynal's *History of the East and West Indies*; Mickle's *Lusiad*, Introduction; and *Modern Universal History*, vol. ix. (q)

GAMBOGE is the name of the concrete, gummy, and resinous juice of the *Stalagmitis gambogioides*, a tall tree, with spreading branches, which grows in Cambodia or Cambogia, Ceylon, Siam, and Cochinchina. The gamboge from Siam is sent home in small tears, which exude from the leaf-stalks, and young shoots that are broken off the tree. The gamboge of Ceylon is obtained from deep incisions in the bark, the juice being afterwards inspissated by the heat of the sun, and formed into cakes or rolls. The external colour is brownish-yellow, leaving a deep reddish-orange tint within. Its surface is smooth, and its texture equal and uniform. It has no smell, and very little taste; but when it has remained some time in the mouth, it leaves an acrid impression. It melts and blazes when applied to the flame of a candle, emitting sparks and a dense black smoke. Its flame is white when the gamboge is good, and its ashes grey. The larger and dark-coloured cakes are not good.

When dissolved in water, gamboge forms a fine yellow pigment, which is well known. It is also employed in making the gold-coloured lacquer for staining white wood, so as to resemble boxwood; and in giving a beautiful and durable citron-yellow stain to marble.

The following Table shews the quantity imported and sold by the East India Company from 1804 to 1808, inclusive. The permanent duty is £5, 12s. per cwt. and the war duty £1 : 17 : 6, amounting in all to £7 : 9 : 4.

Years.	March Sale.		Sept. Sale.		Total.		Aver. Price per Cwt.		
	Cwt.	Price.	Cwt.	Price.	Cwt.	Price.	£	s.	d.
1804	. .	. . .	64	£1270	64	£1270	19	16	10
1805	. .	. . .	51	1095	51	1095	21	9	5
1806	. .	. . .	65	1592	65	1592	24	9	10
1807	. .	. . .	30	1048	30	1048	34	18	8
1808	34	£929	112	2175	146	3104	21	5	2

Gam || Gange

Twenty cwt. of gamboge are allowed to the ton. See Lewis' *Materia Medica*; Neumann's *Chemistry*, by Lewis, p. 300, note *m*; Aikin's *Dictionary of Chemistry*; and Milburn's *Oriental Commerce*.

GAME LAWS. See LAW.

GAMES. See GREECE and ROME.

GANGES, a celebrated river of Asia, whose waters are regarded by the Hindoo as an object of peculiar sanctity and veneration.

Its nam[e]

In Eastern mythology, Ganga, the Ganges, is described as the eldest daughter of the great mountain Himavata, and called Ganga on account of flowing through *gang*, the earth. The Hindoo, willing to adopt what the Brahmin tells him as most congenial to his prejudices of the origin of the sacred river, believes that it issues from the root of the Boohjputre tree, through the semblance of a cow's mouth in stone, and flows directly from heaven; nor does he seek to be undeceived of so agreeable an illusion.

Fabulou[s] origin.

True ori[gin]

Until lately, much obscurity existed with regard to the true source of the Ganges; nor indeed to this day has it been traced up to the fountain head. But on this point the field of conjecture and doubt is much narrowed. All the maps, till 1807, assigned a course to the Ganges many hundred miles within the range of Himalaya mountains, the northern boundary of Hindostan. But the late Lieutenant-Colonel Colebrooke, Surveyor-General of Bengal, refused it so remote an origin, on the grounds, that if it pursued such a length of course, it must have swelled to a river of great magnitude long before it reached Gangoutri, from the supply of mountain-snows and rills. This gentleman was directed by the Bengal government to explore the sources of the Ganges; unfortunately, a premature death deprived the world of his services and professional abilities. Lieutenant Webbe, surveyor, was instructed to follow up Colonel Colebrooke's views, but he failed of success, being stopped by the extreme difficulties of the way, when, by all accounts, he was within a few days reach of the ultimate object of his mission. Geographers now agree in deducing the source of the Ganges from no considerable distance beyond Gangoutri, situated in N. Lat. 31° 4′, and E. Long. 78° 9′, among the Himalaya mountains, in the province of Serinagur.

Reasons [as]signed f[or] its sourc[e]

This opinion rests on the following grounds: that all the mountain streams during Lieutenant Webbe's journey were found to be increased during a course of eight or ten miles, from the smallest rivulet, to a considerable and unfordable river, by the supply of springs and tributary rills. The course of the Ganges and Alacananda rivers having been followed, till the former became a shallow and stagnant pool, and the latter a small stream; and both being affected by the dissolution of snows, in addition to springs and rills, it was concluded from analogy, that the sources of these rivers could be at no great distance from the spot where the observations were made. As we have no reason to suppose that the Bhagirathi branch of the Ganges is governed by laws different from other mountain streams, we are warranted in fixing its source on the southern side of the Himalaya range of mountains, and likewise in concluding that all the tributary streams of the Ganges, with the Sarjew or Goggrah, and the Jumna, whose chief fountain is not remote from the Ganges, rise also on the same side of that chain of mountains. Every account agrees that the source of the Ganges extends beyond Gangoutri, which is merely the point whence it issues from Himalaya. It is said to be here fifteen

Ganges.

or twenty yards broad, the current moderate, and waist deep. But the access beyond this place is much obstructed by snows. The pilgrims, and those who reside in the vicinity of Gangontri, and who gain a livelihood by bringing water from the spot, say that the road is only passable for a few miles, when the current is entirely concealed under heaps of snow, which no traveller ever has surmounted, or can surmount. This river assuming the name of the Bhagirathi, continues to flow from the north till it meets the waters of the Alacananda from the east. Their united streams at the town of Devaprayaga, in North Lat. 30° 8′ 6″, form the Ganges. Thus it appears that the Alacananda, which rises at a place called Bhadinath, in North Lat. 30° 42′ 28″, and East Long. 80° 18′ 22″, divides with the Bhagirathi the honour of forming the sacred river.

Formation of the Ganges.

Contrast of the Bhagirathi and Alacananda.

The contrast of these two rivers is remarkable. The Bhagirathi rushes down a steep declivity, foaming over large stones and fragments in its bed, while the placid Alacananda flows with a smooth and unruffled wave, till it unites its murmurs with the boisterous torrent of its sister stream. The breadth of the former is 112 feet, and it is said to rise 40 feet in the rains. It is crossed by a bridge of ropes, elevated 52 feet above the level of the water.

Fair and pilgrimage of Hairu ca Pairi.

The spot where the Ganges enters the plains, after forcing its way through an extensive tract of mountainous country, is called Hairu ca Pairi, situated at the extremity of the town of Hurdwar, and is regarded with peculiar veneration by the Hindoos. Hither an annual pilgrimage is made by people from all parts of Hindostan and the Deccan, for the purpose of ablution in the sacred stream. The bathing commences on the 10th of April. Every twelfth year is celebrated with greater rejoicings, and is called Cumbla Meba, from the planet Jupiter being then in the sign Aquarius. A fair is held here, and numbers repair to it merely from commercial motives. Merchants from the Penjab, Cabul, Cashmere, and other places, furnish merchandize, and from this mart the principal cities in the Duab, Delhi, and Lucknow, are supplied. At this season, sometimes two millions of people are collected. The temple containing the idol rises from the bed of the river. It is a plain building, surmounted by two cupolas. No particular ceremony is observed at the bathing, which consists of simple immersion. Those who are rigidly devout, or who have any apprehension about going into the water, are assisted by a couple of Brahmins, who having dipped the penitent in the holy stream, reconduct him ashore. Few, however, require this assistance; and as the water is not above four feet deep, the women plunge in without hesitation, and both sexes mix indiscriminately. After ablution is performed, the men whose fathers are dead, and widows, undergo tonsure, and the hair is generally strewed in some frequented path, with the superstitious idea, that good or bad fortune is indicated by the person or animal that first chances to tread on it. An elephant is considered peculiarly fortunate.

The five Pruyags.

Although the water of the Ganges, from Gangoutri to Sagor, is esteemed sacred, yet there are certain places, the resort of pilgrims from a distance, more eminently so than the rest. These are chiefly the five Pruyags, or sacred junctions of rivers, of which the principal is Allahabad, called simply Pruyag by way of distinction. The others are situated in the province of Sirinagur, at the confluence of the Alacananda with small rivers, and are named Devaprayaga, Budraprayaga, Carnaprayaga, and Nandaprayaga. Besides its sanctity, the Ganges is much esteemed for its medicinal properties, and drank on this account by Mahomedans.

Inland navigation.

The Ganges and Brahmapootra rivers, with their numerous branches and tributaries, intersect the country of Bengal in such a variety of directions, as to form the most complete and easy inland navigation imaginable. So equally and admirably diffused are those natural canals, over a country approaching to a perfect plain, that 4-5ths of Bengal may be safely said to be so well watered, as to command some navigable stream, even in the dry season, within a distance of 25 miles. This inland navigation employs upwards of 30,000 boatmen. And when it is considered that all the salt, and most of the food consumed by so large a population, is transported by water within Bengal and its dependencies, and at the same time that the commercial exports and imports, the interchange of manufactures and products throughout the country, the fisheries, and travelling, are all carried on by this means, it becomes less a matter of surprize that the inland navigation should employ such a number of hands.

The Ganges, on escaping from the mountains, flows with a smooth navigable stream, through delightful plains, during its course to the sea, diffusing plenty over the adjacent lands, and affording every facility for the transport of the productions of its borders. Nor is it unimportant in a military point of view; opening a communication between the different posts, it serves as a military way through the country, and renders unnecessary the formation of magazines.

Conflux with the Jumna.

After the Ganges issues from the mountains near Hurdwar, to the conflux with the Jumna at Allahabad, (the first large river that it meets), its bed varies from a mile to one mile and a quarter in breadth. From thence its course becomes more circuitous, and its channel wider, till having received successively the Goggrah, the Soane, and the Gunduck, besides many smaller streams, its channel attains its full width; and though afterwards in some places it narrows to half a mile, yet where no islands intervene, it extends to a breadth of three miles.

Its breadth and depth.

When at its lowest, the principal channel varies from 400 yards to $1\frac{1}{4}$th mile wide, and commonly is about $\frac{3}{4}$ths of a mile in breadth. The Ganges is fordable at some places above its conflux with the Jumna, but the navigation is never interrupted. At 500 miles from the sea, the channel is 30 feet deep when the river is lowest; and this depth continues to the sea, where the sudden expansion of the stream deprives it of force sufficient to sweep away the bars of sand and mud thrown across it by the strong southerly winds, so that the principal branch of the Ganges cannot be entered by large vessels.

Influx of rivers into the Ganges.

In its course through the plains, the Ganges receives 11 rivers, some of which are equal in size to the Rhine, and none smaller than the Thames, besides as many more of lesser note. To this vast influx of water, it is owing that the Ganges exceeds the Nile so much in point of magnitude, while the latter exceeds it by one third in length of course.

Its descent and motion.

The general descent of the Ganges does not exceed four inches per mile; and the mean rate of motion, in the dry season, is less than three miles an hour. In the wet season, whilst the waters are running off from the inundated lands, the current flows from five to six miles an hour, and in particular circumstances and situations,

Ganges.

seven or eight miles. An instance is mentioned by Rennell, in which a boat was carried, against a strong wind, 56 miles in eight hours. Considering that the velocity of the stream is three miles in one season, and five or more in the other, or the same descent of four inches per mile, and that the motion of the inundation is only ½ mile per hour, on a much greater descent; no further proof is required, how small the proportion of velocity is, which is communicated by the descent. It is then to the impetus originating at the spring head, or at the place where adventitious waters are poured in, and successively communicated to every part of the stream, that we are to attribute the velocity, which is governed by the greater or less accession of water.

Annual overflowing.

The annual swelling and overflowing of the Ganges, is attributable as much to the rain water that falls in the mountains contiguous to its source, and to the sources of the great northern rivers that fall into it, as to that which falls in the plains. The dissolution of mountain snow adds but little to its increase; for it rises but 15½ feet out of 32 (the sum total of its rise) by the latter end of June, and it is well known that the rainy season does not commence in most of the low countries till about that time.

In the mountains, the rains begin early in April, and by the latter end of that month, when the rain water has reached Bengal, the river begins to rise, but by very slow degrees, the increase being only about an inch a day for the first fortnight. It then gradually augments to two or three inches, before any quantity of rain falls in the low countries. On the rain becoming general, the increase on a medium is five inches per day.

Increase and decrease.

The following Table shews the gradual increase of the Ganges, and its branches, according to observations made at Jellinghy and Dacca.

At Jellinghy.	Ft.	In.	At Dacca. Ft.	In.
In May it rose	6	0	2	4
June	9	6	4	6
July	12	6	5	6
In the first half of August	4	0	1	11
	32	0	14	3

Its daily increase is nearly in the following proportion. During the latter half of August, and all September, from three to four inches; from September to the end of November, it diminishes gradually from three inches to 1½ inch; and at a medium ½ inch per day, from November to the latter end of April. These proportions relate to such parts of the river as are not affected by the tides. By the latter end of July, all the lower parts of Bengal are overflowed contiguous to the Ganges and Brahmapootra, forming an inundation of more than 100 miles in width, nothing appearing but villages and trees, and here and there the site of an abandoned village, resembling an island. Owing to the quantity of rain that falls in Bengal, the lands are generally overflowed to a considerable height long before the bed of the river is filled, the ground adjacent to the bank, to the extent of some miles, being more elevated than the rest of the country. Dikes, kept up at an enormous expence, guard particular tracks from inundation, yet these are liable to be damaged, owing to the want of tenacity in the soil of which they are composed. It is calculated that the length of these dikes, collectively, exceeds 1000 miles. The inundation is nearly at a stand in Bengal, for some days preceding the 15th of August, when it begins to run off, though great quantities of rain still continue to fall during August and September; but by this time a decrease of rain having taken place in the mountains, a consequent deficiency of supply to keep up the inundation ensues. Of the increase of the Ganges, Rennell remarks that there is a difference in the quantity of this increase at places more or less remote from the sea, the height of the periodical increase diminishing gradually from where the tide reaches to the sea, until it totally disappears at the point of confluence. The ocean preserving the same level at all seasons, (under similar circumstances of tide) necessarily influences the level of all waters that communicate with it, unless precipitated in the form of a cataract. At Luckipoor, there is a difference of about six feet in the height at different seasons; at Dacca, and places adjacent, 14; and at Custee of 31 feet. The last place is about 240 miles from the sea, by the course of the river; and the surface of the river there is, in the dry season, 80 feet above the level of the sea at high water.

Quantity of water discharged.

The quantity of water discharged by the Ganges, in one second of time, in the dry season, is 80,000 cubic feet; but the river, when full, having twice the volume of water in it, and its motion being accelerated in the proportion of 5 to 3, the quantity then discharged is 405,000 cubic feet. Taking the medium of the whole year, it will be nearly 180,000 cubic feet per second of time.

Deviation and depredation of its stream.

Europeans view with wonder the remarkable alterations in the course of the Ganges, and the other rivers of Bengal, although the natives of the country, who have long witnessed the encroachments and deviations of their streams, behold these changes without surprise. The greatest injury is sustained during the periodical floods, and while the waters are draining off; and when it is considered that at this season, at the distance of 200 miles from the sea, there is an increase of more than 25 feet in the perpendicular height of the water, some idea may be formed of the velocity with which it will run off, and of the havoc which it will make on the banks. Accordingly it is not unusual to find, when the rainy season is over, large portions of the banks precipitated into the channel, and the devastation extended over fields and plantations; even trees which, with the maturity of a century, have acquired strength to resist the most violent storms, have been suddenly undermined, and swept away by the stream. But the encroachments are as often carried on gradually, and in the dry season; in this case the natives have time to remove their effects, and change their places of abode, if too near the banks. Whole villages are thus seen deserted, whose inhabitants had retired to safer situations. Along the banks of the Ganges, where the depredations of the flood are most to be apprehended, the people are so accustomed to removal, that they make use of light materials only in huts, and such as, on an emergency, can be easily transported. These effects are attributable, in a great measure, to the looseness of the soil; but this destructive operation of nature is in some degree compensated by the formation of new lands, either by alluvions on the opposite shore, or by islands which emerge in the middle of the stream, and ultimately become connected with the main land, by the closing up of one of the channels. The Ganges gives birth to numerous islands, which are of an extent proportional to the bulk of its waters. The rapidity with which these islands have been thrown up, and the size to which they have swoln, appear objects of astonishment to those who have opportunity of observation. When the

Islands formed by its waters.

4

Ganges.

inundation has subsided, and the river found its ordinary level in the dry season, considerable sand banks are seen in places where, the preceding year, the channel had been navigable. The collection of sand becomes sometimes so great, as to divert the main stream into a new and generally more direct course; for it is only by encroachments on the banks that inflexions in the stream are produced, while the sudden alluvions, and frequent depositions of sand, have a tendency to fill up the channel, into which it had been diverted, and to restore the straightness of its course. Such of the islands as are found on their appearance to have any soil, are immediately cultivated; and water melons, cucumbers, and sursoo or mustard, are the produce of the first year. Even rice is seen growing on those parts, where a quantity of mud has been deposited near the water's edge. Some of these islands, before they have acquired sufficient stability to resist the force of the current, are swept away; but when, by repeated additions of soil, they appear to be firm and consolidated, the natives no longer hesitate to take possession of them, and the new acquisitions become immediately a subject of altercation. The settlers transport their families, cattle, and effects. The highest spots are selected for the villages, and dwellings are raised with as much confidence as on the main land; and though the foundation be sandy, the stratum of soil which is uppermost being interwoven with the roots of grass and other plants, becomes hardened by the sun, and at length sufficiently firm to resist the attacks of the stream. Thus these islands are liable to destruction only by the same process of undermining and encroachment to which the banks of the river are subject. When an island is found too extensive for cultivating the whole of it, it is soon overrun with reeds and long grass, forming impenetrable thickets, and affording shelter to tigers, buffaloes, deer, and other wild animals. The rest of the lands produce good pasturage, and feed thousands of cattle. The subsequent inundations fertilizing the soil, to which the burning of the grass greatly contributes, the inhabitants are induced to extend the limits of their cultivation, and settle permanently. The islands of the Ganges are distinguishable from the mainland, by their having few or no trees, even after a communication has been formed, by the closing up of one of the channels, which generally happens in a few years. Dera Khowaspour, one of the largest, has continued longer in an insulated state than any other, owing to its peculiar situation, immediately below the confluence of the Ganges and Coosa rivers. It is 9½ miles in length, and at the greatest breadth 2½ broad, containing about 20 square miles of land, mostly cultivated, with several villages. In the highest floods the inhabitants are obliged to erect temporary huts on pillars of wood, or stages; but they are seldom reduced to this necessity.

[Pic]ture of [the] islands.

If we present to the imagination a wide extended plain, with pens for cattle, and a few humble huts, whose tops are crowned with gourds, the intervening space highly cultivated with wheat, barley, and pulse of all sorts, whose flowers entertain the eye with a variety of rich tints; if we farther imagine the scene animated with numerous herds of cattle, and a few villages scattered over the distance, the horizon bounding the view with no other remote objects than a long line of grass jungle, and a few trees hardly discernible, from the great distance on the mainland, we shall then have a tolerable picture of an island of the Ganges. Finally, if we imagine the air cool, the sky serene and unclouded, we shall have an idea of the state of these islands during at least six months of the year.

State of its banks.

In the higher parts of Hindostan, where a conker soil, or a hard reddish calcareous earth prevails, the banks are not so liable to be undermined, and are even firm enough to resist the utmost efforts of the stream; but in Bengal, there are few places where a town built on its banks can long retain the advantage of its situation, being either liable to be destroyed by the river, or else to be deserted by it. In its course through Bengal, the Ganges may be said to have under its dominion a large portion of the flat country; for not only the channel which contains the main body of its waters, but also the land embraced by its collateral branches, is subject to inundation, or destruction by encroachment of the stream, and may therefore be considered belonging to the river. Nor can the bed of the Ganges through Bengal be said to be permanent. However, from local causes, at some places the main channel and deepest water will always be found, as at Monghir, Sultangunge, Sicrigully, and Rajemahl; at these places rocky points project into the stream, and some parts of the bed are stony, or the banks consist of conker.

Windings of its course.

The following Table will convey an idea of the windings of the Ganges, and its branches:

	Miles.
Within 100 miles the Ganges increases the distance to	125
The Goggrah, or Dewah, to	112
The Hoogly, from Calcutta to Nuddea, increases from 60 to	76
The Goompty from 100 to	175
The Issamutty and Jaboona from 100 to	217

Delta of the Ganges.

About 200 miles from the sea (but 300 reckoning the winding of the river) commences the Delta of the Ganges. The two westermost branches, called the Cossimbazar and Jellinghy rivers, unite and form what is called the Hoogly river, which makes the port of Calcutta, and the only branch of the Ganges commonly navigated by ships. The city of Calcutta stands about 100 miles from the sea, on the east side of the western branch of the Ganges, named by Europeans the Hoogly, and by the natives the Bhagirathi, or true Ganges, and considered by them peculiarly sacred. The river is here, at high water, fully a mile broad; but during the ebb, the side opposite to Calcutta exposes a long range of sand banks. On approaching Calcutta from the sea, a stranger is much struck with its appearance; the elegant villas on each side of the river, the company's botanic gardens, the spires of the churches, temples, and minarets, and the fine citadel of Fort-William, present a magnificent spectacle. Calcutta possesses the advantage of an excellent inland navigation, foreign imports being transported with great facility on the Ganges, and its subsidiary streams, to the northern nations of Hindostan, while the productions of the interior are received by the same channels. Where the Hoogly is joined by the Roopnarain, a very large sheet of water is formed, but it has many shoals; facing directly the approach from the sea, (while the Hoogly turns to the right,) it occasions the loss of many vessels, which are carried up the Roopnarain by the tide. Here is formed a dangerous sand, named the James and Mary, around which the channel is never the same for a week, and requires frequent sur-

Dangerous sand.

Ganges. The Bore.

veys. The Bore commences at Hoogly Point: So quick is its motion, that it hardly takes four hours to run a distance of 70 miles. It does not flow on the Calcutta side, but along the opposite bank; from whence, crossing at Chitpoor, about four miles above Fort-William, it proceeds with great violence past Barnag-ore and Duckinsore. On its approach, boats must immediately quit the shore, and go for safety into the middle of the river. At Calcutta it sometimes occasions an instantaneous rise of five feet.

Sunderbunds.

The part of the Delta bordering on the sea is composed of a labyrinth of rivers and creeks, named the Sunderbunds, which, including the rivers that bound it, give an expansion of 200 miles to the branches of the Ganges at its junction with the sea. A complete inland navigation is formed from the disposition of these natural canals. In tracing the sea-coast of this Delta, there are eight openings found, each of which appears to be the principal mouth of the Ganges. The course of the river fluctuates from one side of the Delta to the other; nothing appearing in its numerous creeks and rivers but regular strata of sand and black mould: The clay is found deposited below.

Their intricate navigation.

The navigation through the Sunderbunds is chiefly by means of the tides, there being two distinct passages; the one the Southern or Sunderbund passage, the other the Balliaghaut. The first is the longest, leading through the widest and deepest rivers, and opening into the Hoogly or Calcutta river, about 65 miles below the town. The Balliaghaut passage opens into a lake on the east side of Calcutta. The navigation of these passages extends above 200 miles through a thick forest, broken into numberless islands by a variety of channels, differing so much in width, that a vessel is at one time entangled among the trees, and at another sails on a broad expanse of water, beautifully skirted with wood. The water is every where salt; and the forest is abandoned to wild beasts, with the exception here and there of the solitary habitation of a fakeer. During the dry season, the salt-makers who visit these rivers exercise their trade at the imminent hazard of their lives; enormous tigers not only making their appearance on their borders, but swimming off to the boats that lie at anchor. In addition to these, the rivers swarm with alligators. These passages are open throughout the year, and during the season when the stream of the Ganges is low, all the trade of Bengal (the western districts excepted) passes either by Channel Creek or by Balliaghaut, but chiefly by the former.

It is neither practicable nor desirable to reclaim these salt marshy lands, generally overflowed by the tide. This forest has always been considered of importance in a political view, presenting a strong natural barrier along the southern frontier of Bengal. Excellent salt in abundance is here manufactured; the woods also furnish an inexhaustible supply of timber for fuel, boat-building, and other purposes.

Remarkable course of the Brahmapootra.

The British nation, with their allies and tributaries, occupy the whole navigable course of the Ganges, from its entry on the plains to the sea; which, by its windings, is about 1500 British miles. The following circumstance attending the Ganges and Brahmapootra rivers is remarkable. Though the sources of the latter have never been explored, they are in all probability only separated from those of the former by a narrow range of snow-clad mountains, about the 32° of North Latitude, and the 82° of East Longitude. From thence directing their courses to opposite quarters, they are more than 1200 miles apart; but afterwards meet, and roll their mighty streams in conjunction to the sea.

Ganges ‖ Ganjam.

Dolphinus Gangeticus.

There is a species of dolphin peculiar to the Ganges, which is particularly described by Dr Roxburgh in the seventh volume of the *Asiatic Researches*. We shall give merely a general outline of this animal. The body is long and slender, thickest about the forepart, and from thence tapering to the tail. The skin is soft, smooth, and of a shining pearl-grey, or lead colour when dry; diversified with lighter coloured spots, or clouds, particularly when old; but when the animal is alive, and as it appears in the water when rising to breathe, it looks much darker. The length of the one described (a young half grown male) was 6½ feet, and 3 feet in circumference where thickest, rather behind the pectoral fins. It weighed 120 pounds. The head is remarkable, being about one-sixth part of the length of the whole animal, and the jaws are furnished with no less than 120 teeth. When in pursuit of fish, it moves with great velocity. Between the skin and flesh is a coat of yellowish-coloured fat, more or less thick according to the state of the animal. This the Hindoos set a high value on, as an application for removing pains of various kinds. The flesh is like the lean of beef in colour, of no disagreeable smell, yet, so far as was learnt, not eaten by the natives. See Colebrooke, *Asiatic Researches*; Rennel's *Phil. Memoir*; Webbe's *Survey*, *Asiatic Researches*; and Hamilton's *East India Gazetteer*. (W. T.)

GANGLION. See SURGERY.

GANGRENE. See SURGERY.

GANJAM is a town of Hindostan, in the circar of Cicacole, near the Bay of Bengal. It is situated on a small eminence along the river, at the distance of about a quarter of a league from its embouchure. The principal public buildings are a large pagoda, and the house of the governor, built of brick. All the other houses are built of a greasy earth, and covered within and without with lime. They are roofed with straw or bulrushes, which are renewed every two years. The town is of a moderate size; the streets are narrow, and ill arranged; but the inhabitants are numerous. In 1711, when the town was rich and populous, it was situated very near the shore, but a violent storm of wind, which rose in the evening, drove out the sea, and inundated the town, so that only a few of the inhabitants escaped. The harbour of Ganjam is commodious; it has five or six feet of water at neap tides, and nine or ten in spring tides. Vessels are built here at a cheap rate, and in great numbers. The finest muslins that are made on the coast are manufactured at Ganjam. Provisions are cheap, and there is plenty of corn and rice. The town is much frequented by the merchants of Bengal, and by the Armenians.

Ganjam is at present one of the five districts into which the northern Circars are divided, and is the residence of a collector and judge. The fort, which stands on the southern side of the river, is a small pentagon, on plain ground, and is capable of making a considerable resistance when well garrisoned. Sugar and jagary are cultivated in the neighbourhood; but the country north of the town is very low, and is inundated in the rainy season.

Between the 1st of May 1811, and the 30th of April 1812, the total value of imports at Ganjam, chiefly from Calcutta, was 106,250 rupees, of which only 6414 rupees was from places beyond the territories of the Madras government. The total value of exports within the same period, was 471,503 rupees, of which only 8553 rupees was to places beyond the Madras territories, viz. 3157 to Calcutta, and 5396 Arcot rupees to Botany Bay. Distance from Calcutta 372 miles; from Madras 650. East Long. 85° 18′ 15″, North Lat. 19° 22′ 30″, according to astronomical observations. See Hamilton's *East India Gazetteer*; Milburn's *Oriental Commerce*; and Peuchet's *Dictionary*.

GARD, the name of one of the departments of France, in the province of Languedoc, formed out of the dioceses of Alais, Uzes, and Nimes. It is bounded on the north by the department of Ardeche, on the west by those of Lozere, Aveyron, and Herault; on the south by the sea; and on the east by those of the Bouches du Rhone, and Vaucluse.

The territory of this department, though mountainous, is very fertile. It contains many rich meadows, and produces grain of all kinds, wines, olives, silk, brandy, and coal. The wines of St Gilles have the greatest reputation. It has also mines of copper, iron, and other minerals. It is bounded by the Rhone on one side, and is watered by the Gardon, which passes below the Pont du Gard, a splendid specimen of Roman architecture. It is an aqueduct bridge of 49 arches, which crosses a valley not less than 160 feet deep. The forests occupy from 47 to 48 thousand hectares, or about 93,000 acres. More than a third of them belong to individuals, the greater part of the remainder to the communes, and the rest to the nation. The contributions in the year 1803, were 2,866,398 francs. The principal towns are

	Population.
Nimes	39,300
Alais	8,947
Uzes	6,191
Le Vigan	3,848

The population of the department is 309,052. See France, p. 676.

GARDENING is a very general term, being employed to signify both the *laying-out* of pleasure grounds, and the *cultivating* of fruit-trees, culinary herbs, and flowers. To the former branch belong the consideration of the general aspect of the ground, and the capabilities of the entire place, the improver often availing himself of hills, rivers, or forests, beyond the boundaries of the domain immediately under his power; the situation and extent of woods, groves, and clumps; the general grouping of trees, and the characteristics of the different kinds; likewise the management of ornamental water, either in the form of rivers or brooks, with waterfalls and bridges; or as lakes, with islands and fountains; also of rocks and ruins; and, lastly, the mansion-house and offices, it being evident that the house and the grounds must agree in character, or be mutually adapted to each other. To the latter belong the formation and culture of the *garden*, properly so called, including the cultivation of fruit-trees, as standards, espaliers, or wall-trees, of kitchen vegetables, and of ornamental plants, with a number of subordinate operations, such as the management of forcing-houses, hotbed frames, hot-houses, conservatories, and greenhouses. The former branch is properly denominated Landscape-Gardening, and the latter Horticulture; and under these titles we purpose to treat of them. The raising of forest-trees in nurseries, and the general ordering of woods and copses, are subjects connected with gardening, which shall receive due attention in a subsequent part of our work. An account of the mode of establishing orchards, and of managing them, with descriptions of the best orchard fruits, may be expected under the word Orchard.

GARMOUTH, or Garmach, is a seaport town of Scotland, in the county of Moray, situated at the mouth of the river Spey. The houses are principally built of clay, but the streets are regular, and the appearance of the place is respectable. From the great rapidity of the Spey, the tide does not run above half a mile up the river, and hence the harbour is often choked up by the gravel which is brought down by the rapidity of the Spey. At neap tides, the ordinary depth of water is from 8 to 9½ feet. Ships of 400 tons can enter and leave the harbour without any inconvenience. The principal trade of Garmouth consists of wood and salmon. The wood, which is cut on the property of the Duke of Gordon, Sir James Grant, and Mr Grant of Rothiemurchus, are floated down the Spey in rafts to a great extent, and is shipped at Garmouth, partly for Hull, and partly for Deptford and Woolwich. The wood, which is of the very best quality, is often cut into planks where it grows. There are two sawmills at Garmouth: One of these, driven by wind, works about 40 saws; and the other, which is impelled by water, works from 30 to 36 saws. Vessels from 50 to 500 tons have been built here, entirely of homegrown wood. Several sloops are employed in conveying salmon to London during the fishing season. There is a fall of 60 feet in the Spey, from Gordon Castle to Garmouth. Inhabited houses 304. Population 1200. West Long. 3°, North Lat. 57° 39′.

GARNET. See Mineralogy.

GARONNE, Higher, the name of a department of France, in Languedoc, formed out of the dioceses of Toulouse, Rieux, and Comminges. It is bounded on the north by the department of the Lot, on the west by those of Gers and the Higher Pyrenees, on the south by the Pyrenees, and on the east by the departments of Arriege, Aude, and Tarn.

The soil of this department is fertile in vines, grains, and pasturage; and it contains large forests, with quarries of marble and mineral springs. The river Garonne passes through the very middle of the department. The forests occupy 48,940 hectares, or about 95 or 96 thousand acres. Half of them belong to the communes, and the rest to the nation. The contributions in 1803 were 4,554,341 francs. The principal towns are

	Population.
Toulouse	50,171
Castel Sarazin	7,000
St Gaudens	4,155
Muret	3,141
Villefranche	2,035

The population of the whole department is 432,263. See France, p. 676; and Toulouse.

GARRICK, David, the celebrated English comedian, was born in the city of Hereford, and baptized on the 20th of February 1716. His grandfather was a French merchant, who, on the revocation of the edict of Nantz, fled to England with other Protestants, and settled in London. His father, Peter Garrick, obtained a captain's commission in the army, and married a daughter of the Rev. Mr Clough, one of the vicars in Litchfield cathedral. Soon after that time, it appears that Captain Garrick sold his commission, and retired

Garrick.

to Litchfield on half-pay. At the age of ten, his son David was sent to the grammar-school, under the tuition of Mr Hunter; but he does not seem to have displayed any early disposition for study. He very soon, however, discovered a turn for mimickry; and imbibed a relish for theatrical performances from the strolling players who occasionally visited Litchfield. Having engaged a set of his school-fellows to undertake their several parts in a comedy, he exhibited the *Recruiting Officer* before a select audience, in the year 1727. Garrick was then eleven years old; he performed the character of *Serjeant Kite*, and is said to have acquitted himself with great humour.

In the year 1729 or 1730, Garrick was sent out to his uncle, a thriving wine-merchant at Lisbon; but being found too volatile for a counting-house, he returned home in the following year. He was once more placed under the care of Mr Hunter; but his vivacity was still superior to serious application. In 1735, the celebrated Samuel Johnson, a native of Litchfield, formed the design of opening an academy for classical education, in which he was encouraged by Mr Gilbert Walmsley, register of the ecclesiastical court, a gentleman of most respectable character and attainments, and a generous patron of genius. Garrick, at that time turned of eighteen, was, with several other young men, consigned to the care of Johnson, and began to apply, with some diligence, to the study of the classics. At the end of twelve months, however, the master grew tired of his undertaking, and resolved to abandon it altogether. Soon afterwards, Johnson and Garrick, having become weary of the contracted sphere of a country town, and desirous of trying their fortune in a more extensive field, determined on an expedition to the metropolis.

These two friends, who were destined to attain a high degree of celebrity in their separate walks, accordingly set out from Litchfield on the 2d of March 1737, provided with letters of recommendation from Mr Walmsley to Mr Colson, a celebrated mathematician, at that time master of the school at Rochester. It was intended that Garrick should place himself under the tuition of Mr Colson; but he seems to have relinquished that intention upon his arrival in London. On the 9th of March 1737, he was entered a student of Lincoln's Inn; but the state of his finances did not enable him to pursue this profession. About the end of that year, his uncle arrived from Lisbon, with the intention of settling in London; but his design was frustrated by a fit of illness, which in a short time put an end to his life. He left his nephew David £1000; and upon this event, Garrick repaired to Rochester, and remained several months under the tuition of Mr Colson. During his stay at Rochester, his father died of a lingering illness; and his mother did not survive her husband above a year. Garrick now took his leave of Mr Colson, and returned to the metropolis. His eldest brother, Peter, had commenced business as a wine-merchant, and in 1738 David was induced to enter into partnership with him. This gave occasion to the saying of the facetious Samuel Foote, "that he remembered Garrick living in Durham-yard, with three quarts of vinegar in the cellar, calling himself a wine-merchant." It is certain, however, that his business was upon a scale rather more extensive; and his situation, in the neighbourhood of the two play-houses, gave him an opportunity of becoming acquainted with the actors of the time, and confirmed his previous inclination for the theatrical profession.

To that career Garrick now determined to devote himself; and the low state of the stage, at this period, seemed to present ample scope for the exercise of his genius. Quin and Macklin were the only male performers of distinguished reputation, and even their excellence was confined within the limits of a few particular characters. Mrs Pritchard, Mrs Woffington, and Mrs Clive shone in comedy. But with these few exceptions, truth and nature seemed to be banished from scenic representation. Comedy was reduced to mere farce and buffoonery; while in tragedy, violent rant and whining declamation were deemed the only just expression of passion and sentiment. Garrick perceived these defects in the style of theatrical exhibition; but he flattered himself that he should be able to revive a better taste, and to succeed by the truth of imitation. In the beginning of the year 1740, he dissolved partnership with his brother, and passed the remainder of the year in preparation for his great design; studying, with all his attention, the best characters of Shakespeare, and of our most esteemed comic writers. Having consulted his friend Mr Giffard, who was manager of the theatre in Goodman's Fields, he determined, by his advice, to make an experiment of himself at a country theatre. Accordingly, they both set out for Ipswich, where, in the summer of 1741, there was a regular company of comedians. Garrick's diffidence was still so great, that he assumed the name of Lyddal; and to prevent every chance of discovery, he chose, for his first appearance, the character of *Aboan* in the tragedy of *Oroonoko*. His reception, however, was such, that, in a few days, he ventured to throw off his black complexion, and shew himself in the part of *Chamont* in the *Orphan*. He afterwards displayed his powers in comedy, and with the same success. Not only the inhabitants of the town, but the gentlemen all round the country, went in crowds to see the new performer; and thus Ipswich had the honour of having first discovered and patronised the genius of a young actor, who soon afterwards became the brilliant ornament of the English stage, and the first comedian of the age in which he lived.

Garrick returned to town before the end of the summer, and resolved, in the course of the following winter, to present himself before a London audience. With this view he offered his services, first to Fleetwood, and afterwards to Rich, the managers of Drury Lane and Covent Garden; but was rejected by both. He then applied to his friend Giffard, and agreed to act under his management, at a salary of five pounds a week. The part he chose for his first appearance in the metropolis was that of *Richard III.* which he performed at Goodman's Fields, on the 19th of October 1741, in a style so new, so natural, and so impressive, as secured for him a most abundant harvest of applause. His fame quickly spread over the metropolis; and the public rushed in crowds to see a young performer, who burst forth at once a complete master of his art. The most elegant company flocked to Goodman's Fields; the celebrated Mr Pope was drawn from his retreat at Twickenham; and Lord Orrery is reported to have been so much struck with the performance, that he said, "I am afraid the young man will be spoiled, for he will have no competitor." In the course of the season, Garrick appeared in a variety of characters; in *Lothario*, *Chamont*, *Sharp* in his own farce of the Lying Valet, *Lord Foppington*, *Captain Plume*, and *Bayes* in the Rehearsal. In this last character, he seized the opportunity of making keen and powerful strictures on the prevail-

Garrick.

ing taste in dramatic composition; and availed himself of his wonderful powers of mimickry in taking off the most eminent performers of the time.

The unparalleled success which had hitherto attended all his efforts, induced Garrick to attempt a nobler flight, and to aspire to the first character in tragedy, by representing the difficult part of *King Lear*. Never was his genius more conspicuously displayed, than in his portraiture of the madness of that unfortunate monarch; it was, perhaps, the most accurate and impressive imitation of nature that was ever exhibited to the view of a theatrical audience. With that wonderful versatility of powers, for which he was so eminently distinguished, he descended from that first character in tragedy, to the farcical part of *Abel Drugger*, and represented the tobacco-boy in the truest style of comic humour. Hogarth, the famous painter, saw him in *Richard III.*, and on the following night in *Abel Drugger*; he was so struck with the various powers of the performer, that he said to Garrick, "You are in your element, when you are begrimed with dirt, or up to your elbows in blood."

Meanwhile the theatres of Drury-Lane and Covent-Garden were almost deserted; and the actors beheld with jealousy the rapid and unprecedented success of the new performer. Quin said, in his sarcastic manner, "This is the wonder of a day; Garrick is a new religion; the people follow him as another Whitfield, but they will soon return to church again." The joke was relished, and soon spread through the town. Garrick thought it required an answer, and replied in the following epigram.—

Pope Quin, who damns all churches but his own,
Complains that heresy infests the town;
That Whitfield Garrick has misled the age,
And taints the sound religion of the stage;
He says, that schism has turn'd the nation's brain,
But eyes will open, and to church again.
Thou Grand Infallible! forbear to roar,
Thy bulls and errors are revered no more.
When doctrines meet with general approbation,
It is not Heresy, but Reformation.

About this time, Garrick produced the farce of *Lethe*, in which he acted three different characters; and in the month of May 1741, he closed the season at Goodman's Fields, after a career of the most brilliant success. In the beginning of June he repaired to Ireland, in consequence of proposals on the part of the managers of the Dublin theatre, inviting him to perform with them during the summer months. He there performed his various comic and tragic characters to astonished and delighted audiences, and received the same applause that had been bestowed upon him in London. Towards the beginning of August he returned to England.

Garrick's reputation, as an actor of first rate excellence, was now completely established; in so much that Fleetwood, the manager of Drury Lane, now solicited those services which he had formerly rejected with disdain. He accordingly opened a negociation with Garrick; and the treaty was soon concluded on a salary of £500, which was more than had ever been given before. Garrick continued to perform at Drury Lane during three successive seasons, gradually augmenting his list of characters, by reviving the masterpieces of our great dramatic poet Shakespeare. *Hamlet*, *Macbeth*, *King John*, and *Othello*, were successively brought forward, and exhibited in a style of varied excellence, which no actor before his time had been able to attain.

Among the numerous merits of Garrick, it ought not to be reckoned the least, that by the correctness of his taste, and the charms of his acting, he contributed to restore our old standard plays to their just rank on the stage, and excited a relish in the public for the works of that great author, whose sublime conceptions of character; and profound knowledge of the most minute springs of human action, have elevated him to the highest seat among ancient and modern poets.

Towards the end of the year 1745, Garrick went over to Ireland, having received an invitation from Sheridan to be joint manager of the Dublin theatre for the season. On his return to England, in May 1746, he was offered advantageous terms by Rich, the manager of Covent Garden, who proposed, as a further inducement, to open his play-house, which was then shut, for six nights, upon an equal share of the profits. Garrick accepted, and played his capital parts with great success. He was also engaged for the ensuing season at the same theatre. Early in January 1747, he produced his farce of *Miss in her Teens*, which was extremely well received, and when, in the course of this season, Dr Hoadley's excellent comedy of the *Suspicious Husband* was brought forward, Garrick provided the prologue and epilogue.

The following season, Garrick attained the great object of his wishes, by becoming joint-patentee with Mr Lacy of the Drury-Lane theatre. At the opening of the theatre, on the 20th September 1747, he spoke an occasional prologue, written by his friend Dr Johnson, in a style superior to every thing of the kind in the English language, if we except, perhaps, Pope's prologue to the tragedy of Cato. During several years, Garrick continued to devote himself, with unremitting zeal and assiduity, to the concerns of the theatre, bringing forward new productions of merit, reviving the neglected plays of Shakespeare, Otway, and our best dramatic writers, occasionally diversifying the mode of entertainment by the exhibition of pantomimes, and continually delighting the public by the display of his own great powers. In the month of July 1749, Garrick entered on a new scene of life, by marrying the fair Violetti, a native of Vienna, who had chosen to adopt an Italian name. She had an elegant figure, and was much admired as a dancer. She was patronized by Lord and Lady Burlington, who, it was generally understood, gave her a fortune of six thousand pounds. In the summer of 1763, he formed a design to visit the continent, having been told by his physicians that he stood in need of air and exercise, and that Mrs Garrick's health would receive benefit from the waters of Barrege. Accordingly, he set out for Dover on the 15th September, leaving his brother George, as his substitute, to act for him in concert with Mr Lacy. During his absence, the affairs of the theatre continued to be managed with considerable profit; but the public longed for the return of their favourite performer. Garrick and his lady arrived in London about the end of April 1765. The news was announced in the papers, and was received with joy by the town. He did not act, however, during the remainder of the season, which ended, as usual, in the month of June. On the 14th of November 1765, his majesty, after opening the session of parliament, commanded, for his evening entertainment, the comedy of *Much ado about Nothing*. This called forth Garrick from his retreat. He came prepared with an address to the audience, and was received with loud acclamations of joy and approbation. From this period he continued to appear occasionally in his best

Garrick. characters, and to conduct the affairs of the theatre with the same spirit and success as he had formerly done.

In the month of March 1773, Garrick lost an able coadjutor by the death of Mr Lacy, the joint-patentee of Drury-Lane. The whole burden of management now fell upon him, at a time when his infirmities rendered him unequal to the task. He therefore appeared as seldom as possible in the laborious parts of tragedy; but still continued to perform his favourite comic characters. In the beginning of the year 1776, he formed the resolution of retiring from the stage, and this intention was first intimated to the public in the prologue which he wrote to Mr Colman's farce, called *the Spleen, or Islington Spaw.* After describing a tradesman, who quits his business to enjoy the air of Islington, he adds,

> The master of this shop too seeks repose,
> Sells off his stock in trade, his verse and prose,
> His daggers, buskins, thunder, lightning, and old clothes.

On the 10th of June, he made his last public appearance. For some time he proposed to finish his theatrical career with the part in which he at first set out; but he thought that after the fatigue of so laborious a character as that of *Richard III.* it would be out of his power to utter a farewell address to the audience, and he therefore chose the part of *Don Felix* in the comedy of *the Wonder.* The profits of the night were assigned to the fund for the relief of those who should be obliged by their infirmities to retire from the stage. After the play he came forward and addressed the audience in a few words, which he uttered in a manner that sufficiently indicated the feelings which agitated his mind. He then bowed respectfully to all parts of the house, and in a slow pace, and with much hesitation, withdrew forever from the scene of his well-earned fame, amidst the regret of all those who knew how to appreciate his unrivalled genius.

Garrick now retired to his villa at Hampton, resolved to pass the evening of his life in peace and rural tranquillity. Here he enjoyed the occasional society of a numerous circle of friends. He lived in an elegant style, and to the luxuries of the table added the charms of his conversation, and the polished manners of one who had enjoyed the best company. During the year 1778, his former complaints returned with increased violence. But his courage had not deserted him; and he endeavoured to conceal his sufferings by assuming an air of gaiety. He was invited to pass the Christmas of that year at Altrop Park, the seat of Earl Spencer, in Northamptonshire; but his enjoyment of that party was soon interrupted by a violent attack of his inveterate disorder. He arrived at his house in the Adelphi on the 15th of January 1779. Medical aid was found to be in vain. During the last four or five days he suffered excruciating pain with great fortitude, and on the 20th of January, at eight in the morning, he expired without a groan. On the 1st of February his remains were conveyed from the Adelphi to Westminster Abbey, and deposited in Poets' Corner, near the monument of Shakespeare. The funeral was magnificent; it was attended by many noblemen and gentlemen of rank and fashion, and by almost all the admirers of polite literature. The train of carriages reached from Charing-Cross to the Abbey. A prodigious concourse of people lined the way, and by their mournful silence gave the most evident demonstration of their sorrow. A handsome monument was erected to the memory of Garrick by the late Mr Albany Wallis, at his own expence.

Garrick's stature did not rise above the middle size; his frame was delicate; his limbs well proportioned; his countenance animated; his voice clear, flexible, and melodious; and his eyes were remarkably keen and penetrating. In private life he was greatly esteemed for his amiable dispositions, as well as on account of his various accomplishments and agreeable manners. He had a fine flow of animal spirits, and a great share of wit and humour; he delighted in polite and liberal conversation, but generally avoided the discussion of political topics. In the outset of life, when his means were slender, he was a strict observer of economy, and his enemies gave it the name of avarice; but as soon as his circumstances would afford it, he was distinguished by hospitality and munificence. He loved his friends, and his purse was often at their service. To merit in distress his benevolence was sure to be extended. Dr Johnson has been often heard to say, that when he saw a worthy family in distress, it was his custom to collect charity among such of his friends as he knew to be in a state of affluence; and, on those occasions, he received from Garrick more than from any other person, and always more than he expected. He was tremblingly alive to his professional reputation, and his anxiety upon this subject sometimes betrayed him into strange revolutions of temper. However, he had a quick discernment of merit in others, and was ever ready to acknowledge and reward it.

As an actor, Garrick burst forth at once in a style of unrivalled excellence, and continued, during the whole course of his career, to stand at the very summit of his profession. It is impossible for us to convey a just notion of the striking effects of his performance, or to do justice to his various merit. Those traits of excellence, by which an actor draws forth the admiration of his contemporaries, are unsubstantial and evanescent; and leave nothing behind from which an adequate judgement can be formed by posterity. As Mr Sheridan has said, in the language alike of truth and of poetry,—

> "The grace of action, the adapted mien,
> Faithful as nature to the varied scene;
> Th' expressive glance, whose subtle comment draws
> Entranc'd attention, and a mute applause;
> Gesture that marks, with force and feeling fraught,
> A sense in silence, and a will in thought;
> Harmonious speech, whose pure and liquid tone
> Gives verse a music, scarce confess'd its own;
> As light from gems assumes a brighter ray,
> And, deck'd with orient hues, transcends the day!
> Passions wild break, and frown that awes the sense,
> And ev'ry charm of gentler eloquence,
> All perishable!—like the electric fire,
> But strike the frame, and, as they strike, expire;
> Incense too pure a bodied flame to bear,
> Its fragrance charms the sense, and blends with air."
>
> *Monody to the Memory of Garrick.*

We are therefore left to form a faint idea of his talents, from the testimony of those who were eye-witnesses of his performance. To a quick and just conception of the peculiarities of every character, he added a wonderful power of adapting his looks and gestures to the circumstances and situation of the person represented. If we may be allowed the expression, his very silence spoke; his countenance was itself a language. Before he uttered a single word, the varying passions visibly began to work, and wrought such rapid changes in his features, in his action, his attitudes, and the expression of his eye, that he was almost every moment a new man. His talents were versatile as they were powerful; and he was equally sure of attaining his ob-

Garstang || Garth.

ject, whether his aim was to excite terror or pity, or to raise laughter. It was one great excellence of his acting, that he constantly held in remembrance the character he played, throughout all its various stages. No situation of it whatever was neglected; nor was he ever, for a moment, inattentive to the business before him. By his extreme earnestness to appear always what he ought to be, he obtained complete possession of his audience, and roused them to a correspondent approbation of his action.

As an author, Garrick has displayed no contemptible powers. He was not, indeed, an author by profession; the duties of his situation engrossed too much of his time to permit him to apply regularly to literary composition. But the comedy of *The Clandestine Marriage*, his farces, and poetical pieces, sufficiently shew that he wanted leisure, rather than wit or genius, to have enabled him to produce works of greater value. See Davies' *Memoirs of the Life of Garrick;* and *The Life of Garrick*, by Murphy. (z)

GARSTANG, is a market and corporate town of England in Lancashire, situated in the hundred of Amounderness, on the great west road from Edinburgh to London. It stands on the western bank of the river Wyer, which runs parallel to the east side of the principal street, supplying the town with excellent water and fish of different kinds.

The town, which is irregularly built, contains a few good houses. The church is a large Gothic structure, which stands about a mile to the south of the town. It possesses no manufactory; but there are several in the neighbourhood, viz. a printing cotton and calico manufactory at Catteral, and spinning manufactories at Seaton, Dolphinholm, and Catston. Number of houses 62. Population 731. See *Beauties of England and Wales*, vol. ix. p. 113.

GARTER, Order of the, is a military order, which was instituted in 1344 by King Edward III. under the title of "Sovereign and Knight's Companions of the most noble order of the Garter." See Heraldry.

GARTH, Sir Samuel, an English poet and physician, was descended of a good family in Yorkshire, and received his academical education at Peterhouse College, Cambridge, where he took his degree of Doctor of Medicine on the 7th July 1691.

On the 26th June 1692, he was admitted a fellow of the College of Physicians; and in 1694, he published his *Dispensary*, a mock heroic poem, in which he ridiculed the company of apothecaries, and some of the members of the College of Physicians, who had opposed the establishment of a dispensary, for supplying the poor with medicines and gratuitous advice. The "Dispensary," which is an obvious imitation of Boileau's Lutrin, went through three editions, and after receiving successive improvements from the hands of the author, it has enrolled his name in the second class of British poets. In 1697, Garth pronounced the Harveian oration before the College of Physicians. It was immediately published, and was regarded as a good specimen of oratory. Dr Garth pronounced a Latin eloge over the remains of Dryden. He addressed some complimentary verses to Lord Godolphin, on his dismissal in 1710. He lamented, in a complimentary poem, the exile of the Duke of Marlborough; and in 1711 he displayed his attachment to the family of Hanover, by the dedication of an intended edition of Lucretius to the Elector, afterwards George I. The gratitude of this prince was shewn upon his accession to the throne, by conferring the honour of knighthood upon Garth, which was done by the sword of the Duke of Marlborough. Soon afterwards he was appointed physician in ordinary to the king, and physician-general to the army; but he did not long enjoy these distinguished honours. After a short illness, he died in January 1719, and was interred at Harrow in Middlesex, on the 22d of that month.

Garum, Gas Lights.

GARUM, is a name which has been applied by medical writers to a pickle, in which fish had been preserved. The garum of the ancients was greatly esteemed as a delicacy at their tables.

GAS, is a name which was given by Van Helmont to aëriform or elastic fluids. See Chemistry, p. 99, and Gases.

GAS Lights, is the name given to the artificial light produced by the combustion of inflammable gases, obtained from the destructive distillation of pit-coal, and several other combustible bodies.

The late Mr W. Nicholson has very properly observed, that during the combustion of oil, tallow, wax, &c. in producing light, the same change takes place among their respective elements which would have been produced by subjecting them to destructive distillation, the inflammable gas being the substance furnishing the light which they afford. The only difference, therefore, between the light of candles, lamps, &c. and the gas lights, is, that in the former the decomposition of the substance, and the consequent evolution of the inflammable gas, is effected by its own heat. In the gas lights, the decomposition is effected in a close vessel by a separate fire; and the gas given out, after being washed, is conducted to a reservoir, from whence it is drawn through small apertures, where it is set on fire. In candles and lamps, the inflammable gas, which is the source of the light, is more or less accompanied with smoke, which, if not burnt, produces a cloudy yellow flame. In the Argand lamp, where the supply of oxygen is great, the smoke is burnt, which of itself furnishes some light; but the brilliant light is more to be attributed to the purity of the inflammable gas after the cloudy matter is removed.

All substances, whether animal, vegetable, or mineral, consisting of such proportions of hydrogen and carbon as to furnish the inflammable gases, are capable of furnishing artificial light by decomposition. The gases produced in the operation are carburetted hydrogen, olefiant gas, and in some cases carbonic oxide and pure hydrogen.

We are indebted to Dr Henry for some valuable facts derived from his experiments, upon several bodies affording inflammable gas by destructive distillation. The following is a small Table from his paper, exhibiting the relative value of the gases from different substances in producing light. Bodies which afford the inflammable gases by destructive distillation.

100 Measures of	Requires of oxygen for its consumption	Producing of carbonic acid
Pure hydrogen gas	50	. . .
Gas by heating moist charcoal	60	35
—— from dried peat	68	43
—— from oak wood	54	33
—— from cannel coal	170	100
—— from lamp oil	190	124
—— from wax	220	137
Pure olefiant gas	284	179

It is found, as we should naturally infer, that the quantity of light furnished is as the quantity of oxygen required to consume the gas. The carbonic oxide, which is already half saturated with oxygen, produces the least light, while the olefiant gas, as will be observed in the Table, requires the most. The gas from moist charcoal contains about 78 per cent. by weight of carbonic oxide, the rest being principally hydrogen. On this calculation, the specific gravity of this gas comes out 6, hydrogen being 1. Its specific gravity by experiment, according to Cruickshank, is 5.4. Those from oak-wood and dried peat probably differ but little from the latter. This, however, might be ascertained nearly, if we knew their specific gravities. The gas from cannel coal, when purified in the manner hereafter to be directed, consists almost wholly of carburetted hydrogen. Its specific gravity, derived by calculation from Dr Henry's table, is 6.5. Carburetted hydrogen, on the authority of Mr Dalton, is 7.5, hydrogen being 1. If Dr Henry's experiment be correct, and 7.5 be the true specific gravity of carburetted hydrogen, then the cannel coal gas must contain free hydrogen, from its specific gravity being less than that of carburetted hydrogen. The carbonic oxide, sulphuretted hydrogen, and sulphurous acid, which the coal gas will contain, if not purified, would contribute to increase the specific gravity.

Olefiant gas produces the most brilliant light of any other gas, which is to be attributed to its consisting entirely of hydrogen and carbon, and its great specific gravity. The gases, from the distillation of lamp oil and wax, in the way the coal is distilled, will be seen in the table to exceed the coal gas; and that from wax nearly approaches the olefiant gas in the consumption of oxygen, and in the property of producing light. The substances, however, affording olefiant gas are too expensive to be applied to the production of light by the process used for obtaining coal gas.

When the Lavoiserian theory was first advanced, it was generally thought that the light and heat were furnished by the oxygen: hence, whatever might be the combustible body, the greatest light and heat would be produced, the greater the quantity of oxygen which entered into combination in a given time; and the intensity inversely as the space in which the combustion took place. It has since been held, and with good reason, that the inflammable body also contributes light and heat.

There does not appear to be any just theory of the production of light and heat by combustion, but that founded on the change of specific heat between the materials of combustion and the body resulting from the combustion. We cannot, however, expect to derive much practical benefit from such a theory, till we are in possession of a correct table of the specific heat of bodies.

Since chemists are sufficiently acquainted with four inflammable gases to obtain them in a state of purity, namely, hydrogen, carburetted hydrogen, carbonic oxide, and olefiant gas, we might, by a few experiments, get some idea of the relative quantities of light afforded by carbon and hydrogen. If we suppose these gases to consist of pure hydrogen, and still retaining their respective densities, then the intensity and quantity of light would be directly as their densities. In as much, therefore, as their light differs from the ratios of their densities, may be attributed the relative quantities of light afforded by the bodies of which they are composed.

Two small gazometers will be necessary for these experiments, the one to contain hydrogen gas, and the other the inflammable gas to be compared with it. Let the pressure of each be exactly the same, and let the gas from each pass through exactly the same sized aperture, at the time it is burnt. The flames must now be compared with each other, by making shadows in them fall upon a white surface; then remove the strongest light backward, till the shadows are of the same intensity. The squares of the distances of the flames, from their respective shadows, will express the ratio of the illuminating powers of the two flames. If, for instance, hydrogen were compared with olefiant gas, and if the carbon of the latter gas contributed as much to the illumination as the hydrogen, then the ratio of the squares of the distances of the flames from the shadows when the shadows were of the same intensity, would be as 1 to 11.85. If, however, the flame of the olefiant gas will not require to be shifted so far back, in order to make the shadows equal, then it will show that the carbon of this gas has not afforded the same light as so much hydrogen would have done. If now the comparison be made between hydrogen and carburetted hydrogen, the ratio of the squares of the distances, if the latter gas were all hydrogen, would be as 1 to 7.5. But the distance of the flame of the carburetted hydrogen gas will probably fall short of the $\sqrt{7.5}$, owing to the carbon it contains; but it contains a less proportion of carbon on the whole than olefiant gas, and therefore ought to produce more light, in proportion to its density, than olefiant gas. In these instances we have presumed, and with good ground, that a given weight of hydrogen, in its combination with oxygen, affords more light and heat than any other inflammable body. In these and all other instances of combustion, the absolute quantity of light and heat will be the same, whatever may be the density of the combustible body and the oxygen; but the intensity may be much increased by diminishing the time of burning the same quantity of matter, and the space in which the combustion takes place. Hence we accumulate light and heat by means of bellows, and other means of furnishing oxygen, with great facility. We should also get a proportionate effect by increasing the density of the oxygen. If hydrogen and oxygen were increased in their density by artificial pressure, and presented to each other for combustion, the intensity of the light and heat would be in the complicate ratio of their increased density. If each were compressed into half the space, then the effect of their combustion would be four times the intensity of that in their natural state. In this way much greater intensity of both light and heat may be produced than we have hitherto heard of. The carburetted hydrogen would much exceed olefiant gas in producing light, if its density were equal to the latter gas, because it contains more hydrogen than olefiant gas. And if pure hydrogen were of the density of olefiant gas, the intensity of its light would be nearly twelve times greater than when burnt in its ordinary state, and it would be to olefiant gas as about 7 to 3.

Method of measuring the intensities of the lights from different gases.

Cannel coal, and the most bituminous of the Newcastle coal, and many others in the country, when exposed to distillation at a red heat, furnish several gaseous products, the principal part of which is the carburetted hydrogen, a quantity of tar, and an aqueous fluid charged with carbonate of ammonia. The separation of the carburetted hydrogen, which when pure burns with great brightness, and without smell, is now effected with great success, on the largest scale, and the other products, part of which have only been applied to useful purposes, will in time find beneficial sources of consumption.

We shall decline entering minutely into the history of the discovery and progress of the art of lighting with gas. With respect to the discovery, it would be difficult to fix any period to it, or with justice to give it to any particular person. Dr Hales and others, among their numerous experiments in obtaining gases from different bodies by heat, cannot have failed to witness the perseverance of their inflammability.

layton's xperi- ients.

An account will be found in the *Philosophical Transactions*, vol. xli. of some experiments upon the distillation of coal by Dr Clayton. He collected the gas in bladders, and burnt it. In Lord Dundonald's attempts to extract tar from coal, the gas evolved at the time was fired. It is singular to remark, that coal is now distilled for its gas and coak, the tar being of no value; and that this invaluable substance should have been the only thing which his Lordship sought for. We do not hear of any attempt to apply the coal gas to the economy of producing artificial light, before the experiments of Mr Murdoch, made at Redruth, in Cornwall. He distilled coal and other inflammable bodies from an iron retort, conveyed the gas to a distance through tinned copper pipes, and burned it as it escaped through small apertures. These experiments were made in the year 1792. After leaving Cornwall, he resumed his experiments at Old Cumnock, in Ayrshire, in 1796, where he exhibited the new phenomena to numerous friends. He after this, in 1798, went to the Soho Foundery, where he constructed an apparatus for lighting the building, in which he made some improvements in the means of purifying the gas, to get rid of the smell. In the spring of 1802, on the event of the general peace, he made a grand display of these new lights at the Soho works, which excited much curiosity.

Ir Mur- och first pplies the ght of the as to eco- omical urposes.

Although Mr Murdoch was certainly not the first observer of the inflammability of the coal gas, he may lay just claim to the application of it to economical purposes; and doubtless first pointed out the practical means of bringing it into use. The manufactory of Messrs Lee and Philips of Manchester was lighted with gas, under the direction of Mr Murdoch, as early as 1805, which, in the present state of gas lighting, is considered as very complete. At that period Mr Lee had his house lighted with the gas.

Mr Clegg, late of Manchester, and originally with Boulton and Watt of Soho, has given much attention to the subject of gas lights, and has contributed many useful improvements in the apparatus used for preparing it. He has given a description, with the aid of a drawing of a gas apparatus, to the Society for the encouragement of Arts and Manufactures, which is published in their transactions for 1808. This apparatus, with some few improvements, is at present considered the best. As we shall describe one embracing several improvements upon Mr Clegg's, it will not, in this limited article, be possible to give a copy of his in addition.

The apparatus generally consists of an iron retort of a cylindrical form, its length being from seven to eight times its diameter. It has an opening at one end, which can be closed by a lid with a conical edge, and pushed up to its place by a catch or wedge. The retort is placed horizontally in a furnace, which allows the flame to pass under it in the direction of its length, and over it on its return, after which it enters the chimney.

The fire should be so intense as to be capable of heating the retort to a bright red heat, and of keeping it up at the same time; but should not be capable of heating it very hot, as the retort itself might be melted, or at least much injured, and the gas less perfect.

Description of the gas light apparatus.

At some distance from the mouth of the retort, which projects a little way beyond the brick work in front, a pipe ascends from the upper side, and at right angles to the length of the retort. Through this the gas escapes, ascending first, and then the pipe turning, it descends into a wide pipe, placed in a horizontal position. This last is called the condenser. From the end of this pipe, an inclining pipe proceeds which conveys the gas, and also the tar, after it has accumulated in the condenser, till this last admits it to run off. The gas and tar now proceed together, the former occupying the upper half of a longitudinal section of the pipe, and the latter the lower half. The tar is at length deposited in a vessel, from whence it can be drawn at pleasure. The gas first ascends from the pipe in which it was accompanied by the tar, and then descends into a vessel containing a mixture of lime and water, by which it is purified. It then passes into an apparatus called a Gazometer. This consists of an outer vessel filled with water. A second vessel, less in diameter, is inverted and immersed into the first. If the common air be allowed to escape from the inner vessel, it will freely descend, and water will occupy the place of the air. If now the source for the escape of air be stopped, and the inner vessel counterpoised by a weight, the inflammable gas, purified as above, may be admitted under the inner vessel, which will ascend to make room for the gas. The suspended vessel is a little heavier than the weight, so that if the force of the entering gas were withdrawn, and an opening made to permit the air to escape, the vessel would descend. This apparatus is not only a reservoir for the gas while its production is going on, but it serves to force out the gas to be burnt, with a gradual and uniform pressure, which gives steadiness to the flame. The gas is set on fire when it is escaping through one or more small apertures, about one-thirtieth of an inch in diameter. These are sometimes disposed in a circle, about the size of the circular wick of the Argand lamp, and hence have been called Argand burners. A glass is placed over them, similar to the Argand lamp. The gas tube sometimes terminates in a spherical head, perforated with different numbers of holes.

Before we proceed to enter into any particulars relative to the practice of gas lights, we shall give a more minute description of the apparatus, in reference to the Plate. Fig. 1. Plate CCLXIV. is a plan and section of the furnace containing the retort. The latter is seen to more advantage in the perspective view. In Fig. A, *e e e* are projecting pieces marked similarly in Fig. 1, for the retort to rest in a horizontal position: *p* is the place where the two parts of the retort are screwed together. The front part contains two ears *t t*. Fig. B is the lid or cover, having a conical edge, which fits the mouth of the retort, and is forced into its place by a wedge Fig. C, which passes through two holes in the ears *t t*; *s* is a pipe, with a plunge to receive the pipe *n*, (Fig. 2.) being cast with the front part of the retort. The fire-place is shewn at *m* (Fig. 2.), *d* is the door, *g* the grate, A the ash-pit, and *f* the flue. The flame first passes along the flue under the retort, where it reaches *r*, and rises to the upper side of the retort, and passes, in the direction of the returning darts, into the chimney C. The separation of the lower half of the flue from the upper is seen in Fig. 3. at *f f*; *b b* are long fire-bricks, which separate the fire place from the

Plate CCLXIV. Fig. 1. Fig. A, B, C. Fig. 2. Fig. 3.

bottom of the retort; this prevents the immediate action of the flame upon the retort, which would soon destroy it. The retort, notwithstanding this apparent power, ultimately receives the whole of the heat without being liable to oxidation. When the retort is charged, and the lid secured, the gas and the other volatile products rise through the pipes *s* and *n*, and enter the larg[illegible]e *c*, which is called the condenser; see Fig. 7. A portion of the tar, &c. condenses in this vessel; till it rises to the level of the pipe *i*, along which the gas and tar descend through a succession of pipes, passing round the inside of the vessel AB, which is filled with cold water. This vessel is square, so that the pipes passing along its sides are of equal length. They are so inclined to the horizon, as to come to the point *v* when they have passed quite round the vessel. The pipe *v x* now brings it out at the point *x*. This pipe continues its direction into the vessel, Fig. 6. which cannot be seen in the profile, Fig. 7. The gaseous products rise up the pipe *h*, Fig. 7, and then descending, terminates in the vessel L; the plan of which is Fig. 5. The tar and ammoniacal liquor condense in the vessel, Fig. 6. which is called the tar vessel. It is made perfectly air tight, and its contents are drawn off at an aperture on a level with the bottom, so that no air can escape till the whole of the liquid is discharged. We now return to the gaseous products, which enter the vessel L; and in order the better to see how they are disposed of, it will first be necessary to describe its office. The vessel in Fig. 7. is a reservoir to contain a mixture of lime and water, for the purpose of supplying the vessel L. The vessel *m* is of a limited depth, in order just to supply the vessel L to a certain height. The transfer from *m* to L is made by means of the pipe *p*, by drawing out the plug *s*. As soon as the vessel L has received its proper quantity, the plug is replaced. The gas enters at *o*. The lime water, which now stands at the level of the top of the vessel *m*, is pressed down to the point *d*. The same quantity, rising along the passage *d e f g*, reaches to the point *g*. The gas now enters at *d*, and passes to *e*, then returning, ascends to *f*, from whence it rises up to *g*, where it enters the pipe *b c*, and the larger pipe *l*, which surrounds *b c*. The pipe *l* is closed at the top, but below the height *l* it is perforated with a number of holes. The vessel AB is filled with water up to the lower extremity of the vessel D. When the gas has passed out at the top of *b c*, it displaces the water in *l*, which is on a level with that in AB, till it sinks to *l*. It now escapes at the holes above mentioned, and bubbles through the water. In this state it is preserved in the gazometer, and is fit for burning. The gazometer we shall now explain more particularly. It may be first proper to return to the lime vessel L. The cavity *d e f g* is formed by six plates of iron, lead, or wood, of the width of the vessel L, arranged in pairs parallel to each other, forming cells, which contain a stratum of fluid three inches thick, fifteen inches wide, and of a length equal to *d e* added to *e f* added to *f g*. This cavity, and the space L, constitute the whole of the capacity of this vessel, which is employed for the liquid, the rest being shut out by the partition 3 *d*, and the plates forming the zig-zag cavity. The gazometer, which receives the gas after it has been purified by the lime water, consists of an outer vessel AB filled with water. It is made of cast iron plates screwed together by flanges. D is a vessel made of plate iron, the plates being united by rivets. This vessel, in an inverted position, falls and rises in the outer vessel as more or less gas is contained in it. For this purpose it is suspended by chains, which pass over the pullies 1, 2. The ends of both these chains are fastened in separate grooves in the edge of the pulley M, which is of such a diameter that the vessel D rises to its full height before the pulley makes one revolution. In another groove in the edge of the pulley M, is fastened the end of a second chain, to which the weight W is suspended. This weight is nearly equal to the weight of the vessel D, and assists it in rising as the gas comes under it. It will be evident, that when the whole of the vessel D is immersed in the water, it will become as much lighter as is equal to its own bulk of water. The vessel will therefore require a greater counterpoise as it rises higher, and will be the heaviest when it is at the top. This is compensated by forming the groove in the pulley M, which contains the weight chain so as to make the radii of the wheel change reciprocally with the relative weight of the vessel D, by which the pressure of this vessel, which is always a little heavier than the weight, will be uniform in every part of its ascent and descent. Before the gas can be admitted, the vessel D is allowed to descend to the bottom of the vessel AB, which is effected by opening the stop cock *y* in the pipe *z q y*, which opens into the gazometer above the water. The common air is expelled, and its place occupied by water. The cock *y* is now shut, and the gazometer is ready to receive the gas.

We have already traced the progress of the gas to the lime vessel, where it is purified. It now rises through the pipe *b c*, as has been already described. When the cock *y* is opened, the preponderating weight of the vessel D forces the gas along the pipe *z q y*, from which it is conveyed by other branches into situations where the light is required. The pipes T and *t* are firmly inserted into the top of the vessel D, and in their motion up and down constantly envelope the tubes *b c* and *q z*. They are for no other purpose than keeping the vessel steady D in its ascent and descent. That part of each projecting above the vessel, forms a recess for the reception of the ends of the pipes *b c* and *z q*, in order that the mouths of the latter may be above the water, when the roof of the vessel D comes to the surface. Without this contrivance, the whole of the common air at the commencement could not be expelled. It will be easy to see, that, from improper management, the gas may, under some circumstances, come over so rapidly as to raise the vessel D quite to the top, and, still accumulating, would bubble out at the lower edge of the vessel. Such gas mixing with the common air of the room, would be liable to explode by the light of a candle; indeed, several serious accidents have already happened from this cause. There are several ways of avoiding the danger attendant on this circumstance, but the most effectual we have yet seen, we shall explain by Fig. 8. AB is a section of the outer vessel of the gazometer, D the inner vessel, *p* a pipe inserted in the top of the latter open at both ends; the lower end being above the surface of the water, while the vessel D remains a little immersed. The part *b c* is a portion of a larger tube, with a bottom which is perforated to receive the pipe *p*, to which it is soldered, so as to form a recess capable of holding water, and hence has been called a water-lute. When another pipe, such as *f*, has been placed in the recess filled with water, a gaseous fluid passing up *p*, would be induced to pass through *f*, if not resisted by a force less than the column of water at the recess *b c*. It will now be evident, that if the tube *f* be fixed in the roof

Plate CCLXIV. Fig. 7. Fig. 6. Fig. 7. Fig. 8.

of the building, and open at both ends, when the vessel D rises till the recess bc receives the end of the pipe f, that the lower end of p will be above the water. The gas will therefore rise through p, and pass forward through f into the open air, and thus prevent its escape into the room.

ᴇ KIV. ¹.

In carrying on the process, the water in the vessel AB will frequently require to be changed, as well from being contaminated with the remaining impurities of the gas, as from becoming warm by the pipes from the retort passing through it. Where water is very plentiful, it would be advisable to have a constant current of warm water from the top of the vessel, and a cold current in at the bottom. The lime-water in the lime-vessel L, Fig. 7, will require changing much oftener than in the vessel AB. The sulphureous acid, carbonic acid, and sulphuretted hydrogen, which come with the carburetted hydrogen, are all taken up by the lime, forming sulphate, carbonate, and hydrosulphuret of lime. From this it will be obvious, that the lime will ultimately be all consumed; but it should be removed long before it arrives at complete saturation. The mixture of lime and water in the vessel m should be about the thickness of cream, and hence has been called the *cream of lime.* When the liquid in the vessel L requires to be changed, the plug k is taken out, while the plug s is kept secure. When the vessel L is emptied, the plug k is replaced, and the plug s taken out. The fresh lime and water in m is now transferred to L; the proper quantity being as much as will run in till m remains full. It must be here observed, that the vessel m is rather a measure with which to fill the vessel L to a proper height, than a reservoir. It is hence supposed to be supplied from a large cistern, in which the cream of lime is prepared in considerable quantity.

e con- on of rners.

When the gas has been carried through the pipe zqy, and its different ramifications, to the places where it is to be burnt, the passage terminates in a small apparatus, called a burner, perforated with one or more small holes, about one-thirtieth of an inch in diameter. The most simple of these terminates in a spherical surface, as seen in Fig. 9. There is one hole in the centre, and several others around it. The surrounding holes, if it were not for the upward current of air, would give flames, radiating in straight lines from the centre of the spherical burner; but the upward motion of the heated air causes the flame to curve upwards, like the spur of a game cock, and hence they have been technically called *cockspur burners.* Fig. 10. is a bracket, at the end of which is a burner, terminating in the face of a cylinder, near the outer edge of which is a circular series of holes, from which the flame rises perpendicularly. These are surrounded by a glass like the Argand lamp. In its general appearance it is so like this lamp, as to have acquired the name of the *Argand burner.* Figs. 11. and 12. are a plan and section of this burner upon a larger scale. The holes in the inner circle, Fig. 11. are supplied with gas from the cavity C, Fig. 12: The same holes appear in section at ab, Fig. 12. The holes in the outer circle, Fig. 11. communicate with the cavity cf, Fig. 12. which also communicates with the atmosphere by the openings ik; gh, is an ornamented rim for the reception of the glass. The air from the glass becoming heated by the flame, rises, and a current takes place from ik, through the cavity ef, and between the burner and the glass. This current in the Argand lamp is both within and without the circular flame, and serves to supply the lamp with oxygen for burning the smoke, as well as to keep the flame steady. In the gas lights there is no smoke to burn: the current of air, therefore, is not so essential. It has the good effect, however, of keeping the flame steady, which otherwise would be agitated by the slightest motion of the surrounding air. Fig. 10. shews the manner of bringing the gas to supply a bracket-lamp fixed to the wall: The stop-cock a is connected with the pipe behind the board cd, which also communicates with the pipe b leading to the burner. Fig. 9. is provided with a similar plate to screw to the wall. These brackets are capable of moving in a horizontal direction. The end of the tube b is ground into the little globe s, so that it will turn round without allowing the air to escape. Fig. 9. is similarly constructed. A great variety of these ornamental brackets, chandeliers, candelabras, &c. will be found in Mr Accum's work upon gas-lights.

Gas Lights. PLATE CCLXIV. Fig. 10.

The apparatus above described, is upon a small scale compared with what would be required for lighting a large manufactory, or upon the scale practised for lighting the streets and shops in the metropolis. The gazometer, lime-vessel, and tar vessel, are all made of cast and wrought iron, precisely in the same way that would be recommended upon the largest scale. It would be found impracticable to increase the fire and the retort to the same extent to which the other apparatus may be increased. It would be improper to make a fire to heat a greater length than from six to eight feet. And if the cavity of the retort were more than 12 inches wide, the coal would not be completely decomposed in the centre. It is found, therefore, more advantageous when a greater supply of gas is wanted, than would be afforded by a vessel of the above dimensions, to use additional retorts and fires, all communicating with the same gazometer, lime-vessel, &c. In Fig. 7. there is but one furnace, but it may easily be supposed that a series of furnaces may join this on the left hand. Each retort having a tube n, they may all be connected with one common pipe c, which is the condenser: to show this, the pipe c in this figure is broken off on the left hand.

When the vessel D is made very large, it requires to be first formed in a skeleton of wrought or cast iron, and afterwards covered with iron plate.

It is strongly advised, where it is practicable, that the retorts should be kept in constant action night and day for the season, or at least never allowed to go below a red heat. The first portion of oxide which forms upon the surface, when allowed to cool, cracks and falls off, leaving a new surface to be acted upon the next time it is heated. By thus being every day heated and cooled, a retort will be destroyed in a few months. When they are kept continually red hot, they frequently last three winters. The writer of this article is indebted to Mr Lee of Manchester for this fact.

In discharging the retort at a red heat, the coak may drop through an opening into a cellar below, the hole being afterwards closed; without this contrivance, the operation would be much annoyed. In applying the gas lights to the streets and shops, pipes of cast iron are employed running along each side of the street, of different sizes, from two to four inches in diameter, according to the supply. The main streets have larger pipes, called *mains*, from which smaller pipes proceed to light the cross streets, alleys, and courts. The pipes are perforated opposite to the shop to be lighted, and an iron pipe ground air tight into the hole. With this, other iron pipes are connected to convey

Gas Lights.

the gas to the place where it communicates with the burner. The pipes in the streets are laid so near the surface, as not to be disturbed by the carriages, or interfere with the paving. They are joined together by slipping one end of one into a widened part in the end of another. The cavity between the inside of one, and the outside of the other, which is nearly one inch, is filled with melted lead, which when set, is afterwards hammered in by the end of a punch.

Having generally described the apparatus used in lighting by gas, we shall give some statements respecting its economy compared with other means of lighting.

Mr Murdoch, of whom we have before spoken, has published a statement of the expence of gas lighting, compared with candles, in the *Philosophical Transactions of London*, for the year 1808. He begins by ascertaining that a tallow candle, of six in the pound, is consumed at the rate of 175 grains, or 1.4 of an ounce in one hour; and that half a cubic foot of carburetted hydrogen, such as comes from cannel coal, burnt the same time, producing a light of the same intensity.

In the calculation of the expence of lighting by gas, he takes his estimate from the manufactory of Messrs Lee and Philips of Manchester, the apparatus being put up by himself. He employed 271 Argand burners, each being equal to four candles of the size above-mentioned, and 633 cockspur burners, each being equal to $2\frac{1}{4}$ candles, the whole amount being equal to 2500 candles of the same size. From what has been stated, it will appear, that to keep so many lights up, will require an hourly consumption of 1200 cubic feet of gas.

He states the average time of working by the gas light throughout the year at two hours per day, this will require a daily consumption of gas equal to 2500 cubic feet; and allowing 313 working days, the yearly consumption will be 782,500 cubic feet.

He found, that to produce this gas, there was required 110 tons of cannel coal at 22s. 6d. per ton,	£124	0	0
Consumption of common coal for distilling the gas, 40 tons, at 10s.	20	0	0
Interest of the capital, and wear and tear of the apparatus,	550	0	0
Total expence	£694	0	0
Deduct the value of 70 tons of coak,	£93	0	0
Nett expence	£601	0	0
The price of 2,347,500 candles, equal to 391,250 lb. at 1s. per lb.	£2000	0	0
Then deducting	600	0	0
Leaves the clear annual saving	£1400	0	0
If the working time per day were three hours, the annual saving would then be	£2350	0	0

The veracity of this author would alone be sufficient to give great weight to these facts; but they have gained greater strength by their strict agreement with subsequent experience.

It is now found that the best form for the retorts is a cylinder, and that they should not much exceed 10 inches in diameter, nor be much more than six feet in length. If they were much wider, the heat would not penetrate the loose coal within sufficiently; and as regards the length, the fire would not act to much advantage, nor the heat be uniform, if the length were much beyond the above statement. This should be the limit for one furnace. If more gas is wanted, more furnaces must be made, as has been shewn in the Plate.

In an apparatus on the scale of these in London for lighting the streets, from 24 to 36 such retorts and furnaces would be required. These retorts contain, independent of the mouth-pieces, about 5655 cubic inches, and will hold conveniently 100 lb. of cannel coal. When the fire is applied to good advantage, each retort gives out all its gas in about four hours. There is no good policy in pushing the distillation very far, as the gas which comes the last, is the least combustible. The retort should not be heated beyond a brightish red, as the gas is not only injured, but the retort would soon be destroyed,

In order to condense as much as possible the most useful facts, we have given a Table founded upon the statements already made. We are indebted to Mr Murdoch for the comparative light given by gas and candles, the gas and coak afforded from a given quantity of coal, and the consumption of common coal to produce the necessary heat for the distillation. The proportion of tar and ammoniacal liquor we have quoted from Mr Accum's work on gas lights.

Explanation of the Table.

The first column gives the number of retorts, each being 10 inches in diameter, and 6 feet long. The second column gives the capacity of the gazometer. The third column, the weight of coal used to furnish the gas. The fourth and fifth columns give the same by measure. The sixth, the coal used to distil off the gas. The seventh, the cubic feet of purified gas. The eighth, the weight of coak left in the retorts. The ninth, the weight of tar. The tenth, the ammoniacal liquor; and the eleventh, the number of candles to produce the same light with the gas; the candles being six to the pound each, when fairly burnt, consuming 175 grains of tallow in one hour.

This Table is formed by doubling the first numbers of each column for the second number, then adding the first number to the second for the third, the third to the first for the fourth, and so on, so that it may be easily extended to any greater number of retorts.

Gas Lights.

TABLE

Shewing the relative proportions of Gas, Tar, and Coak, produced by the Distillation of Coal, and the illuminating power of the Gas compared with Candles.

Number of retorts, 10 inches diameter by six feet long, exclusive of the mouth-piece.	Capacity of the Gazometer.	Coal for producing the Gas in Pounds.	By Measure in Bushels and Pecks.		Coal consumed to distil off the Gas.	Cubic feet of Gas purified.	Coak in ditto.	Tar. *	Ammoniacal Liquor.	No. of Candles, 6 in the lb. to give an equal light with the Gas.
			Bushels.	Pecks.						
1	295	100	1	$\frac{4}{5}$	34	320	64	5.4	7.85	96
2	390	200	2	$1\frac{3}{5}$	69	640	128	10.8	15.7	192
3	485	300	3	$2\frac{2}{5}$	102	960	192	16.2	23.55	288
4	780	400	4	$3\frac{1}{5}$	136	1280	256	21.6	31.40	384
5	1075	500	6	0	170	1600	320	27.0	39.25	480
6	1370	600	7	$\frac{4}{5}$	204	1920	384	32.4	47.10	576
7	1665	700	8	$1\frac{3}{5}$	238	2240	448	37.8	54.95	672
8	1960	800	9	$2\frac{2}{5}$	272	2560	512	43.2	62.80	768
9	2255	900	10	$3\frac{1}{5}$	306	2880	576	48.6	70.65	864
10	2550	1000	12	—	340	3200	640	54.0	78.50	960
11	2845	1100	13	$\frac{4}{5}$	374	3520	704	59.4	86.35	1056
12	3140	1200	14	$1\frac{3}{5}$	408	3840	768	64.8	94.20	1152
13	3435	1300	15	$2\frac{2}{5}$	442	4160	832	70.2	102.05	1248
14	3730	1400	16	$3\frac{1}{5}$	476	4480	896	75.6	109.90	1344
15	4025	1500	18	—	510	4800	960	81.0	117.75	1440
16	4320	1600	19	$\frac{4}{5}$	544	5120	1024	86.4	125.60	1536
17	4615	1700	20	$1\frac{1}{5}$	578	5440	1088	91.8	133.45	1632
18	4910	1800	21	$2\frac{2}{5}$	612	5760	1152	97.2	141.30	1728
19	5205	1900	22	$3\frac{1}{5}$	646	6080	1216	102.6	149.15	1824
20	5500	2000	24	—	680	6400	1270	108.0	157.00	1920
21	5795	2100	25	$\frac{4}{5}$	714	6720	1334	113.4	164.85	2016
22	6090	2200	26	$1\frac{3}{5}$	748	7040	1398	118.8	172.70	2112
23	6295	2300	27	$2\frac{2}{5}$	782	7360	1462	124.2	180.55	2208
24	6390	2400	28	$3\frac{1}{5}$	816	7680	1526	129.6	188.40	2304
25	6885	2500	30	—	850	8000	1590	135.0	196.25	2400
26	7180	2600	31	$\frac{4}{5}$	884	8300	1654	140.4	104.10	2496
27	7475	2700	32	$1\frac{3}{5}$	918	8640	1718	145.8	111.85	2592
28	7770	2800	33	$2\frac{2}{5}$	952	8960	1782	151.2	119.70	2688
29	8065	2900	34	$3\frac{1}{5}$	986	9280	1846	156.6	127.55	2784
30	8360	3000	36	—	1020	9600	1910	162.0	135.40	2880

If it were required to find the number of candles of any other size, or a different number in the pound, multiply the number of candles in the Table by the given number in the pound, and divide the product by 6, the number in the pound of those in the Table; the quotient will be the number required. For example, the number of candles equal to the gas from 800 lb. of coal, which is 2560 cubic feet, is 768, what will be the number of candles of 5 to the pound? $5 \times 768 = 3840$; then, $3840 \div 6 = 640$, the number of candles required.

From this Table it may be seen how much coal is equal to a given weight of tallow. If the number of candles in the last column be divided by 6, the quotient will give the weight of tallow in pounds to the coal in the third column. For instance, the candles equal to 800lb. of coal are 768; the last divided by 6 gives 128lb. of tallow, equal to 800lb. of coal, which is 1lb. of tallow to 6.25 of coal.

Gas light may be compared with candles in another point of view. That is, what number of candles of a given size give a light equal to that produced by the gas when its rate of burning is given; that is, when a given quantity in cubic feet is burned in a given time. We have seen, by the data already given, that half a cubic foot of gas will be consumed in the same time, giving the same light as 175 grains of tallow from a candle 6 to the pound. We therefore should say, that when a cubic foot of air is burnt in two hours, its light will be equal to that of a mould-candle of 6 to the pound; but if the same gas were burned in one hour, either from doubling its velocity or its aperture, then it would require two such candles to produce an equal light in all respects. If the candles to give an equal light with the gas when burnt in one hour be divided by the time, it will give the candles for that time. To find the quantity of candles of any other size, use the rule above given.

Practical rules for the management of the apparatus.

Before we conclude this article, we think it right to give a few useful rules to those who may have the management of the gas light apparatus. These are the substance of the rules drawn up by Mr Clegg for the use of the workmen.

1st, Before closing the retort, take common clay, dried, pulverised, and sifted, to which add as much

* This fluid on distillation affords about one-fourth its weight of a thin light inflammable fluid resembling naphtha, leaving a residuum like pitch or asphaltum.

Gas Lights. water as will give it the consistence of treacle; make both the surfaces where the lid fits the retort very clean, spread the luting thinly over the turned part, then secure the lid in its place by the wedge, Fig. C Plate CCLXIV. If this is not strictly attended to, the retort will lose the gas, and the smell will be very offensive, and injure the health of the operator.

2d, The bridge of bricks, *b b*, Fig. 2. which separates the fire place from the retort, must never exceed a bright red heat. If they are raised to a white heat, the gas will be injured, and the retort be soon destroyed. This may be regulated by a damper in the chimney, or by the register door to the ash pit. See Fig. 7.

3d, The gazometer should be examined at least once a week, which is done as follows: shut the stop cock *y*, Fig. 7. and likewise the retort from the gazometer, no operation going on. Mark the suspended vessel at the surface of the water when it is nearly full of gas. If the mark sinks below the surface, there is some opening where gas escapes. To find out this place, walk slowly round the vessel, and if the leak is not very small the gas may be smelled. Apply a candle to the place, and the issuing gas will be inflamed. Mark the place, and blow it out. In the same way search the vessel all round. There, however, may be a small leak, and yet it will not inflame. About the suspected part apply with a brush a little white lead paint. The place where the gas escapes will become yellow, and ultimately black, from the sulphur in the gas. The place being discovered, take a small piece of linen, dip it in a little melted pitch and bees wax, and apply it to the part while hot, and keep pressing it on till it is cold.

4th, Keep the water in the outer vessel of the gazometer at its proper height, in order that the gas may have to rise through the same column of water.

5th, In the place where the lights are, appoint one person only to superintend their management. Be careful to shut the cocks when the lights are not wanted, and do not suffer them to be opened till they are to be lighted, and then hold a lighted paper over the aperture while the cock is turned. Do not use a candle for this purpose, lest it drop on the burner. (C. S.)

GASES, Sounds produced by. In our article Acoustics, vol. i. p. 119, we have mentioned the experiments by Dr Chladni, on the sounds of different degrees of acuteness produced by the same organ-pipe, when blown with different gases, in appropriate receivers; and in page 118 we stated that the number of vibrations which the same column of gases of different specific gravities should make in a given time, are inversely proportional to the square roots of their specific gravities.

We propose, in the present article, to exhibit, in a tabular form, the results of the principal experiments that are recorded on this subject, for comparison with calculations on the above principles, and with other calculations from the velocities with which sound is propagated though different gases, considering the pitches of the sounds to be inversely proportional to the velocities of propagation.

In the first column of our Table are mentioned the names of fifteen kinds of gases, on which Messrs F. Kirby and Arnold Merrick made repeated experiments, which are fully detailed, and their apparatus described in Nicholson's *Philosophical Journal*, vol. xxxiii. p. 171; and in the second and third columns are set down the mean results of these several experiments, as they have been calculated by Mr John Farey, in the *Philosophical Magazine*, vol. xlv. p. 28. The intervals in column 2. being stated in his notation, (as usual in other parts of our work,) reckoned upwards and downwards from note C, to which the experiment pipe in atmospheric air is supposed to be accurately adjusted. Column 3. shews the nearest notes on the Rev. Henry Liston's Euharmonic *Organ*, (see that article,) followed by the differences, whether more acute +, or grave —, expressed in Schismas; small and capital Italic letters marking the octaves, above and below C *c*.

In column 4, the specific gravities of the gases have been taken from the mean of those mentioned in our article Chemistry; and column 5, (like col. 2.) shews the calculated intervals above and below C; wherein it will be observed, that ether vapour, and sulphuretted hydrogen, appear to be graver notes than C, and olefiant gas more acute than it, contrary to the results of experiments thereon, in col. 2.

In column 7. are contained the velocities with which sound is propagated, extracted from Acoustics, Vol. I. p. 122; in col. 8. are the intervals; and in columns 6. and 9. the several notes and differences, as already described.

By subtracting the intervals in columns 2, 5, or 8, (with due attention to the signs,) the relation or interval of any two gases may be found, and the name of such interval may often be obtained from our 30th Plate, in Vol. II. Thus, in the experiments in col. 2, *hydrogen* appears to yield a sound higher than *azote* by 610 Σ + 12 f + 53 m, or only 1.49 Σ less than an octave. Again, the interval of *azote* and *oxygen*, in col. 5. is 55.29 Σ + f + 5 m, or S — 1.71 Σ; and between the sounds of *oxygen* and *olefiant* gases, is 55.70 Σ + f + 5 m, or S — 1.3 Σ, &c.

The Table here presented will at least serve to shew, that much remains to be done, to reconcile the facts and the principles that have been advanced by different writers on the subject. Careful and numerous repetitions of these experiments, with gases carefully prepared, and in well contrived apparatus, conducted as Mr Farey has recommended, with reference by means of *the beats*, to *fixed notes*, carefully tuned on Liston's organ; not trusting to *unisons* for the comparisons of the sounds in any case, but resorting to the thirds and fifths by way of checks: Experiments so conducted, might, perhaps, so adjust these several intervals, that they may prove of use, in giving greater precision and consistency to the *specific gravities*, *velocities of propagated sounds*, and perhaps to the *weights of atoms* also, of the several gases; if it be true, as has been conjectured (and, as seems nearly true of most of the gases in our Table, and perhaps of others,) that, with the exception of *oxygen* and *olefiant* gases, the weights of atoms, nearly as stated by Dr Thomson in his *Annals of Philosophy*, are exactly double (or octave) of the specific gravities, respectively, (to oxygen, 1.); but *nitrous* gas seems here to form a remarkable exception, as Dr Chladni found it to present, on another point, in his experiments, as mentioned in our first volume, p. 119. It may not be amiss to add, that the specific gravity of nitrous gas being 1.094, its note will be C'♭—3.63 Σ=39.63 Σ + f + 3 m, below C, according to the principle of calculation used in our Table; whereas in Messrs Kirby and Merrick's first set of experiments (see *Phil. Mag.* vol. xxxvii. p. 4.), this gas was observed to sound 52.95 Σ + f + 5 m above C. It must however be observed, that the results of the first and second sets of experiments by these gentlemen, are most of them so greatly different, as to shew strongly the necessity of the repetitions thereof that we have recommended above.

Gases, and Mixtures of such, experimented on.	Intervals above or below the Sound with Atmospheric Air,			Liston's Notes and Differences in	Specific Gravities of the Gases.	Intervals above or below the Sound with Atmospheric Air.			Liston's Notes and Differences in	Velocities of Sound.	Intervals above or below the Sound with Atmospheric Air.			Liston's Notes and Differences in
	Σ	f	m	Σ		Σ	f	m	Σ	.	Σ	f	m	Σ
Ether vapour	661.82	13	57	c※+2.82	2.250	—358.00	7	31	*F*					
Carburetted hydrogen .	644.59	13	56	c`※—3.41	0.5554	259.63	5	32	*F*+5.63					
Hydrogen . .	623.89	12	54	c′+0.89	0.0807	1111.10	22	96	*a*※+1.10	6899	1093.57	21	95	b′♭♭—1.43
Sulphuretted hydrogen .	77.97	1	7	C※※—5.18	1.161	—65.95	1	6	*B*`+2.05					
Ether vapour and com. air	24.80	1	2	C※—11.21										
Azote, or nitrogen . . .	13.38	0	1	C′+2.38	0.977	10.03	0	1	C′—0.97	1149	14.77	0	1	C′+3.77
Common Air	0	0	0	C	1.000	0	0	0	C	1130	0	0	0	C
Carbonic and hydrog. gases	32.06	1	2	C′♭+3.95										
Oxygen and nitrog. gases	32.69	1	2	C′♭+3.31										
Oxygen . . .	43.19	1	3	*B*′+2.81	1.108	45.26	1	4	*B*′+0.74	1064	53.15	1	4	*B*+3.86
Olefiant gas .	51.87	1	4	C♭—4.87	0.9745	+10.44	0	1	C′—0.56					
Chlorine and olefiant gases	137.91	3	12	*B*♭♭+2.09										
Chlorine . . .	160.73	3	14	*A*+0.27	2.713	440.55	9	38	*E*′♭—0.55					
Carbonic acid	189.04	4	16	*A*′♭3.04	1.500	178.93	4	15	*A*′♭+7.08	922	179.55	4	16	*A*′♭+6.45
Nitrous oxide	197.59	4	17	*A*♭—0.59	1.603	208.33	4	18	*A*`♭—0.33					

(e)

A very interesting memoir on the sounds produced by hydrogen gas, was published in the *Journal de Physique*, vol. lv. p. 165, by Dr Delarive of Geneva. Dr Higgins and Brugnatelli were the first who published an account of the sounds produced by hydrogen gas passing through a small tube. Professor Pictet made a series of experiments on these sounds, and describes the various musical phenomena which are produced. He explained the influence on the sounds occasioned by the length or width of the tubes, and the situation where the hydrogen is burned; but it was left to Dr Delarive to assign a very ingenious and plausible cause for the phenomena: He supposes, that a brisk vibratory motion is caused by the continual production and condensation of aqueous vapour; and that, in order to produce a sound, this vibratory motion must be able to harmonise with the dimensions of the tube, and is then regulated and equalised by the regular reflexions from the tube, so as to constitute together a clear musical sound. For this purpose there must be a great difference of temperature in the air, and the tube near the flame. For farther information on this subject, see Nicholson's *Journal*, vol. i. p. 129, and vol. iv. p. 23; and Dr Thomas Young's *Natural Philosophy*, vol. ii. p. 267.

GASSENDI, Peter, an eminent French philosopher, was born at Chantersier in Provence, in 1592. After giving very premature indications of his talents, which he did before he had reached his fifth year, he was sent to school at Digne, where he made rapid progress in the Latin language, and acquired a decided pre-eminence among his school-fellows. He was next sent to study philosophy at Aix, and when he had continued there two years, he returned to his father's house, with the view of prosecuting his studies in retirement. A vacancy, however, having taken place at Digne, he was invited, at the early age of sixteen years, to teach rhetoric in that city; and he had scarcely filled this situation for three years, when he was appointed to the vacant chair of philosophy in the university of Aix. The authority of Aristotle was still acknowledged in almost all the public schools of France, and it required no ordinary boldness to call in question his philosophical system. Gassendi, however, did not scruple to expose the errors of that great master, in the indirect form of paradoxical problems, which he published under the title of *Exercitationes Paradoxicæ adversus Aristotelem.* This work obtained for Gassendi the particular friendship of Nicholas Peiresc, president of the university of Aix, who succeeded, by the assistance of Joseph Walter, prior of Vallette, in procuring for him a canonry in the cathedral church of Digne, where he was admitted to the degree of doctor in divinity, and appointed rector of the church. This new situation, which enabled him to resign his chair at Aix, allowed Gassendi the uncontrolled management of his time. He composed a second book of his *Exercitationes Paradoxicæ,* for the purpose of pointing out the absurdity of the Aristotelian logic, and intended to pursue the subject to a much greater extent, but he was violently assailed by the powerful adherents of the ancient sage, and he considered it prudent to abstain from any farther attacks upon the Aristotelian system.

In the year 1628, Gassendi travelled into Holland, in order to make himself acquainted with the philosophers of that country; and during his visit, he composed an apology for his friend the learned Mersennus, in answer to the attack of Robert Fludd on the subject of the Mosaic philosophy. Upon his return to Digne, he resumed with great diligence his astronomical studies. He had the good fortune of being the first that observed a transit of Mercury over the sun's disc. This happened on the 7th of November 1631, the transit having been calculated by Kepler. In the year 1641, Gassendi was called by a lawsuit to Paris, and gained the acquaintance and esteem of the distinguished characters of that metropolis, and particularly of the Cardinal Richelieu, and his brother the Cardinal of Lyons. He had long preserved an intimacy with the great Descartes; but a circumstance now occurred, which for a long time interrupted their friendship. In the year 1629, the singular phenomenon of two parhelia had been seen at Rome, and Gassendi published a dissertation on the subject. Descartes, in his *Treatise on Meteors*, described the same phenomenon, but forgot to make any reference to the dissertation of his friend. Gassendi chagrined at this neglect, and probably not uninfluenced by a secret jealousy of Descartes' fame, attacked the philosophical system of his friend, in a work entitled, *Disquisitio Metaphysica seu Dubitationes*, &c. which was put into Descartes' hands by their mutual friend Mersennus. Descartes replied to the objections of Gassendi, which he has published with his own answers under the head of the *Sixth objection* in his *Meditations.* In 1643, Gassendi composed his *Instantiæ*, as a reply to the answer of Descartes, and circulated it in MS. in Paris, before it was sent to M. Sorbiere to be printed at Amsterdam. This circumstance widened the breach between the two philosophers, which was still farther increased by their respective friends. In 1645, Descartes wrote a reply to Gassendi's *Instantiæ*; but the differences between these philosophers were now on the eve of being adjusted. The Abbé D'Estrees, afterwards Archbishop of Laon and a Cardinal, lamented the dissensions which had so long separated these distinguished philosophers, and resolved to use all his influence in reconciling them. He invited a large party of their friends, among whom were Mersennus, Roberval, and the Abbé Marolles, to meet the two philosophers at a public dinner. Gassendi was prevented by an illness from attending; but so anxious was the Abbé to effect his purpose, that he took the company to Gassendi's apartments, where he and Descartes made mutual apologies for their conduct, and declared that their friendship should not again be interrupted by any difference of sentiment. By the interest of the Cardinal of Lyons, Gassendi was, in 1645, appointed regius professor of mathematics at Paris. He read lectures on astronomy to crowded audiences, and added greatly to the reputation which he had formerly acquired. His constitution had now suffered from the severity of his studies, and having caught a cold, which occasioned an inflammation in his lungs, he was compelled in 1647 to return to Digne for the recovery of his health. His native air produced a considerable amelioration in his strength, and he was able to return to Paris in 1653. He now published his lives of Peiresc, Copernicus, Tycho Brahe, Purbachius, and Regiomontanus; and forgetting the weakness of his constitution, his astronomical studies brought back his former disorder, of which he died in 1655, in the 63d year of his age. A short time before he breathed his last, he is said to have laid his hand on his heart, and feeling the langour of its pulsation, he said, "See how frail is the life of man!" Gassendi was intimately acquainted with the most distinguished characters of his age. His library and philosophical apparatus were purchased by the Emperor Ferdinand III. and deposited in the imperial library at Vienna. His works and MSS. were collected and published after his death in 6 volumes folio by Sorbiere in 1658. They contain the philosophy and life of Epicurus; the philosophy of Gassendi; his astronomical works; the lives of Peiresc, Copernicus, &c.; a refutation of the meditations of Descartes' epistles; a tract on the theory of music; and other treatises. See Bougerelle's *Vie de Gassendi*, Paris, 1737; and Baillet's *Vie de Descartes*, passim.

GAUGING, is the art of measuring the contents or capacities of vessels of any form. See the article MENSURATION, where this subject will be fully treated.

GAUL. See FRANCE, p. 543 and 673.

GAUTS. See GHAUTS.

GAY, JOHN, a celebrated English poet, was born in 1688, at or near Barnstaple, and descended of an ancient family, long possessed of the manor of Goldworthy in Devonshire. He was educated by Mr Luck, the schoolmaster of Barnstaple, a teacher of good reputation, who cultivated a taste for poetry, and published a volume of Latin and English verses.

Inheriting no fortune, and without the prospect of any, Gay was sent to London when young, and placed apprentice to a silk mercer. It is not known how long he continued behind the counter. Feeling, however, the irksomeness of the restraint or servility of his occupation, he procured his discharge from his employer.

In 1712, the Duchess of Monmouth took Gay into her service as secretary. Availing himself of his leisure, he published his first poem, *On Rural Sports*, and inscribed it to Mr Pope, then fast rising into reputation. Pope was much pleased with the compliment, and attracted by the manner and conversation of Gay, he admitted him to the fullest confidence, and a friendship was formed between them which lasted unabated till death. Though Gay was caressed by the association of wits, he appears to have been regarded rather as a play-fellow than a partner, and treated more with fondness than with deference.

Like most poets, he was anxious to place his muse under the fostering wing of a patron, and paid his court accordingly to princes and their favourites; yet his assiduity was not rewarded in proportion to his expectations. When the Earl of Clarendon was appointed envoy extraordinary to Hanover in the room of Lord Paget, Gay was made secretary, for which situation he considers himself obliged to Swift, as he declares in a letter to the Dean. How far Gay would have succeeded in establishing himself as an expert diplomatist, cannot well be ascertained from his short continuance in office, for the death of the Queen deprived him of an opportunity of distinguishing himself; and his dedication of the *Shepherd's Week* to Lord Bolingbroke, is supposed to have excluded him from the patronage of the house of Hanover. Gay, however, still enrolled himself as an expectant of Court favour, and hailed the arrival of the Princess of Wales with a poem. This compliment procured him but little solid advantage. She and the Prince went to see his mock tragedy of the "*What d'ye call it.*" This mark of regard flattered Gay's hopes of farther countenance; but meeting with disappointment, he sunk into despondency, from which his friends conspired to raise him. Lord Burlington dispatched him into Devonshire for amusement; next year he accompanied Mr Pulteney to Aix, and the year following Lord Harcourt invited him to his seat.

Gay having attained celebrity, in 1720 he published his poems by subscription, by which he raised £1000. He seems to have been at a loss how to dispose of his money, and called a consultation of his friends. Lord Oxford's steward, Lewis, advised him to invest it in the funds, and live on the interest; Arbuthnot bid him live on the principal, and trust to providence for a fresh supply. Pope recommended him to purchase an annuity, in which advice he was seconded by Swift. In the calamitous year of the South Sea scheme, Gay having got a present of some stock from young Craggs, he began to dream of nothing but dignity and splendour, and resisted all the importunities of his friends to sell his share. He was even deaf to entreaties to secure himself from want, in case of failure, by selling as much as would give him a hundred a year for life, and enable him, at least as Fenton told him, to command a clean shirt and a shoulder of mutton. Gay risked and lost every thing, and was so completely overwhelmed by the blow, that it required all the tenderness of his friends to restore his health. On this occasion, the attention of Pope was conspicuous. Gay at length having recovered his health and spirits, resumed his studies, and produced his tragedy of the *Captive,* which he was invited to read before the Princess of Wales. On his introduction into the room, Gay found the Princess and her ladies waiting in state to receive him; being completely engrossed by the importance of the occasion, he stumbled over a stool, and in his fall threw down a Japan screen. The Princess was alarmed the ladies screamed, and Gay, after all this flutter and trepidation, had still to read his play.

On the advancement of the Prince and Princess to the throne, Gay expected that something would be done for him; but on the settlement of the household, finding himself appointed gentleman usher to the Princess Louisa, he thought himself insulted, and declined the place. Still, however, he was assiduous in paying court to favourites, and flattered Mrs Howard, afterwards Countess of Suffolk, who was in high favour with the King and Queen. The lady listened to his verses, and did nothing. But the unrivalled success of his *Beggar's Opera* may be supposed to have been some compensation for the neglect and ingratitude of the court. When shewn to Cibber at Drury Lane, it was rejected; it was then carried to Rich; and, as was ludicrously remarked, had the effect of making "Gay rich, and Rich gay."

At length Gay secured himself an asylum for life in the house of the Duke and Duchess of Queensberry. The Duke is said to have undertaken the management of his money, in consideration of his want of economy, and to have allowed him only enough for his necessities. But even the affectionate attentions of the Duke and Duchess failed to soothe the mind of Gay into a state of complacency; his disappointments at court preying on his spirits, he fell into his old distemper, an habitual cholic, in which state he languished with many intervals of ease and health, till a violent fit hurried him to the grave with unusual precipitancy. He died on the 4th December 1732, and was buried in Westminster Abbey. Pope sums up his character as follows: "Gay was a natural man, without design, who spoke what he thought, and just as he thought it; and was of a timid temper, and fearful of giving offence to the great."

Gay dying without a will, his two maiden sisters inherited what he left; amounting to £2000, besides the profits of his opera of Achilles.

Although the genius of Gay was not of the highest order, or deeply inspired, yet it was not destitute of originality; and he must be allowed to be the inventor of the ballad opera, a new species of composition, which has long kept possession of the stage. We have the following account of the origin of the Beggar's Opera, in the words of Pope: "Dr Swift had been observing once to Mr Gay, what an odd pretty sort of a thing a Newgate pastoral might make; Gay was inclined to try at such a thing for some time; but afterwards thought it would be better to write a comedy on the same plan. This was what gave rise to the Beggar's Opera. He began on it; and when first he mentioned it to Swift, the Doctor did not much like the project. As he carried it on, he shewed what he wrote to both of us, and we now and then gave a correction, or a word or two of advice; but it was wholly of his own writing. When it was done, neither of us thought it would succeed. We shewed it to Congreve, who, after reading it over, said, it would either take greatly, or be d——d confoundedly. We were all, at the first night of it, in great uncertainty of the event, till we were very much encouraged by overhearing the Duke of Argyle, who sat in the next box to us, say, 'It will do, it must do, I see it in the eyes of them.' This was a good while before the first act was over, and so gave us ease soon; for that Duke, (besides his own good taste), has a particular knack, as any one now living, in discovering the taste of the public. He was quite right in this, as usual; the good nature of the audience appeared stronger and stronger every act, and ended in a clamour of applause."

It is generally known that the run of this piece was unusually great in London, and all over England. The ladies carried about its songs in fans, and houses were furnished with it in screens; besides, it expelled from England for that season the Italian opera, which had carried all before it during ten years. Of the merit of this performance when it was published, there were a variety of opinions. By some it was commended for the excellence of its morality, placing vice in the strongest and most odious light; while it was censured by others as giving countenance to crimes, by making a highwayman the hero, and dismissing him unpunished. Swift was of the former opinion, and Dr Herring, Archbishop of Canterbury, was of the latter. After the representation of the *Beggar's Opera,* the number of robbers is said to have greatly increased. But perhaps this play, written merely for amusement, was not intended by its author for any moral purpose; yet, in our opinion, such a representation is more calculated to inflame than amend the bad passions of our nature. The picture of a criminal who converts the horror of a prison into a scene of merriment and debauchery, and consumes those hours that are given him for repentance among his cups and prostitutes, can have no good effect upon an audience. And though perhaps, as Dr Johnson observes, highwaymen and housebreakers seldom frequent the playhouse, yet the latent seeds of robbery and pillage may spring up the more readily from viewing highwaymen dignified as heroes, and hearing their speeches made the theme of popular applause. Some such objection as this, (either moral or political,) prevailed with the Lord Chamberlain, who prohibited a second part which Gay produced under the name of *Polly;* he was, however, no loser by this repulse, as he gained thrice as much by a subscription, on publishing the latter, as he did by the publication of the former.

From the variety of his performances, Gay may be reckoned a writer of versatile talents, though perhaps not equally well qualified to shine on every subject he attempted. His *Fables* appear to have been with him a favourite work; he published one volume, and left behind him another. They are told with liveliness; their versification is smooth, and the diction happy. The origin of the *Shepherd's Week* is somewhat singular. Steele having praised Philips' pastorals, as yielding only to those of Theocritus, Virgil, and Spenser, Pope, who was a competitor for fame in this way, piqued at the comparison, incited Gay to write his *Shepherd's Week,* in order to prove that if nature be scrupulously followed, rural manners must be delineated as gross and ignorant. But Gay mixed so much truth and nature with the coarseness and humour of his compositions, that his pastorals became generally popular as just representations of country manners. (W. T.)

GAZETTE, or NEWSPAPER, is a term derived from *Gazetta,* a species of coin formerly current at Venice, which was the ordinary price of the first newspaper printed in that city. The first Gazette is said to have been published at Paris in 1631. The first English Gazette appeared at Oxford on November 7, 1665, in a folio half sheet. When the court removed to London, it was called the London Gazette.

GAZOMETER. See Chemistry, p. 155; and Gas Lights.

GELATINE. See Chemistry, p. 130.

GEMS. This appellation is employed in two different senses: first, in denoting jewels or precious stones, which, from rarity and beauty, have always been highly prized by mankind; secondly, in characterizing stones, which, though not of the former description, are sculptured or engraved with various subjects, and more especially if executed by the ancients. But the name of gems is likewise applied, in a less appropriate signification, to artificial compositions designed to imitate the finer precious stones, either when polished in the natural state, or when they have passed through the hands of the engraver. In our article Mineralogy, we shall have occasion to consider the subject of precious stones at some length, and we shall at present confine our attention to the subject of Engraved Gems.

Engraved gems.

It is probable that no stone of sufficient hardness was excluded from receiving the engravings of the ancients; but it has been doubted whether they were acquainted with the means of cutting the diamond, or sculpturing the emerald and topaz. Much difference is experienced in working hard stones: the emerald is only to be conquered by uncommon patience, and a long time is requisite to produce a good engraving. The Eastern nations are unacquainted with the proper method of cutting and polishing the diamond; and it is said that little more than a century has elapsed since the means of disposing its lustre to the greatest advantage in brilliants was discovered. The ancient Jews, in the days of Aaron, according to Scripture, could engrave on diamonds; and if the same art was unknown to the Greeks or Romans, they were sufficiently acquainted with the use of this stone in cutting other jewels. But if we consider the ingenuity of the Greeks and Romans, it is not unreasonable to conclude, that they frequently engraved on precious stones. There are indeed few instances of the fact: thousands of their works must have perished many centuries ago, and many are still to be brought to light. Yet it is affirmed, that the art of polishing the diamond, as it now appears, is not of anterior date to the year 1456, and that engravings upon it belong exclusively to the moderns, having been attempted only about the succeeding century. In the year 1500, Ambrose Caradosso, an Italian, engraved the portrait of a father of the church on a diamond, which he sold to Pope Julius II. a great patron of the arts, for £5500, an immense sum at that period. His example was followed by subsequent artists, and diamond dust was used in reducing this gem itself.

Substances chosen.

The substances most frequently sculptured by engravers, both ancient and modern, are rock crystal of different colours, jasper, calcedony, cornelian, onyx, blood stone. Rock crystal, which is well known, is not considered of sufficient hardness, and the same has been observed of malachite, which is also sometimes used. Jasper is found in great variety, as well in appearance as quality, and in pieces of large dimensions; none but the finest and most compact is employed; and this occurs both in the colder and warmer climates. Cornelian and calcedony are so nearly allied, that their names are mutually interchanged according to the tinge which either exhibits; but the latter, which is also called white cornelian by lapidaries, is to be distinguished by a greyish-white colour, bearing marks which resemble the scoopings of a knife on wood, and occasionally exhibiting a sky-blue colour. The ancients are supposed to have obtained the best species by the route of Carthage, from the mountains of the Nasomenes in Africa, and also from Thebes. One of their most favourite stones was the cornelian, on which all the ingenuity of their art has been anxiously bestowed: its colour, hardness, and texture, are the most favourable for delicate engravings, and it seems to have been diffused in much greater abundance than any other. This stone is seen of different shades, from cherry red to flesh colour, and sometimes of a yellowish tinge, or brownish colour; but exposed to moderate heat it becomes white. The ancients divided it into two species, male and female, the latter being pale yellow; and they obtained both from India, Arabia, and other parts of Asia, as well as the Mediterranean islands. At present the finest cornelians come from the east, particularly the Indian peninsula, where they are found from the size of a nut to several inches in diameter, and constitute a considerable article of traffic: the Dutch also brought a quantity from Japan, during the subsistence of their trade with that island. A large proportion of ancient and modern engravings are executed on beautiful cornelian, the colour of which may be deepened and improved by the proper application of heat. The onyx has been esteemed valuable since the earliest periods of Jewish history, from the singular combination of its colours; and it was equally prized by the Greeks and Romans, who applied it to their most valuable works of art. This stone is considered a calcedony, the colours of which are disposed in alternate zones or strata. Generally they do not exceed two or three; five or six are extremely rare. The proper gems of onyx consist of parallel zones, as these only can be worked to advantage; but there are other two varieties with undulated zones, or concentric nuclei, resembling the eye of animals. Where the stripes are of various colours, lapidaries commonly call the stone a sardonyx, a vague and indefinite appellation, and used in another sense by mineralogists. But some apply the name of sardonyx where the ground is coloured, and that of onyx where it is white. It is not known where the latter was obtained by the ancients, but it is now found principally in Germany and Scotland. Artists have ingeniously disposed of the combination, particularly in sculpturing cameos or figures in relief: a white subject appears on a dark ground; or if there be three colours, the third is artfully converted to drapery, or some accessory of the general design. This may be easily understood on reflecting, that the thickness of each zone is worked so as to leave one surface entire, or penetrating still deeper, the artist avails himself of two. M. Mariette speaks of a gem of this kind, consisting of four equidistant zones of different colours, describing four ellipses within each other in as great perfection as if drawn mathematically; and in the centre was engraved a small figure of a Bacchante adapting his footsteps to the sound of his lyre, as if it had been a picture fitted into a frame. The largest onyx said to exist, is an oval of eleven inches by nine, on which is sculptured the apotheosis of Augustus in four zones, two of which are brown and the others white. Several stones of the same species have attracted the particular notice of antiquarians: such is the Brunswick vase six inches in height, representing Ceres in quest of Proserpine; Venus on a marine animal surrounded by Cupids, engraved upon an onyx of two zones;

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Marcus Aurelius and Faustina in one of four zones, two white, and two of lilac. Many are wont to consider the finest works of art as insipid when not diversified by colour; but this objection is removed by the onyx, and it has hence been in great request both among the ancients and ourselves. Scipio Africanus, according to Pliny, first brought it into notice. Engraved gems of two colours, as the onyx, are called cameos, a word of uncertain etymology. It is more usually applied to such subjects as are in relief or elevated, while all hollow engravings are called intaglios, a name adopted from the Italian, or in French *en creux*. Some artists are inclined to distinguish an onyx with a red ground as the cornelian onyx. The ancients seem to have been well acquainted with blood stone, called *heliotrope* by them, and on the continent at present, *speckled agate*. There are two species in use with engravers, one of which has the ground of deep green irregularly sprinkled with red specks, and not opaque. It is found in Siberia, Sicily, Germany, and likewise in Scotland, in considerable pieces, but of very unequal quality; and the red which is thought to be iron, sometimes separates from the substance of the stone. Engravers have here, as in the former instance, availed themselves of colour; and M. Brard acquaints us, that there is a gem, though not antique, in the national library at Paris, representing the head of Christ under flagellation, where the crimson specks imitate the drops of blood. In the other species, the specks are so numerous, that at a little distance the whole stone appears of a reddish cast. Besides these, the art of engraving has been exercised on many other stones, even on some which, from softness and the intermixture of colours, were ill adapted for it.

Ancient nations which engraved on gems.

Before alluding to the subjects represented by engraving on stones, a few words may be said of the nations among which it was anciently practised; and here it is natural to expect the utmost diversity according to the progress of the arts. The Egyptians had gems both in intaglio and relief, but more commonly the former; and those preserved are for the most part called *scarabei*, from the figure resembling a beetle, consisting of green jasper, cornelian, and calcedony. The Jews perhaps learned engraving from the Egyptians among whom they dwelt, and some notices respecting it are preserved in sacred writ, while describing the decorations of the high priest. Of the jewels which were in the ephod, Moses was directed to take two onyx stones and grave on them the names of the children of Israel, six of their names on one stone, and the other six names of the rest on the other stone, according to their birth. "With the work of an engraver on stone, like the engravings of a signet, shalt thou engrave the two stones with the names of the children of Israel." The Greeks, before the decline of their own country, and afterwards when their artists were under the patronage of the Romans, have been much more eminent for their gems than all the other nations of antiquity. The most refined taste for the arts prevailed among them: they excelled alike in architecture, sculpture, and painting; and almost every succeeding artist has formed his works after their model. They practised seal-engraving at a remote period, though it does not appear to have been upon stones; for we are told, that a law of Solon prohibited engravers from keeping or making copies of seal-rings; and Mnesarchus, the father of Pythagoras, was a seal engraver. The names of many celebrated artists are preserved on their works, which M. Millin, a learned antiquarian, has endeavoured to arrange in chronological order; an undertaking of much difficulty, and one that can never be free of doubt. But the catalogue given by him of the Greeks and later engravers being long, we can only make a brief excerpt from it. Those who flourished anterior to the era of Alexander, he supposes, were Theodore of Samos, who engraved a lyre on a famous emerald belonging to the king Polycrates, 750 years before Christ, which the owner, to mortify himself, threw into the sea; Mnesarchus, none of whose works are extant; Heius, Phrygillus, Thamytos. Pyrgoteles was cotemporary with Alexander, who is reported to have issued an edict prohibiting all other artists from engraving his effigy. Between the era of this sovereign and the Augustan age, are enumerated Admone, Apollonides, Polycletes, who was also a statuary, Tryphon, whose period is well ascertained, and others. They become still more numerous on descending later; Aulus, Chronius, and especially Dioscorides, to whom some of the most beautiful works are ascribed, and who engraved the Roman emperor Augustus. Alphæus Ehvodus, Antiochus, Æpolian, flourished in the age of his more immediate successors; but the exact era of the greater number cannot be ascertained. Some of the most celebrated of these are Aetian, Agathemeros, Allion, Apollodotus, said to be the first engraver who added his profession to his name; Pamphilus, whom some have supposed a pupil of Praxiteles, and who engraved upon an amethyst Achilles playing on a lyre; Teucer, Carpus, and others, whose names would protract the catalogue to a great length. Among the Roman artists, M. Millin includes all those whose names do not appear of Greek origin, or are written in Latin; such as Aquilus, Felix, Quintillus, Rufus, and a few, but not many more. The Greeks still preserved their taste for engraving on fine stones during the earlier part of the darker ages; nor was it obliterated entirely from among the Romans. But the doctrines of Christianity, which gradually spread over the eastern and western empire, were adverse to the art, from discountenancing images; and those again being supplanted in the seventh century by the Mahometan religion, it may be said to have entirely disappeared. Here the history of ancient gems concludes; because the empire of the ancients was overrun by barbarians, the arts sunk into insignificance, and those that had shone with the greatest lustre were obscured in the gloom of ignorance.

Greek artists.

In retracing the qualities of the gems anterior to the first centuries of Christianity, we find the Egyptians did not produce any works of excellence; their engravings were principally symbolical, or representing rude figures of their divinities in partial human shape, or the animals that they worshipped. The Jews are said only to have written names. The Etruscans present few if any works of skill, or of much interest. But what remains of Grecian workmanship, or that of the Romans in their zenith of refinement, exhibits beauty and perfection belonging to no other people. Wherever the arts are patronised they flourish; for mankind, always guided by self-interest, will soon discover the way to celebrity. Many circumstances conspired to encourage engraving in Greece: The opportunity of receiving the best materials from foreign nations; the historical events of their own advancement to power; the variety, complication, and allurements of their religion, all contributed to afford an infinite variety of interesting subjects. The taste for gems may be called original with the Greeks: Among other nations, it is rather to be deemed imitative, and to have been introduced along with a taste for the various arts. The Greeks chose many interesting subjects; the heads of emi-

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nent men; their divinities, with their adventures either in heaven or on earth; historical events, which were transmitted to posterity; and the like. They were particularly successful in the beautiful representation of the human body naked; and they always preferred pictures undisguised by drapery. They were masters in engraving animals either in a passive state, or when animated with rage and ferocity. Dioscorides engraved naked figures at Rome; but the Romans, whose works do not bespeak the same character as those of the Greeks, generally concealed them in drapery. These nations produced works in relief and intaglio; and there are rare examples of gems being engraved on both sides. The artist just alluded to, worked in very slight relief, which is reputed to be of extremely difficult execution; but many figures rise highly prominent on the gem. It has been supposed by the learned, that the Greeks had better models than have fallen to the lot of the more modern nations. "To judge by the heads alone which we see on engraved stones, and particularly by those which unquestionably are portraits, their models abounded in beauties rarely found among ourselves. The set of the eyes, the figure of the nose, the smiling lips, the majestic countenance, in short, those undefinable graces, which are the offspring of internal sensation, never were the fruit of the artist's imagination only. The work declares, that he must have beheld them in his model, and that nothing belonged to him but to make a faithful representation. The Greeks besides had another advantage in being able to study the proportions and attitudes of the human body. Far from being disgraceful to appear naked in public, the most distinguished characters contended for the prizes bestowed for wrestling, running, and similar exercises. Many opportunities were thus presented for artists to examine the natural motions of the person, far preferable to the constrained or languishing postures of our mercenary models. Their draperies too were so simple, that we might affirm they were devised to betray the human figure itself; and of this we are so well aware, as invariably to adopt them when dignity or expression are required."

Amidst all the variety of subjects represented on gems, it is not wonderful that antiquarians should be led into errors and controversies; of which, a notable instance appears in Michael Angelo's seal, now preserved at Paris. By one, this subject is supposed to be Alexander the Great represented as Bacchus; by another, it is thought a religious procession of the Athenians; and there are others, who suppose it simply a vintage, or sacrifical rites relative to the conquest of India. But it is said to be proved, that instead of being an antique, this gem was engraved by an intimate friend of Michael Angelo himself; which is sufficient evidence of the uncertainty relative to ancient engravings. The seal is a cornelian; it was bought by the keeper of the cabinet of Henry IV. of France for 800 crowns; and Louis XIV. having afterwards acquired it, frequently wore it as a ring. Specimens of Greek workmanship are always more anxiously sought by those who appreciate the arts of antiquity.

Modern engraved gems.

We can scarcely recognise the appearance of gems, before the revival of the art of engraving among the Italians in the fifteenth century. It experienced several fluctuations during those which succeeded, but was at length completely re-established, and several masters have produced works which almost rival those of the ancients. The names of Dominico de Camei, Maria de Pescia, Caradosso, Tagliacarne, Valerio de Vincenti, and more recently Sirleti, who died in the year 1737. This artist claimed his descent from a cardinal of the same name, who had distinguished himself in ecclesiastical affairs; he was a goldsmith, as well as an engraver on fine stones, and the style of his performances bears a close analogy to that of the Greeks. Amidst a multitude of subjects, he engraved the Apollo Belvidere, the Farnese Hercules, and the rest of the finest statues preserved at Rome; but his *chef d'œuvre* is esteemed the groupe of Laocoon on an amethyst. The art has been successfully cultivated in that country, in the most recent times, by Santarelli, Capperoni, Rega, and by a female artist, Signora Talani, of great celebrity in Rome. France has produced some good engravers, though the ability which they have displayed has been less permanent than in Italy; but the best was probably M. Guay, a native of Marseilles, who flourished in the middle of the preceding century, and is extolled by Gori as *opificum gemmarum decus et ornamentum.* He studied first at Paris, next at Florence, and afterwards at Rome, where he prosecuted his profession in imitating the chosen productions of the ancients. After returning to his native country, he was appointed engraver of fine stones to the king; and with his decease the art is considered to have expired in France, until restored under the patronage of the National Institute, in awarding a preminm to M. Jeuffroy in 1810. There are very few, if any, of the arts in which the Germans have not excelled; indeed, they seem to stand pre-eminent among the moderns for mechanical ingenuity. Yet their first engraver on gems, Henry Enghelhart, was only a cotemporary of Albert Durer. One of the best was Laurence Natter, a native of Biberach in Suabia, who followed the profession of a jeweller both there and in Switzerland; then travelling through Italy, he established himself at Venice, devoting his attention exclusively to engraving gems. After visiting England, he repaired to Denmark and St Petersburg. In Denmark he engraved several of the royal family, especially the Princess Royal, whom he represented on an oval black and white onyx, three inches long, and in relief so prominent, that the head projected about half an inch from the stone. He next engraved an elephant, for one of the royal orders, also in relief, on an oriental jasper, which being of different colours, enabled him to make the elephant and a man mounted on it white, the tower reddish on its back, and the feet of the animal darker, while the ground of the whole was a fine deep green. Natter was treated with particular regard by the King, Christian VI. who assigned him an apartment in his palace, and bestowed upon him valuable presents when he departed for England, where he died in the year 1763. Natter was the author of a treatise on gems, wherein he draws a comparison between the works of the ancients and the moderns, and lays down the principles of the practical part of the art. It has been erroneously maintained, that he is the only author who does so; but in a treatise by M. Mariette, a few years anterior, it is discussed still more at large: Both these works are extremely useful to the artist and antiquarian.

Counterfeit gems.

Modern gems, by common consent, are judged inferior to those of antiquity, and hence many attempts have been made to substitute fictitious gems for those which are real. This is accomplished by two or three different methods: the improvement of a stone, which is really precious,—the imposition of an absolute counterfeit of it, —or the insertion of the name of an ancient engraver on a production of modern origin. This last expedient is by no means uncommon; and some of the most reputable engravers are accused of lending their assistance to the fraud, which may be detected, at least in some instances, in the inferiority of the spurious work compared with that of the master. The beauty of the gem should always correspond with his celebrity; and, if a number should be offered under the same name, strong suspicions may be entertained whether they be genuine, because engraving on hard stones is a tedious and difficult art. The principal engravers, for the most part, employed themselves only on the finer stones; and therefore the names of these annexed to stones of inferior quality render them doubtful, especially if ascribed to the Greeks, or if they are of indifferent execution. Greek engravers inscribed their names in their own characters, which are borrowed by the Romans for the same purpose; and even modern engravers have not hesitated to use Greek characters on the works from which they themselves expected to gain celebrity. The most common deception is the insertion of a celebrated name on a gem, ancient or modern, where it is entirely wanting; and the artists most successful here were Natter, Pichler also a German, and Sirleti. The first of these rather appears to defend the practice; for he observes, "Scarcely had I arrived at Rome when the Chevalier Odam engaged me to copy the Venus of M. Vettori, and convert it to a Danae, adding the name of Aulus. I afterwards sold this production, though a trifle, to M. Shwanav, who was then governor of a young prince, and he seemed to prize it highly, knowing it to be in my style. I have no hesitation in avowing, that I still continue to make similar copies whenever they are commissioned; but I defy all the world to convict me of having sold any one of them as an antique." A gem with a counterfeit name was sold in 1749 for 450 Roman crowns, to a Polish nobleman, who presented it as genuine to the Marchioness of Luneville. Precious stones are of unequal value, from their faintness or intensity of colour, which has led to different methods of improving them. This is generally done by heat, which, if applied in a proper degree, and sufficiently regulated, has sometimes an admirable effect. From the uniform beauty of the ancient cornelians, and the great inequality of the modern, it has been suspected there was some method of purifying them, as is alluded to by Pliny. The Japanese are said to possess the secret; and it is common elsewhere to raise the pale yellow of a species bearing little value, to a fine glowing red. Gems being transparent, their colour is affected by that of the substance whereon they rest; and hence the variety of foils employed in setting them, which may deceive an uskilful person. But a more ingenious kind of deception is practised, in interposing the thinnest possible layer of any colour between two pieces of fine rock crystal, which counterfeits the real gem. Many rules are given for the detection of frauds; but they are of difficult acquisition, and can be learned only by practice.

Independent of these expedients in counterfeiting ancient gems, or in improving the appearance of hard stones, the imitation of the latter has been carried to a very great extent, as forming a branch of experimental chemistry. Seneca acquaints us, that Democritus had discovered the art of making artificial emeralds; but, in the opinion of Professor Beckmann, this was nothing more than giving a green colour by cementation to rock crystal. Pliny mentions several artificial stones; and Trebellius Pollio relates, that Gallienus, enraged at a deception in selling "certain glass gems to his wife for real jewels," punished the cheat with castration; and when the byestanders expressed their surprise, he ordered the crier to proclaim, *imposturam fecit et passus est.* The difficulty of obtaining glass in extreme purity, was in itself a sufficient guide to colour it in imitation; and this art was undoubtedly known from an early age. At Alexandria, the glass manufacture was in high repute, which is corroborated by an Egyptian priest presenting several glass cups, sparkling with every colour, to the Emperor Adrian, who valued them so highly, that he allowed them to be used only at festivals. The coloured glass of this city was ascribed by Strabo to a kind of earth found in the neighbourhood. Many of the antique fictitious gems, or pastes as we more commonly denominate them, are preserved; and the art seems to have been one of the few which was not lost during the darker ages. Heraclius, an author of the ninth century, gives directions, in uncouth Latin verses, how to imitate precious stones after this manner, in a treatise *de Artibus Romanorum.* We do not know what perfection was then attained; but the imitations were so successful, or the people so unskilful, that coloured glass passed current for the precious original, and donations were unsuspectingly made by crowned heads of this as of the most valuable substance. A celebrated vase belonging to the cathedral of Genoa was believed to be a real emerald during centuries, and, on a certain emergency, was pledged for a sum equivalent to £30,000 sterling. Natter, one of the most skilful modern artists, was long deceived by a composition in imitation of onyx. The surface was blue, with a black ground, and the whole so intimately resembled a natural production, that it was not before some accidental circumstance induced him to put it to the test, that the truth was ascertained. An antique green paste belonged to the same artist with a white zone in the middle exactly like an onyx, and which did not undergo any alteration from heat. The ancients were, besides, acquainted with the art of compounding such party coloured pastes of large size, which they are supposed to have accomplished by dipping a black, blue, or brown lump of glass in a mass of milk-white enamel glass, and blowing it into its proper form; then the outside being cut away, the figures required were represented in relief. Mr Raspe says, that something of the same kind is at present practised in the glasshouses of Bohemia. The art of making fictitious gems was revived and carried to an uncommon degree of excellence by ingenious chemists of the seventeenth and eighteenth century, whereby the most accurate imitation of precious stones, combined with antique engraving, has been effected. Neri, Kunkel, and particularly Orschall, who all flourished in the former period, made important improvements; but the two latter seem to have attended more to the imitation of a ruby colour, which was considered most difficult to obtain, and was then the subject of animated controversies. They were succeeded by Homberg, an eminent chemist, who was patronised by the Duke of Orleans, regent of France, and who has left a tract on the subject in the Memoirs of the Royal Academy for 1712; Lippert of Dresden, originally a glazier; Riffenstein at Rome; Dr Quin of Dublin; James Tassie of Glasgow; and a female artist, M. Feloix, who of late years carried on the fabrication of artificial gems with great success in Paris. To these names must be added that of M. Fontanieu, who, by a numerous series of experiments, has explained an improved method of making pastes for every different species of stone. Tassie perhaps extended the art farther than any of the rest; for, availing himself of the skill and industry of others, he collected no less than 15,000 subjects, originals, counterfeits, and impressions, the whole of which he seems to have imitated. This artist

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was born in Scotland, and practised modelling and sculpture in Dublin during three years preceding 1766. He then repaired to London, where, amidst the study of various branches of the fine arts, he confined himself principally to the composition of coloured pastes and artificial gems. The former were first brought into repute by the London jewellers, employing them for ornamental purposes; the latter consisted of a beautiful hard white enamel, which struck fire with steel, and was not affected by heat. Tassie carried on an extensive traffic in these fictitious gems, which he sold from eighteen pence to two guineas, according to the quality; and the late empress of Russia, a liberal patron of the arts, commissioned a complete set of his whole collection. This he executed in a masterly manner, imitating original gems where circumstances admitted of it, where otherwise the pastes were chiefly transparent; and cabinets containing them are now in the imperial palace of Czarsko Celo. As public fashions are fluctuating, pastes began to lose their value, and fictitious engraved gems are at present in little repute in Britain, though imitations of precious stones are still worn as personal ornaments.

Practical art of making fictitious gems.

The practical part of the art of making fictitious gems, in so far as relates to colour and consistence, is amply explained by M. Fontanieu, from whose work we shall quote a few observations, as his principles have received general approbation. M. Fontanieu's primary object was the discovery of a colourless base, constituting the elements of all gems, which, by the addition of metallic oxides, would imitate their respective tinge; and he found it might be obtained from different siliceous substances, pure sand, flint, pebbles, or rock crystal. Any of these, such as crystal or pebbles, being pounded, are put into a crucible and heated red hot; the contents are emptied into a wooden bowl filled with clean cold water, and being shaken from time to time, the lighter particles of extraneous matter escape and rise to the surface, while the rest, together with any metallic particles, remain below. The water is then decanted, and the mass being dried and pounded, is sifted through a sieve of the finest silk, after which the powder is digested four or five hours in the muriatic acid, shaking the mixture frequently. Having poured off the acid, a pure vitrifiable earth remains, which, being frequently washed, is again dried and sifted when it becomes fit for use. From the earth now obtained, M. Fontanieu formed six different bases, of which the fifth seems to be that which, in respect of quality, is preferred by himself; and his proportions are all calculated in parts of eight ounces each. The first base is formed by 20 ounces of lead in scales, 12 ounces of prepared rock crystal or flint, 4 ounces of nitre, 4 ounces of borax, and 2 ounces of arsenic, which being well pulverized and mixed, are melted in a Hessian crucible, and poured into cold water. The mass is melted again a second and a third time, always in a new crucible, and after each melting poured into cold water as at first, taking care to separate the lead that may be revived. This forms the first base. The second is obtained from a mixture of 20 ounces of white ceruse, 8 ounces of prepared flint, 4 ounces of salt of tartar, and 2 ounces of calcined borax, all melted in a Hessian crucible, and poured into cold water. The melting must be repeated, and the mass washed a second and third time with the same precautions as before. A compound of 16 ounces of minium, 8 ounces of crystal, 4 ounces of nitre, and 4 ounces of salt of tartar, constitutes the third base, being treated as in the preceding examples. The fourth is formed by 8 ounces of rock crystal, 24 ounces of calcined borax, 8 ounces salt of tartar mixed and melted together, and poured into warm water. The mass being dried, an equal quantity of minium is to be added, and the whole repeatedly melted and washed as before. Fifthly, a base judged by the author as one of the finest crystalline compositions, and called by him the *Mayence* base, is procured in the following manner: Eight ounces of rock crystal, or flint pulverised, is baked along with 24 ounces of salt of tartar, and the mixture left to cool. It is afterwards poured into a crucible of hot water to dissolve the frit, and the solution is received into a stone ware pan, and the nitrous acid added until it no longer effervesces. The water being decanted, the frit must be washed in warm water until it ceases to have any taste; and the frit being then dried and mixed with 12 ounces of fine ceruse, or white lead in scales, the mixture is to be well levigated with a little distilled water. An ounce of calcined borax is now to be added to twelve ounces of this powder when dried, the whole well mixed in a marble mortar, then melted and poured into cold water, in the same manner as in the rest of the bases already described. After repeating these fusions and lotions, and the mixture being dried and pulverised, five drachms of nitre are to be added, and the whole being melted for the last time, a mass of crystal will be found in the crucible with a beautiful lustre. Lastly, a very fine white crystal may be obtained from eight ounces of ceruse, two ounces of borax finely powdered, half a grain of manganese, and three ounces of rock crystal treated as above.

The colour of artificial gems is obtained from metallic oxides, a fact that must have been almost coeval with the discovery of vitrification; but the opinion of chemists has differed as to their proportions and combinations. The diamond being colourless, is imitated simply by the Mayence base; and M. Fontanieu gives receipts for making all other fictitious gems, of which the following are examples. The oriental topaz is prepared by adding five drachms of antimony to colour 24 ounces of the first and third base: the amethyst, by taking 24 ounces of the Mayence base, to which are added for colour, four drachms of manganese, prepared by being exposed to a red heat, and quenched in distilled vinegar; then dried and powdered, and passed through a silk sieve, and also four grains of precipitate of cassias. The hyacinth is obtained from a base of prepared rock crystal, and two drachms 48 grains added for colour. To imitate the beryl, 96 grains of antimony, and four grains of the calx of cobalt, are added to 24 ounces of the third base. Precautions, however, are necessary in preparing the oxides; and these the author has detailed at length in his original work, of which there is an abstract in the *Journal de Physique*, 1778. A fictitious turquoise, from a composition by M. Sauviac, has lately appeared in France, which is a perfect imitation of the original, and the colours penetrate the substance of the mass. It is now ascertained that the genuine turquoise is not what may be called an original product of nature, but the petrified bone of an animal. The same artist, M. Sauviac, has likewise made fictitious malachite.

The quality of artificial gems consists in their absolute uniformity of texture, compactness, hardness, and lustre; and it is surprising to what perfection repeated practice has brought the art. Fictitious gems may be detected from their softness, which always yields to the file, and from their small specific gravity.

The artist having chosen his natural gem, it is put into the hands of the lapidary to give it surface and

Practice of Engraving Gems.

figure. Next he models the subject in wax, as delicately as possible, which he means to represent, in order that he may constantly avail himself of the resemblance, or he has some other subject which he is to imitate before him. His tools are few and simple, consisting of a lathe nearly on the same principle as the turning lathe, into the end of the spindle of which he can insert points, knobs, or circles. These project a certain distance, and receive a rapid motion from a wheel below. The gem is fixed with mastic to the end of a small piece of wood as a handle, and the artist sketches the subject upon it with a copper point or a diamond. It is then applied to the end of one of the tools in motion, which, being wet with diamond dust and olive oil, quickly grinds off the surface; and, by long perseverance, or frequent repetition, produces the outline of the figure, and then the hollow or relief. Frequent impressions must be taken in the course of the work, to shew where there is any excess or defect; for the slightest error in one part, may occasion the alteration of the whole. Such impressions, however, are necessary only in intaglios,* not in cameos, because both the prominences and depressions are there obvious to the eye; and experienced artists consider it more easy to work on a convex surface, from the distance interposed between the tool and the hand. Although the most elegant curves may be produced with skill and attention, much difficulty is experienced in cutting angles; for the tool being the segment of a circle, can never be closely applied; and hence all the letters on the ancient gems, even of the first masters, are imperfect.

The tools employed are either of soft iron or copper; and in defect of diamond powder, that of the ruby, or other hard stones, may be substituted. In cutting the amethyst, the Bohemian emerald, or crystal, water is used to wet the diamond dust instead of oil. Tools of still softer metal, along with tripoli, or rotten stone, and lastly brushes, are used in giving gems their final polish; but it has been observed, that, in this respect, the moderns have never been able to equal the ancients. We describe this process in few words, but it is a slow and tedious operation, and requires a penetrating eye, and a delicate hand. The artist must be master of drawing and modelling, and he must be a sufficient naturalist to be intimately acquainted with the properties and imperfections of the various finer stones.

Various ... [margin note partially cut off]

Although the art of engraving gems might have been preserved during the darker ages, it is doubtful whether the method of giving impressions to paste, without engraving, was not entirely lost. It was revived, however, by M. Homberg, who, in the year 1712, explained it in such a manner, that all later artists have been enabled to follow his precepts. A quantity of soft, smooth, red tripoli is pounded in an iron mortar, sifted through a fine silk sieve, and set aside for use. Another species, called yellow, or Venetian tripoli, which has a natural kind of unctuosity, is then scraped with a knife, and bruised in a glass mortar, with a glass pestle, until reduced to a very fine powder; the finer it is the more favourable for the impression. The red tripoli is now to be mixed to the like consistence of paste with water, and when moulded between the fingers, it is put into a small flattish crucible, scarcely exceeding half an inch in depth, and little more in breadth at the surface than the size of the gem, whose impression is to be taken. The crucible is then to be filled with the paste, slightly pressed down into it, and the dry yellow tripoli strewed over its surface. Here the stone which is to give the impression must be laid, and pressed down so much on the paste, as to give it a strong, clean, and perfect impression; and the tripoli is to be collected and applied nicely to the edges, with the fingers or an ivory knife. After the stone has lain a few seconds to allow the humidity of the paste to moisten the dry powder of the yellow tripoli scattered over it, the operator must raise it carefully by a needle fixed in a wooden handle, and the crucible being inverted, it will fall out, while the impression remains on the tripoli still adhering to the crucible. The stone must now be examined, to ascertain that none of the paste has come off along with it, otherwise there will be a corresponding defect in the impression, and the operation must be repeated. Having allowed the crucible and paste to dry, the artist selects a fictitious gem of the suitable size to be laid over the mould, but in such a manner as not to touch the impression, which would thus be obliterated or injured; and the crucible being gradually brought nearer the furnace, is to be heated until it can no longer be touched by the hand, when it must be placed in the furnace under a muffle, surrounded with charcoal. When the gem begins to appear bright, it is the sign of being ready to receive the impression. The crucible must now be taken from the fire, and the hot gem pressed down with an iron implement, to make it receive the impression from the mould below it; after which the crucible is to be set by the side of the furnace, to cool gradually without breaking. When cold, the gem may be removed, and its edges nipped or grated round with pincers, to prevent it from cracking, which sometimes happens. Red tripoli is used for the paste only from economy, as it is the yellow species alone which is adapted for the purpose. Casts of plaster of Paris may be substituted for both, made into small cakes half an inch thick, and being put into a furnace without a crucible, the gem is to be pressed down upon it to take the impression.

Many discussions have arisen among the learned concerning the use of those ancient gems, now preserved with so much care in our cabinets. The beauty and rarity of natural jewels constitute their principal recommendation, and they have always been employed as personal ornaments, some being more prized than others, according to fashion or ideal properties. It has been supposed that engraved gems were applied in the same manner, and purposely sculptured for ornaments.

During some time, there was an ordonnance of the Roman emperors, prohibiting the use of rings bearing their portraits, the infringement of which was little less than a capital crime; and we are told of the prætor Paulus being exposed to imminent danger, from having a cameo representing the Emperor Tiberius. Vespasian wisely removed this restriction. But the use of those elegant subjects of mythology and history, which appear in relief, is less evident, unless it had some relation to the religious principles of the owner, or was like a picture, designed to perpetuate historical events. It is said that the Romans long abstained from engraving any image of their gods on gems; but adopting the religious fashions of other nations, they became enslaved by superstitions. Augustus sealed with the head of Alexander, and then substituted his own, engraved by Dioscorides. Before resorting to either, he had sealed with a sphynx. Nero is said to have had a seal engraved with the subject of Apollo flaying Marsyas; that of Pompey represented a lion holding a sword; and the Emperor Galba retained the seal of his ancestors, representing a dog on the prow of a vessel. Sylla, proud of the capture of Jugurtha, caused a representation of the King Bocchus, deliver-

* An intaglio may be raised into a cameo optically, and *vice versa*, by viewing it with a microscope which inverts objects. Ed.

Gems || Genera.

ing up the Prince, to be engraved on a ring which he wore on his finger, and always sealed with it; and Scipio Africanus did the same to commemorate one of his conquests.

The ancients entertained a great partiality for rings; they wore many of the most valuable kinds at a time, loading their fingers, in the words of Pliny, with extravagant wealth, *censu opimo digitos onerabant;* and these rings, as we have seen, contained either natural jewels or engraved gems. Most probably, numerous cameos were worn in the same way, merely for ornament, and cutting them might simply be a display of art in miniature, as sculpturing a statue, or painting a picture. But they had special collections of gems; as a taste for works of nature and art was not inferior at certain periods of ancient empires to what now prevails. Cæsar had a splendid cabinet, which he had collected at an immense expence, and of which the pearls of Great Britain constituted a valuable portion. This he consecrated to the temple of Venus Genetrix; and Pompey deposited the gems and rings found among the spoils of Mithridates in the capitol at Rome.

With the irruptions of barbarians, the arts were overthrown; and the most ingenious works of antiquity were consigned to oblivion. Among those which escaped, some became votive offerings in the hands of the earlier Christians to the shrines of their saints, and have thus been preserved through ages; but by far the greater part were lost or destroyed.

See Pliny *Historia Naturalis*, lib. 37, 38. Gorlæus *Dactyliotheca.* Gorius *Dactyliotheca Smithiana. Gemmarum antiquarum, delectus ex præstantioribus desumptus quæ in Dactyliothecis Ducis Marlburiensis conservantur.* Le Chau et Le Blond, *Description des Principales Pierres Gravèes du Cabinet de M. le Duc d'Orleans.* Mariette, *Traite des Pierres Graveès.* Stosch, *Gemmæ Antiquæ cælatæ sculptorum nominibus insignitæ.* Natter, *Traité de la Methode Antique de Graver en Pierres fines.* Raspe, *Descriptive Catalogue of Tassie's Gems*, 2 vols. in 4to. *Memoires de l'Academie Royale*, 1712. Orschall, *Sol sine veste.* Fontanieu, *l'Art de faire les Cristaux*, Paris 1778, in 8vo; and *Journal de Physique.* (*c*)

GEMMI, is the name of a lofty mountain of Switzerland, situated between the Upper Vallais and the canton of Berne. Its name is derived from *Gemini*, indicating the two summits of the mountain. The height of Gemmi above the level of the sea is 6985 feet. On the southern side of the mountain, which is extremely precipitous, a road has been cut in the rock, which is accessible to mules and beasts of burden, and is reckoned the greatest wonder in Switzerland. It was constructed by the Tyrolese, between the years 1736 and 1741, at the joint expence of the Vallais and the canton of Berne. It is about nine feet broad, and the traveller is separated from the precipice only by a small parapet. The descent of this mountain is particularly alarming to those who are subject to giddiness. The invalids from the north of Switzerland, who frequent the baths of Leuk, are carried upon a barrow by eight men, who relieve one another by turns. When they arrive at the frightful passage, the invalid is turned with his back to the precipice; his eyes are tied up, and the undaunted guides endeavour to dispel his fears by singing. From the baths of Leuk to the Chalets of Gemmi is a distance of 10,110 feet, and the vertical height of the wall of Gemmi above the baths is 1600 feet. From the highest part of the road, there is a magnificent view of the Southern Alps, which separate Piedmont from the Vallais. See Alps, p. 578.

GENDER. See Grammar.

GENERA, in Music: with Euclid and others of the ancient Greek writers, implied or included the various modes of dividing and disposing of the divisions of the Tetrachord, or minor *Fourth*, which Interval seems to have been considered as the constant boundary of sounds with the ancients, as the Octave is now with us. The three genera were called Chromaticum, Diatonicum, and Enharmonicum. The two first of these genera have been already treated of under their respective articles, and the other remains to be described.

Gen

According to Euclid, in the *Enharmonic* genus, the Tetrachord was so divided, that the first degree was a diesis or quarter of a major tone, the second degree the same, and the third degree such a ditone as would make up the true fourth: that is, in our notation, Plate XXX. Vol. II.

$$\begin{aligned} & 202\,\Sigma + 4\ f + 17\tfrac{1}{2}\,m \\ \tfrac{1}{4}T = {} & 26\,\Sigma + \tfrac{1}{2}f. + 2\tfrac{1}{4}\,m \\ \tfrac{1}{4}T = {} & 26\,\Sigma + \tfrac{1}{2}f + 2\tfrac{1}{4}\,m \\ \hline 4th = {} & 254\,\Sigma + 5\ f + 22\ m \end{aligned}$$

According to Aristoxenus, in this genus, the tetrachord was divided into 30 equal parts, which were thus distributed, viz. $3+3+24=30$; or

$$\begin{aligned} \tfrac{24}{30}\text{ths, or } \tfrac{4}{5} \times 4th = {} & 203.19686\,\Sigma + 4\,f + 18\,m \\ \tfrac{1}{30}\text{ths, or } \tfrac{1}{10} \times 4th = {} & 25.32674\,\Sigma + f + 2\,m \\ \tfrac{3}{30}\text{ths, or } \tfrac{1}{10} \times 4th = {} & 25.32674\,\Sigma + f + 2\,m \\ \hline 4th = {} & \begin{cases} 253.85034\,\Sigma + 6\,f + 22\,m \\ 254.00000\,\Sigma + 5\,f + 22\,m \end{cases} \end{aligned}$$

Dr Pepusch, Mr Overend, and Dr Boyce, were of opinion, that this genus was thus constituted, viz.

$$\begin{aligned} T + t \text{ (or III)} = {} & 197\,\Sigma + 4\,f + 17\,m \\ \mathcal{E} = {} & 21\,\Sigma + 2\,m \\ \vartheta = {} & 36\,\Sigma + f + 3\,m \\ \hline 4th = {} & 254\,\Sigma + 5\,f + 22\,m \end{aligned}$$

According to Ptolemy, this genus is said, by Dr Wallis, to have been $\frac{45}{46} \times \frac{23}{24} \times \frac{4}{5} = \frac{3}{4}$; or

$$\begin{aligned} \tfrac{4}{5} = {} & 197.00000\,\Sigma + 4\,f + 17\,m \\ \tfrac{23}{24} = {} & 37.53974\,\Sigma + f + 3\,m \\ \tfrac{45}{46} = {} & 19.46026\,\Sigma + 2\,m \\ \hline 4th = {} & 254.00000\,\Sigma + 5\,f + 22\,m \end{aligned}$$

(ς)

GENERATION. See Physiology.

GENEVA, is a city in Switzerland, and capital of an ancient and independent republic of the same name. It is situated on the confines of Savoy and France, at the southern extremity of the Lake of Geneva, where the Rhone issues from it in two rapid transparent streams of a beautiful blue colour, which unite after passing the city. These two branches of the Rhone are crossed by two wooden bridges destitute of beauty, and divide the town into two unequal parts. The principal part of Geneva is situated on the left bank of the Rhone upon a rising ground, about 80 or 90 feet above the level of the Lake.

Geneva is surrounded, except towards the Lake, with high walls and fortifications, which were begun at the commencement of the seventeenth century under the direction of Agrippa D'Aubigné. The building of the bastion of Hesse, which is well worthy of being visited by strangers, cost no less than 10,000 crowns, which Philip, landgrave of Hesse, had given to the republic for this purpose. The southern gate of the city is remarkably beautiful. The double ditches round this gate are filled with water. Fortifications.

The town of Geneva is irregularly built. Some of the streets are extremely steep. The houses are lofty, consisting frequently of four or five stories; and in the commercial part of the town, particularly in the Rue Basse, they have gloomy arcades of wood supported by huge wooden pillars, which rise to the very top of the eneva.

house, and thus protect the foot passengers from the effects of the sun and the rain. In this street, there are two rows of low wooden shops in front of the houses, separating the street from the foot pavements.

The upper part of the town forms a striking contrast with the lower part, not only from the splendid views which it commands, but also from the admirable houses that it contains. The Rue Nouveau de Beauregarde, commanding a splendid view of the Lake and the Western Alps, contains many elegant houses; and the Terrace, which looks to the mountains of Sion, consists of the houses of M. M. Tronchin, Boissier, Sellon, Saussure, &c. which are large quadrangular buildings.

lic dings.

The principal public edifices and establishments, are the cathedral of St Peter's; the Hotel de Ville; the arsenal; the college; the public library; the hospital; the theatre; and the places of worship.

Cnedral.

The cathedral, situated in the upper part of the town, is a large modern church of Gothic architecture in the interior, with a fine organ, and windows of painted glass. The portal is in imitation of that of the Rotondo at Rome. It is built of rough marble, and consists of a fine peristyle of six Corinthian columns supporting a pediment which is surrounded by an ugly substitute for a dome covered with tin. In the time of the Allobroges and the Romans, a temple, consecrated to the sun, occupied the spot on which the cathedral now stands. It contains the tombs of the Duke de Rohan, the head of the Protestant party in France, who was banished by the Cardinal Richelieu, and who died of the wounds which he received at the battle of Rhinfeld. His wife, the daughter of the great Sully, erected this monument to his memory. Another tomb is erected to his son Tancred; and another to the celebrated Agrippa D'Aubigné, who died in 1630. The view from the top of the cathedral is very extensive and magnificent. The other churches of Geneva have nothing remarkable in their appearance. That of St Madelaine is very plain without, but neat within; and the church of Fustiere, in the square of the same name, is more like a large house than a religious edifice. The Hotel de Ville is situated in the upper part of the town. It is an ancient and uninteresting building, with large Gothic halls, and has a singular paved staircase without any steps, like an inclined plane. Between the two principal gates, is an inscription in commemoration of the abolition of the Catholic religion. The arsenal, like all other buildings of the kind, contains specimens of ancient armour, and arms for 12,000 men.

C ege.

The college is a quadrangular building. Each class has a separate and commodious school-room on the ground floor, so as to occupy the two sides of the quadrangle, and the upper part of the building contains apartments for the use of the principal or general inspector, and for the public library of the city. The public library was founded by Bounivard, prior of St Victor, who lived in the time of the Reformation, and who was twice imprisoned, for having asserted the independence of Geneva against the Dukes of Savoy. He bequeathed to it his manuscripts, relative chiefly to the history of Geneva, and his books, and left his fortune

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for the support of the college. It now contains about 50,000 printed volumes, and 200 MSS. of which an account was published in 1779, by M. Senebier the librarian, entitled, *Catalogue raisonnée des Manuscrits conservés dans la Bibliotheque de Geneve.* Among these, are 24 volumes of Calvin's sermons, and a large collection of the letters of that celebrated reformer. There are also MS. letters of Beza and Bullinger, the homilies of St Augustine, written upon the papyrus in the sixth century, and a book of the expences of Philip le Bel for 1314. This curious journal consists of six tablets of wood covered with a kind of wax, in which the letters are engraved. One of the chambers of the library contains a collection of optical and mathematical instruments, anatomical preparations, and antiquities. Among these is a round buckler of silver 34 oz. in weight, with the following inscription: *Largitar D. N. Valentiniani Augusti.* It was found in the bed of the Arve in 1721, and it is the only one of the kind in existence, excepting that which is preserved in the royal library of Paris. The library is also adorned with paintings of several eminent men; and at one end of it is a fine bust of Charles Bonnet, the celebrated naturalist. One of the halls of the college contains several models in gypsum of ancient statues, groups, busts, and bas-reliefs, and also some fine paintings of St Ours and De la Rive.

Hospitals.

The public hospital is a large and elegant quadrangular building, and along with other four charitable establishments, it has an annual expence of 80,000 crowns. In these establishments about 4000 persons are annually relieved, and their benefits are extended even to indigent foreigners.

Theatre.

The theatre is a neat edifice, situated at the south gate. The front of the theatre consists of six Ionic columns, fluted two-thirds of their length from the capital downwards. Geneva is supplied with water by a hydraulic machine, which raises it to the height of 100 feet, and furnishes 500 pints of water in a minute to the public fountains. The principal piece of antiquity at Geneva is the Tour Maitresse, a remnant of the ancient wall, built in 1366 by William de Marcossai.

Collections of natural history.

Among the collections of natural history in Geneva, one of the most celebrated is that of the able chemist Theodore de Saussure, the son of the celebrated Saussure. It contains a fine collection of minerals, petrifactions, volcanic productions, insects and birds, and a collection of philosophical instruments and chemical apparatus. The collection of Dr Jurine, besides a cabinet of ornithology and entomology, contains a collection of all the fossils of St Gothard. There are also collections of minerals in the possession of M. M. Pictet, Tollot, Tingry, De Boissy, and De Luc.

Baths and mineral springs.

Geneva is well supplied with excellent baths both warm and cold. The baths of Lullin are erected in the very middle of the Rhone, where it issues from the lake. The warm baths in the quarter called *Le Derriere du Rhone*, are much frequented, on account of the fine view which some of the apartments enjoy. A warm mineral spring was some years ago discovered at St Gervais, in Savoy, at a little distance from Sallenche. Buildings have been erected on the spot, and have been in use since 1809. The temperature of the water is 33° of Reaumur. Fifty pounds of it contain,

	Oz.	Dr.	Gr.
Sulphate of lime mixed with one-seventh of carbonate of lime	1	0	2
Sulphate of soda	1	6	0
Carbonate of soda	0	7	2
Carbonate of magnesia	0	2	20
Petroleum	0	0	2
Concrete carbonic acid	0	1	8

It is supposed to have the same medicinal qualities as the baths of Leuk in the Vallais.

Views and promenades.

There is perhaps no town in the world, which can boast of such an immense variety of splendid and interesting views as Geneva. Within the city, the houses which form the lofty terrace already mentioned, those in the street of Beauregard, and those which are near the cathedral, enjoy, from their elevated situation, very interesting views of the lake of Geneva, the Eastern Alps, the Saleve Mountains, &c. The principal promenades within the city, are the *Treille*, the Bastions, and the Place de St Antoine, from which there is a fine

Geneva.

view of the lake, with the various villas on the side of Cologny as far as Yvoire, where the Lake begins rapidly to expand itself. It commands also a view of the opposite side of the lake, including Copet, the seat of Madame de Stael, Nyon, and Morges, which is not far from Lausanne. The Little Languedoc is also a favourite promenade, when the wind blows from the north.

View of Mont Blanc and the Alps.

The country around Geneva is so extremely grand and beautiful, that it is impossible to walk in any direction without being gratified with the views and objects which are constantly presented to the eye. The right, or western bank of the lake, is more interesting than the Savoy side. Mont Blanc, in clear weather, is a principal feature in every landscape. About a quarter of a league from the town, on the road to Fernay, the Mole, a hill about 4516 feet above the level of the lake, first presents itself among the Eastern Alps. To the right of this rises the Great and the Little Saleve, 3022 feet high, remarkable for the whiteness of their rocks. On the left, the round mountain of the Voiron (3112 feet high) stretches its enormous and well wooded flanks far to the east, and between it and Saleve, rises the round and beautifully shaped hill of Montoux, 625 feet high. Between the Mole and the Voiron is seen the Aiguille des Argentieres, and at a little greater distance the rounded summit of Mont Buet. The mountains of Brezon and Vergi (4000 or 5000 feet high) appear between the Mole and the Saleve; and above them Mont Blanc rises in all its majesty to the height of 13,428 feet. In looking to the north-east, we can observe from the village called Little Sacconez, all the mountains which stretch beyond Montreux and Chillon, (at the eastern extremity of the lake,) as far as Molesson, which is 5047 feet high, and is situated above the Gruyeres, in the canton of Fribourg, about seventeen leagues in a straight line from Geneva. To the west and the north, the grand ridge of Jura stretches its uninterrupted length. Its three highest summits are, the Reculet de Thoiry, 4062 feet high; the Dole, 3948 feet; and the Montendre, 4036 feet high, and to the north of Reculet.

The splendid view which we have now described, becomes more distinctly seen as we advance along the road to Fernay, and is developed in all its majesty from the beech tree promenade, in the garden of Voltaire. The writer of this article had the good fortune to see this magnificent prospect under the most favourable circumstances; but he was much more overpowered with the majesty of Mont Blanc when he saw it from the heights of Fourriere, or from the Quai de la Guillotierre, at Lyons, a distance of about 160 miles.

System of education.

The system of education which prevails at Geneva, is perhaps not surpassed by that of any other city in Europe. It is not associated, indeed, with those splendid establishments, nor supported by those rich endowments, which are to be found in the other cities of Europe; but it is kept alive and regulated by a love of science, and an enlightened and patriotic zeal among the learned men of Geneva, which we believe has no other example. The system of public education which prevails in this city, relates to the studies of childhood, those of adolescence, and those of the learned professions of divinity, law, and physic.

The first of these departments resembles that of our Eton or Westminster schools. It is conducted by eleven masters, called *regens*, under the superintendance of a rector, a principal, and the academy of professors. Children from the age of five to sixteen are successively taught reading, writing, orthography, arithmetic, and the elements of Greek, Latin, and mathematics. The college is divided into nine classes, each having a separate and commodious class room. The scholars generally continue a year in each class, and no one is permitted to leave his form, till he is fit for being promoted to a higher one. An account of the degrees of good and bad conduct of every boy is regularly and faithfully kept, which is summed up at the end of the week. Twice every year prizes are distributed for good conduct, and for progress in study; and once in the year, generally in the beginning of June, exercises are proposed to each class, and prizes are adjudged to the best. These prizes are distributed on the day called the Day of Promotion, the day before that on which the properly qualified students are promoted to a higher class. A grand solemnity is on this occasion celebrated in the cathedral church, and is attended by all the public bodies in their robes, and by crowds of citizens of every class. On the celebration of this fete on the 20th June 1814, 88 silver medals were distributed.

The second department of the system of education at Geneva, is entrusted to the professors, who occupy the highest station in the academy. It is subdivided into different classes, called *auditoires*. All the courses of lectures begin on the first Tuesday of August, and continue summer and winter, with several vacations, which amount to between four and five months in the year. Four years attendance is necessary to complete the studies of this department: the two first are devoted to the Belles Lettres, and the two last to the different branches of philosophy. The pupils are examined daily on the subject of the preceding lecture.

When the student has completed this course, which he generally does at the age of 18, he may then attend to the study of divinity, law, or physic. The following is a list of the subjects on which lectures are delivered:

Natural philosophy	M. A. Pictet.
Mathematics	M. M. D'Huillier and Schaub.
Rational or moral philosophy .	M. Prevost.
Pharmaceutical chemistry . . .	Dr De la Rive.
Botany	M. M. Vaucher, and Necker, sen.
Mineralogy	M. Theodore Saussure.
Geology	M. Necker, jun.
Chemistry applied to the arts	M. M. Tingry, Boissy.
Zoology	M. Jurine.
Anatomy	M. Maunoir.
Theory and practice of medicine	Dr Odier.
Rhetoric	M. Weber.
Belles Lettres	M. Sismondi.
History and statistics	M. Picot, jun.
Latin and Greek literature . .	Duvillard.
French literature	M. Weber.
Roman law	M. M. Fort and Girod Jolivet.
Sacred eloquence	Rev. M. Picot, sen.
Sacred Oriental languages . . .	Rev. M. De Roches.
Dogmatic theology	Rev. M. Duby.
Ecclesiastical history	Rev. M. Vaucher.
Evangelical morals	Rev. M. Peschier.

Our readers will no doubt be surprised to learn that the preceding establishment, in which more than 1000 pupils are educated, is supported exclusively by a population of 30,000. The annual salary of the professors is not more than 60 guineas, and scarcely half of the professors are entitled to this sum, the rest being merely honorary teachers, who give their labour to the community without any remuneration. The honour of teaching is here considered as a sufficient compensation for its labour; and such is the esteem in which even the masters of the schools are held, that one of the

Geneva.

regents, was made a member of the provisional government at the restoration of the republic.

As it is very probable that many of our countrymen will send their sons to Geneva for the sake of acquiring the French language, and other advantages which cannot be easily obtained at home, we have dwelt more minutely on the subject of education than we would otherwise have been entitled to do. There is certainly no place in the world to which a father may send his children with fewer anxieties than to Geneva. The vices which prevail in many of the principal towns of Europe, are here in a great measure unknown. The young men are regularly instructed in the duties and principles of Christianity, and all the decent proprieties of religion are observed here, as in our own country. An Englishman, and a Scotchman still more, finds himself at home in the society and customs of this happy republic. The religion of Geneva has lost much of the austerity which she wore in former times. Cheerful and enlightened, she now appears in her native character; and there is no danger of the religious habits of our youth experiencing any violent change among the virtuous inhabitants of this city. The similarity of our institutions to theirs, the civil liberty and religious toleration which distinguish both countries, have attached the Genevese to the English character; and we have no hesitation in saying, that if an Englishman could for one moment expatriate himself, even in imagination, he would wish to be a citizen of Geneva.

Society of Natural History.

There are several literary societies at Geneva, the principal of which is the Society of Natural History, composed of all the distinguished individuals in the city. It meets, we believe, alternately at the houses of the different members: and the memoirs which are read are in general published in the *Bibliotheque Britannique*, a monthly journal, which is perhaps the best conducted in Europe. It was founded by M. A. Pictet, who is one of the principal editors; and the chief object of the work is to give an account of British publications. Geneva has also a society for the advancement of the arts, founded by M. Fuisar, a clockmaker. There is a small observatory at Geneva, which contains some good instruments; and a botanical garden.

Manufactures.

Geneva cannot be considered as either a commercial or a manufacturing town. It has long been celebrated for its manufactures of watches and jewellery; and towards the end of the 18th century, five or six thousand persons of both sexes were employed in this occupation. London and Geneva were long regarded as the general magazines from which the rest of Europe was supplied with clocks and watches; and it is stated by Peuchet, that 25,000 gold and silver watches are manufactured every year. The rough part of the work is in general done by the inhabitants of the mountainous districts of Switzerland, and they are sent to Geneva to be finished for sale. There are also in this city manufactures of velvet, India stuffs, silk stockings, hats, and leather. A great manufacture of imitation India shawls is carried on by M. Pictet of Rochemont. In order to accommodate the manufacturing class, a kind of bank called *Caisse d'Escompte*, has been established. Manufacturers and tradesmen can here obtain money upon good bills, at a moderate discount.

Climate.

The climate of Geneva is extremely salubrious, though rather cold. The air is always colder than at Paris. In the greatest colds at Geneva, Reaumur's thermometer stands at from 14° to 18°; and in the greatest heats, from 26° to 27°. There is a very singular coincidence in the variations of the barometer at London, Paris, and Geneva. Geneva is situated in North Lat. 46° 12′, and East Long. 6° 9′ 30″. Population 26,140.

Republic of Geneva.

GENEVA, Republic of, is a small territory comprehending the following districts:

	Population.
Town of Geneva	26,140
The suburbs	4,104
The Chatellenie of Peney and its dependencies	2,622
The Chatellenie of Jussy and Vandœuvres	1,301
The two seignories of Tuvretin and Chateauvieux	537
Total population	34,704

These inhabitants, with about 300 strangers, making in all 35,000 nearly, are contained in $3\frac{7}{100}$ square leagues which gives 11,080 to every square league; a density of population which is very remarkable.

The Genevese territory is extremely fertile and beautiful. The villages are large and well built, and the country is adorned with numerous villas.

Geneva formed part of the territory of the Allobroges. Cæsar established here a place of arms against the Helvetians, and built on the left bank of the Rhone a wall 9000 paces long, and 16 paces high, to oppose the passage of the Helvetians across the Roman province. The city was twice destroyed during the Roman emperors. In 1032, under the successors of Charlemagne, it was united to the German empire. After the 13th century, it was a constant source of discord among the bishops, the counts of Geneva, and those of Savoy; and from the middle of the 13th century, till 1536, it had to struggle against the ambition of the Dukes of Savoy; but, in consequence of the alliance which it formed with the towns of Berne and Fribourg, it was enabled to establish its independence. This epoch of the civil liberty of Geneva was also marked by the commencement of its religious freedom. The doctrines of the Reformation were preached in 1533 by William Farel; and in 1535, the reformed doctrines were adopted in full council. Calvin and Beza now adorned this asylum of liberty, and men of principle and character found here a sanctuary from the cruelties of civil and religious tyranny. In 1542 and 1543, the plague committed dreadful ravages in the city. In 1584, a treaty of alliance was formed between Geneva, Zurich, and Berne. The house of Savoy made its last attempt against the liberties of Geneva in 1602; but though this perfidious attack was bravely repelled, the independence of the republic was never solemnly recognized by the house of Savoy till the year 1754.

In the year 1768, 1782, 1789 and 1793, Geneva was agitated with intestine commotions, of which we cannot find room to give any particular account. On the 15th April 1798, it was occupied by French troops. Its independence was destroyed, and it was incorporated with the French empire, forming part of the department of Leman. The restoration of European independence, in 1814, by the overthrow of the colossal power of France, restored Geneva to the possession of its independence and its ancient laws; and we had the good fortune, a few months after this glorious event, of witnessing the happiness of a free people newly emerged from a foreign and oppressive yoke.

In our article Switzerland, our readers may expect an account of the constitution of this republic.

GENEVA, Lake of, in French *Leman*, and in Latin *Lemannus*, is an extensive lake in Switzerland, resembling in its general shape the form of the moon when she is a few days old. The concave side embraces Savoy, the convex side the Pays de Vaud, and a line joining its extremities stretches in the di-

Lake of Geneva.

rection NE. by E. Its length measured along the great arch which forms the coast of Savoy, is $18\frac{3}{4}$ leagues, but when measured in a straight line across Chablais, it is only $14\frac{3}{4}$. Its greatest width, which is between the towns of Rolle and Thonon, is $3\frac{1}{4}$ leagues. Its breadth at Nyon, near Geneva, is $1\frac{1}{4}$ league; and from this place it constantly diminishes to Geneva, where it is only 300 or 400 feet wide. It is about 620 feet deep about a league from Evian; near the castle of Chillon it is only 312 feet, but in an intermediate place in the environs of Meillerie its depth is 950 feet. The lake occupies 26 square leagues; and its height above the level of the sea is 1134 feet according to M. Pictet, and 1154 feet according to Sir G. Shuckburgh. The lake of Geneva is said to have once extended as far as Bex, about 4 leagues up the Rhone. The village of Port Vallais, once on the banks of the lake, is now half a league distant from it. From the year 1626 to 1726, a large tongue of land, half a league long and 120 feet wide, has been formed between Villeneuve and the mouth of the Rhone. No fewer than forty-two rivers empty themselves into this lake. The Rhone, which is the principal of these, enters it by three branches, and issues from it in two; and after forming an island containing part of Geneva, they both unite, and at the distance of one fourth of a league below that city they receive the Aar. In 1711, the Aar was so much swollen that it pushed back the Rhone, and their united waters flowed back into the lake of Geneva, which they discoloured even to the distance of a league from the town.

The lake of Geneva never freezes, excepting a few paces from its margin; and in very severe winters it freezes between Geneva and the bank of sand. Its waters have a beautiful blue colour; and such is the purity of the atmosphere, that a town upon its banks illuminated by the sun, may be easily seen at the distance of about forty miles. In autumn, fogs 1200 feet in perpendicular height often rest upon the lake when it is the finest weather among the mountains. On the 1st of November 1793, during a fall of snow, a singular waterspout was seen at Cuillus by M. Wild. The foaming waters appeared to rise to the height of 100 feet, and the surface of the lake immediately below it appeared to be excavated. The lake is also subject to sudden agitations similar to those which have been seen in Loch Tay. (See the article AGITATION.) The water rises suddenly to the height of four or five feet, and descending, forms a species of ebbing and flowing which lasts for several hours. This phenomenon, which is called *Seiches*, is particularly seen near Geneva. There are no islands in the lake, excepting a small one with a few trees near Villeneuve. The lake of Geneva contains twenty-nine different species of fish.

The most common winds on the lake, are the *Bise* or north wind, and the *Sechard* or north east wind; and the most dangerous are the *Bise* and the *Vaudaise* or south east wind. Sometimes when the *Bise* is very strong, boats can go from Savoy to Geneva, a distance of fifteen leagues, in 4 hours.

The lake of Geneva is undoubtedly the most beautiful lake in Europe, and that of Constance alone has been supposed to equal it. It is impossible to convey any idea of its varied beauties to those who have not travelled along its banks. On the south east, east, and north east, it is encircled with lofty mountains 5000 feet high, while on the south, the south west, and the west, the banks of the Pay de Vaud rise in terraces from 200 to 600 feet high, resting on the flanks of the ridge of Jura, which occupies the whole of the western horizon.

The scenery which is presented to the traveller between Villeneuve and Vevay, and as far as Lausanne, is certainly the finest and the most varied in Switzerland, and we had an opportunity of viewing it in the finest weather, and at that season of the year when nature developes all her beauties. In travelling down the Vallais along the banks of the Rhone, after passing the village of Rennaz, we first obtain a view of the lake and the Pays de Vaud. Over its blue waters appears the town of Vevay, at the bottom of a round hill, and in the distance rises the hill and town of Gourze, finely projected against the dark blue range of Jura. A little farther on, the town of Villeneuve is seen on the very margin of the lake, situated at the mouth of a finely wooded valley, and the lake gradually discloses itself as we approach the town. The road is now almost washed by the blue waves. The dark flanks of the Savoy hills, clothed with gloomy forests, and occasionally enlivened with smiling villages, form a fine transition from the verdant borders of the lake to their peaked and rugged summits. Numbers of vessels open their white sails to the wind, and on the Swiss side, one town appears after another, disclosing a succession of the most sublime and picturesque views. The old castle of Chillon, almost immerged in the lake, and the ivy clad precipices which overhang it, next attract the notice of the traveller; the hills on the right now retire from the lake, and open more extensive prospects. The wooded recess which embraces the hamlet of Vaiteau, is the commencement of this new scenery, and at the village of Montreux, both the distant and near objects are combined in forming the loveliest landscape we have ever seen. The terraced vineyards begin to diminish the picturesque effect of the woods and rocks, and the beauty of the scenery declines as we approach to Vevay. The view of the lake of Geneva from the terrace of the cathedral of Vevay is much admired; but we had the good fortune to be wandering along the promenade on the margin of the lake, when the sun had just begun to descend behind the ridge of Jura. A bright glow of purely yellow light gilded the whole of the western sky. A warm tinge of red appeared at a greater altitude, and the whole expanse of the lake, towards the west, shone with the liveliest purple. As the sun descended, the yellow tints of the sky gradually deepened into orange, and the purple colour of the water declined into a more sober hue. In turning the eye to the south, this lively scene became less brilliant. The mountains of Chablais faintly reflected the red twilight, and the Alps of the Vallais, and the part of the lake which intervened, were involved in almost impenetrable darkness.

GENITIVE. See GRAMMAR.

Lake of Geneva || Genoa.

GENOA, a celebrated city in the north of Italy, is situated in Lat. 44° 25′ N. and Long. 8° 58′ E. on the northern shores of the Mediterranean. It is built in the form of an amphitheatre, on the slope of a mountain, rising gradually from the sea, having for a centre the harbour, which is of very considerable extent, and having sufficient depth of water to admit a ship of 44 guns. The harbour is protected on two sides by piers, which, however, are sometimes found insufficient to shelter the vessels from the south-west wind, which although it does not blow directly into the port, often occasions considerable damage. The entrance also to the harbour, although wide, is not free from danger, and can only be approached with safety from the east side.

Genoa is surrounded by two ramparts, one of which incloses the town, and is about six miles in circuit; and the other, which forms a circumference of thirteen miles, is carried round the hills which command the city. The external appearance is extremely magnificent. In no other city in the world is there to be found such a profusion of marble and other rich materials, both in public and private edifices; while their situation on terraces, ascending one above the other, adds an additional degree of splendour to their appearance. On entering the city, however, the narrowness and darkness of the streets produce a mean effect, but ill corresponding with its magnificent exterior, although lined with palaces of vast and lofty dimensions, some entirely of marble, and all ornamented with marble portals, porticos, and columns. The interior of these mansions is no less magnificent. The staircases are of marble, and the long suites of spacious saloons opening into each other, are adorned with the richest marbles and tapestries, with valuable paintings, and gilded cornices and pannels. Of these, the most remarkable are those of the Doria, Durazzo, Balbi, and Serra families. The first of these (consecrated by the recollection of the restorer of his country's liberties,) is a beautiful specimen of the pure and simple stile of architecture, but in magnitude and splendor is far surpassed by the Durazzo palace, which, both in its materials and furniture, is superior to the abodes of most of the sovereigns of Europe.

The public buildings of Genoa are no less splendid than the abodes of her citizens; but the profusion of party-coloured marbles and gilding, which gives an air of wealth and grandeur to the palaces, is offensive to the eye of taste in churches and temples, where all unnecessary and gaudy ornaments detract from that simplicity which should always characterize such edifices. Of this description are the cathedral of St Laurence, the churches of the Annunciation, St Siro, and St Dominic. That of Santa Maria di Carignano is in a purer stile, and placed in a very commanding situation. It was built about the middle of the 16th century, at the expence of Bendinelli Sauli, a noble citizen of Genoa. The approach to this church is by a lofty bridge of three arches, about 90 feet high, across a deep dell, now a street. Genoa owes this building also to the munificence of the Sauli family. It was begun by the grandson, and finished in the years 1725, by the great-great-grandson of the founder of the church di Carignano.

The great hospital or infirmary is a magnificent building, which was formerly possessed of ample funds, dedicated to the relief of the sick or infirm of the poorer classes; but these and the funds of the Albergo dei Poveri, another charitable institution on the same grand scale, have been swallowed up by the exactions of the French armies, and the edifices remain as monuments of the munificence of former times, and serving only, like the city itself, to recal to the recollection of the traveller the days of the commercial greatness, the military glory, and the freedom of the republic.

The population of Genoa in the year 1766, amounted to 100,000, and in 1800 to 80,000. The suburbs of Bisagno and Polcevera were supposed to contain 20,000, and the total population of the Ligurian territory, 480,596. The ordinary military force of the state was about 3000; in the Spanish succession war, however, the contingent of the republic amounted to 10,000.

Commerce was always the favourite pursuit of the Genoese; and as it was considered by no means disgraceful for the nobles to become merchants, the bulk of the capital of the nation was invested in commercial speculations.

The exports from the Genoese territory consist chiefly of silks, fruits, oils, &c. There are also marble quarries of considerable value. The manufacture of velvet is at present the most extensive branch of Genoese trade. Velvets of every sort are made in the neighbourhood of Genoa, but principally black velvets; and it was computed that at one time 6000 workmen were employed in the manufacture. There is also a considerable manufacture of a coarse sort of paper, the most of which is exported to the Indies. It is to be presumed, that while under the dominion of France, the trade of Genoa, like the rest of the empire, must have suffered much during the late war; and the comparative poverty to which its late wealthy nobles have been reduced, together with the decay of public credit, and the failure of the bank of St George, render it improbable that it will ever regain its former state of prosperity.

From the barren nature of its territory, the articles imported into Genoa are very numerous. From France she is supplied with wine; from Italy, with corn, cattle, fuel, &c.; from Germany and Switzerland, linen; from England, woollen cloths; from Holland, spiceries; from Sweden with wood, iron, and copper; from Russia with furs and hides; and from Spain and Portugal with dressed leather, bullion, and American produce.

The earliest mention in history of Genoa, is in the year 241 B. C. when it is described as one of the principal cities of the Ligurians, at that time defending themselves against the encroachments of the Romans, a struggle which they maintained for more than 80 years. It was then erected by the Romans into a municipal city; and continuing faithful to that republic during the Punic wars, was destroyed by Mago, the Carthagenian general, in the year 205 B. C. It was, however, soon rebuilt, and, from the advantages of its situation, and the enterprizing spirit of its inhabitants, appears to have early acquired such a degree of importance, as to be stiled by Strabo, *Emporium totius Liguriæ*.

After the ruin of the Roman empire, Genoa, separated by its mountains from the rest of the world, long maintained its connection with the Grecian emperors; and although for a short period successively under the power of the Lombards, Franks, and Saracens, soon expelled its invaders, and before the end of the 10th century, had established a free constitution resembling in its form the Roman republic. The government, however, as in the other Italian cities, was far from being fixed or stable; and for a long series of ages, the history of Genoa presents little else at home but a continuation of struggles between the nobility and the people. Frequently too, the latter, worn out by the vexatious oppressions of the nobles, threw themselves under the protection of some foreign prince, choosing rather the impartial dominion of a distant sovereign, than the name of liberty and real subjection to a haughty and tyrannical oligarchy. For a more particular account of these revolutions, see the article Italy. But tedious and uninteresting as the relation of the struggles of the Genoese factions may be, the history of its external transactions gives us a high idea of the enterprizing greatness of the republic. In the year 1050, the Genoese forces, united with those of Pisa, achieved the conquest of the island of Sardinia, at that time under the possession of the Moors.

In 1100, in conjunction with Venice and Pisa, they sent to the assistance of the crusaders a fleet of 28 galleys, and six vessels, and a body of troops commanded by one of their consuls, who, after a short siege, took by assault the city of Cesarea. The republics of Pisa and Genoa were soon after engaged, by a mutual jealousy, in a bloody war, which lasted, with various success, for many years, till put an end to in the year 1162, by the interposition of the Emperor Frederick Barbarossa. But this peace was of no long duration; and in two years the war was again renewed from a quarrel between the vassals of the two republics in Sardinia. In 1190, however, we find them both arming a fleet to assist the Emperor Henry VI. in an unsuccessful enterprise to recover the crown of Sicily.

In the succeeding century, a much wider field was opened for the restless and enterprizing spirit of the Genoese. The Venetians having, with the other crusaders, dethroned the Greciam Emperor, received, as their share of the spoil, one fourth and a half of the empire, in which were included all the maritime parts of Greece, with the island of Crete or Candia, and most of the islands of the Archipelago. Unable, however, to colonize their conquests, many of them were left unoccupied, a circumstance which the Genoese did not fail to take advantage of. Their first attempts to obtain settlements in Candia, the Morea and Corfu, were conducted by a private individual, and the Venetians soon succeeded in expelling them.

About this period also, having warmly engaged on the side of the Pope, their fleet sustained a signal defeat from the united forces of the Pisans and Neapolitans, of 27 galleys, three being sunk, and 19 taken. Undismayed by this reverse, they still continued in the papal interest, until 1261, when, having engaged in a long and bloody war with Venice about their possessions in Palestine, they entered into a strict alliance with Michael Paleologus, and bound themselves to assist him against the Venetians, French, and the other crusaders. In this war they were successful; and on Michael's regaining the throne of Constantinople, obtained from him the grant of many commercial privileges, with the isle of Chios in the Archipelago.

Shortly afterwards, a fresh war broke out with Pisa, on account of their Corsican possessions; and large fleets being armed on both sides, continued for some time inactive, until the year 1284, when the Genoese, under the command of Oberto Doria, completely destroyed the Pisan fleet, of above 100 sail, commanded by Alberto Morosini, at Meloria. In this battle, the Pisans lost 5000 men, besides 11,000 prisoners, whom the Genoese retained for 16 years in captivity.

In 1298, commanded by another Doria, they obtained a signal victory over the Venetians at Corzola, which for a time put an end to the war. Their mutual jealousy, however, still continued; and, in 1306, the Venetians having embraced the interests of Charles of Valois, and the Genoese that of the Grecian Emperor Andronicus, the war broke out with fresh vigour. It was also about this time that civil dissensions arose at Genoa between the nobles and the people, which terminated in 1339 in the elevation of Simon Boccanigra, to the dignity of Doge, under whose vigorous administration the republic at length enjoyed a season of tranquillity.

The Genoese had now obtained many valuable settlements in the Grecian empire, and had extended their commercial relation with the Russians and the north of Europe: they possessed the colonies of Kaffa and Tana in the Crimea, and of Pera and Galata near Constantinople, which served as a depot for the merchandize brought by them from India, Armenia, Egypt, and Arabia.

Their riches and power now began to excite the envy and avidity of Cantacusenus, the Emperor of Constantinople, whom they soon overcame, but to whom they granted peace on moderate terms. With the Venetians they were not so successful, and the war continued with great obstinacy and various success for many years. At one time the Genoese, discouraged by the signal defeat of their Admiral Grimaldi, threw themselves under the protection of John Visconti, Archbishop of Milan. Some time after his death, however, in the year 1356, they threw off the yoke of his cruel and tyrannical nephews, and reasserted their liberty.

On the other hand, in the year 1379, the Genoese reduced the Venetians to the last extremity; took the fort of Chiozza, and nearly made themselves masters of Venice.

At length, in 1381, the peace of Turin put an end to the war. In it the Venetians lost their continental possessions, and the greater part of their wealth. Nor was it less fatal to the victorious Genoese. Deprived of their best fleet and the flower of their sailors, and the finances of the republic exhausted by the length of the war, they were again forced to throw themselves under the power of a foreign master, and submit to the authority of Charles VI. king of France, and afterwards of the Dukes of Milan; a slavery under which they continued for more than a century, notwithstanding many ineffectual attempts to recover their liberty. At last, in 1528, Andrew Doria having expelled the French, restored the ancient form of government and freedom to his country;—a rare instance of disinterested patriotism, as, supported by his fleet and the powerful assistance of the Emperor Charles V. he might easily have retained possession of the sovereign power, and have even been aided by the people, to whom his liberality and military virtues had justly endeared him. See Doria.

After this period, the republic, although deprived of its former conquests, for a long time enjoyed, with liberty, peace and prosperity.

In 1624, it was engaged for a short time in a war with France and Savoy; and in 1636, the city was unsuccessfully attempted to be surprised by the Spaniards; but these wars were of no long duration.

In 1684, having incurred the displeasure of Louis XIV. the republic was attacked by that monarch, and obliged to give up the island of Corsica, and to submit to other terms peculiarly mortifying and degrading; the Doge and four of his counsellors being forced to appear in person at Versailles to sue for peace, and the state bound to disarm all their gallies except six, with a promise not to fit out more without the consent of the king.

During the remainder of the 17th and the early part of the 18th century, the republic continued to observe a strict neutrality; but in the war which broke out in 1743, having joined the French and Spaniards against the Austrians, Savona and other Genoese ports were bombarded by the English fleet, and the city, in 1746, obliged to capitulate to the Austrian army. The people, however, soon expelled their invaders, even without the concurrence of the senate; and in 1748, the peace of Aix-la-Chapelle again restored to the state tranquillity.

In 1798, by the ascendancy of the French, the ancient form of government was abolished, and one resembling the French constitution adopted, under the name of the Ligurian Republic. The following year, General Massena's lines in the neighbourhood of Genoa being forced by the Austrians, he was obliged to throw himself into the city, which was besieged for some time, and suffered considerably. By the treaty of Campo Formio in 1801, between the Austrians and French, the Ligurian republic's independence was acknowledged; but it continued under the power of France, and might actually be considered as a part of that empire. The British having made themselves masters of Savona, blockaded Genoa, which in 1814 surrendered to Lord William Bentinck, who issued a proclamation, holding out some hopes to the Genoese that their liberties should be restored. It was however determined, at the congress of Vienna, that the territory of Genoa should be united to Savoy and Piedmont. It was accordingly, in 1815, given up by the British to the troops of the King of Sardinia, and may now be considered as an integral part of that monarchy. See Sismondi's *Histoire des Republiques Italiennes;* Accinelli's *Revolutions of Genoa;* Eustace's *Classical Tour through Italy,* &c. (E. J.)

GENTOOS. See Braumins and India.

GEOGRAPHY.

Geography. Definition.

The term Geography, is derived from two Greek words, *γη the earth*, and *γραφω I write*, and in its original acceptation signifies *a description of the earth*. In the progress of science, however, its meaning has become gradually more extended, and it is now taken to denote, not merely an account of the divisions, produce, inhabitants, &c. of the earth taken as one whole, but also the explanation of various phenomena arising from its relation to other bodies of the solar system. It was indeed from discoveries respecting the heavenly bodies, that men first derived correct notions with regard to the figure and magnitude of their own planet; and it is only by the application of astronomical principles, that the apparently simplest of all geographical problems can yet be solved,—that of accurately measuring, or distinctly expressing, the distance between two points on the surface of the earth. Astronomy and geography have thus become intimately connected, not as two sciences which have merely a certain affinity to each other, and which philosophers, from a wish to generalize and simplify the subjects of their investigation, have thought proper to combine, but because the latter separated from the former ceases to be a science. It is not merely for the language of geography that we are indebted to astronomy. It is from the same source, that we derive the method of constructing a correct representation of the globe, determining the relative position of different places on its surface, and exhibiting a familiar view of the various changes that are continually taking place in its position and outward circumstances.

General division of Geography. Mathematical.

In a system of geography, therefore, it is necessary, in the first place, to consider the earth as a part of the solar system; to illustrate, from astronomical principles, its figure, magnitude, and motion; to explain the construction of the globes, with their application to the solution of problems; and describe the various methods of projecting maps and charts. This constitutes what is properly called *Mathematical Geography*. The geographer may then proceed to consider the globe as one whole, and examine its internal structure; the natural divisions and inequalities of its surface; the phenomena of tides and currents; the modifications of its atmosphere with regard to weight, temperature, humidity, and motion, with other natural appearances usually included under *Physical Geography*.

Physical.

And, in the last place, he may view it as the habitation of animated and rational beings, divided into different kingdoms and states, and exhibiting various monuments of human industry and skill. This forms what may be called *Political Geography*.

Political. Object of the present article.

In the following article, we shall confine ourselves to the first of these, leaving physical geography to be discussed under Physical *Geography*, Meteorology, Mineralogy, &c.; and political geography under the names of the respective countries, and other articles, where they will be treated more fully, and with greater propriety, than they could possibly be in the present article. Before entering on the subject, however, it may be proper to take a short view of the origin and progress of geographical discoveries.

History of geographical discoveries.

In a rude state of society, it seems to have been the universal opinion, that the earth was a large circular plane or disc, every nation supposing itself to be placed in the centre. Of the unexplored parts of this plane, various fanciful and absurd opinions were entertained.

History. Geography of the early Greeks fanciful and absurd.

The early Greeks, for example, imagined, that in the immense expanse of the ocean numerous islands were scattered up and down, inhabited by giants, pigmies, and a vast variety of other beings, which never existed but in the extravagant dreams of a fertile and untutored imagination; while the extreme verge of the disc terminated in a chaotic gulf of unknown extent, and impenetrable darkness. The difficulties and dangers which travellers and navigators at first encountered, in attempting to pass the limits of their own country, and which they were on all occasions disposed to magnify, served rather to confirm than refute these erroneous notions. This remark is strikingly exemplified in the case of the Phœnicians, who, as early as a thousand years before the birth of Christ, had navigated the whole of the Mediterranean from the eastern extremity to the Atlantic Ocean, and had founded the colonies of Utica, Carthage, and Gades. That bold and enterprising people, anxious to reap the whole advantages of their discoveries, were careful in concealing the success of their adventures, but took all possible pains to magnify the dangers and difficulties which they had encountered. Accordingly we find, that long after this period the Greeks still regarded the islands in the western part of the Mediterranean, and even Sicily, as the habitations of monsters, and the scenes of enchantment. Nor did the discovery of their error in one instance, lead them to suspect the accuracy of their opinions in general. So firmly indeed were they persuaded of the truth of that system, which the writings of their poets, and particularly of Homer, had rendered in some measure sacred, that they no sooner became acquainted with a new region, than they immediately transported to more distant islands those fanciful beings, which they had at first erroneously supposed to be inhabitants of places less remote.

Drawn from the writings of Homer.

Common to all rude nations.

Even in later times, when the true figure of the earth was understood, the notions of the ancient Greeks, which were perhaps common to all nations in similar circumstances, continued to pervade the writings of travellers, navigators, and historians, and thus prejudice tended to suppress that spirit of curiosity and adventure, which the discoveries of science might otherwise have inspired. No motive perhaps less powerful than avarice, could induce men to engage in an expedition in defiance of difficulties and dangers, against which they were taught to believe, that human strength and human prudence were equally unavailing; and when such expeditions were undertaken, it would generally be by men little qualified, and still less disposed to communicate correct and interesting information to their less adventurous brethren. In such circumstances, it does not appear at all surprising, that so many ages should have elapsed, before any very extensive or regular intercourse was established between different countries.

Geography of the Hebrews. B. C. 1700.

The first authentic account that we have of any considerable portion of the earth's surface, is derived from the writings of Moses. The object of that writer, indeed, was not to teach men a system of geography; and therefore the information which he affords, regards the earth considered rather as the habitation of moral beings, than as the subject of physical research. We

History.

learn, however, from his writings, that, 1700 years before Christ, a commercial intercourse subsisted between the Midianites, who inhabited the country on the northern extremity of the Persian Gulf, and Egypt, by way of Palestine. From that period, till within 500 years of the Christian era, the Hebrew writings make frequent allusions to the commerce of eastern countries, and it is probable that the Phœnicians were at this time acquainted with many countries, particularly to the west, of which history makes no mention. The geography of the Hebrews themselves, however, does not appear to have extended, at this period, beyond Mount Caucasus to the north, the entrance of the Red Sea to the south, and the Archipelago to the west, including the countries of Asia Minor, Armenia, Assyria, and Arabia in Asia, with Egypt, and a little of Abyssinia in Africa.

Limits of the geography of the Hebrews. B. C. 500.

The Greeks, about the same period, reckoning Delphi the centre of the habitable world, were acquainted with little more than the country included under the name Greece, together with the islands in the Archipelago, the western part of Asia Minor, the sea-coast of Egypt and Lybia in Africa, and a little of the south of Italy. Beyond this circle all was involved in darkness and conjecture.

Geography of the Greeks. B. C. 500.

With regard to the Egyptians, with whom it has been supposed that the science of geography originated, there are no authenticated facts to show, that they had ever been distinguished for enterprise or adventure, previous to the period of which we are speaking, still less that they had ever led the way in geographical discoveries. From the peculiar circumstances of their situation, they must have been obliged, at an early period, to apply themselves to topography, as they did to geometry; but there is every reason to believe that, for their knowledge of foreign countries, they were indebted to the Phœnicians and others, who visited them for the purpose of commerce.

Claims of the Egyptians to the origin of geography

Such was the condition of the most enlightened nations of the world with regard to geographical knowledge, at the commencement of the fifth century, before the birth of Christ. In the course of the next seventy years, however, many interesting and important discoveries were made by the Greeks. Colonies of that people, either driven from their native country by intestine commotion, or induced by the prospect of wealth to go in quest of new settlements, successively established themselves in Sicily, Sardinia, Corsica, and even some of the southern provinces of Spain. For their success in these enterprises, they are said to have been greatly indebted to the geographical and nautical charts which they contrived to obtain from the Phœnicians, and which, with the sphere alleged to have been constructed by Anaximander the Milesian, and disciple of Thales, were the first attempts of which we have any authentic information, towards delineating the whole, or any considerable portion of the earth's surface. But whatever might have been the merits of Anaximander's globe, or of the Phœnician maps, it is certain that the Greeks had not borrowed from either, any correct notions with regard to the figure of the earth. It was reserved for Herodotus to contradict, from his own personal observations, the idea of the habitable world being a circular plane, surrounded by the *river Ocean*. This distinguished writer, who has been styled the father of history, and who, as an attentive and intelligent traveller, has never been surpassed, perhaps seldom equalled by any, either in ancient or modern times, was a native of Halicarnassus, in lesser Asia. Imbibing, in all probability, that spirit of commercial enterprise for which his countrymen were distinguished, and possessing confidence in himself sufficient to raise him above vulgar prejudices, and opinions not founded in facts, he pushed his researches into many countries, which till that time had never been explored. He visited the Greek colonies on the Black Sea, and measured the extent of the latter from the Bosphorus and the mouth of the Phasis at the eastern extremity. He traversed the country between the Borysthenes and Hypanis, now a part of southern Russia, explored the coasts of the Palus Mœotis, (sea of Azof) and obtained correct information with regard to the situation and extent of the Caspian Sea. He visited Babylon and Suza, and was well acquainted with the greater part of the Persian monarchy. He travelled through the whole of Egypt, where he obtained a great deal of interesting information respecting the caravans from the interior of Africa, and also visited the Grecian colonies of Cyrene. From his description of the straits of Thermopylæ, it is obvious that he had been in Greece, and he traced the course of the Ister (Danube,) from its mouth almost to its source. He terminated this career of discovery and adventure, as useful to others as honourable to himself, in the southern part of Italy, where it is also supposed that he finished his much admired history.

The Greeks colonize the islands in the Mediterranean and part of Spain. B. C. 500 to 430.

First artificial sphere constructed by Anaximander. B. C. 568.

Discoveries of Herodotus. B. C. 484 to 413.

History.

In estimating the extent of the geographical information furnished by Herodotus, we are by no means to limit it to the circle which he described, and which we have just traced out. Possessing in an eminent degree those qualifications which distinguish the intelligent traveller from the mere tourist, he was enabled to collect much valuable information respecting countries which he had no opportunity of visiting; and the accounts which he gives of these countries have been confirmed by the most unquestionable of all evidence, the striking similarity in the characteristic features of their ancient and modern inhabitants. Viewing it in this light, the geography of Herodotus extended to the greater part of Poland and European Russia, western Tartary, the country on the Indus from its source to the confines of the Cashmere, Arabia, and the northern parts of Africa. He sometimes mentions Carthage, and gives an account of a traffic carried on without the intervention of language, between the Carthaginians and a nation beyond the Pillars of Hercules, which has been considered as applicable to that of Senegambia. There is nothing explicit, however, in the text of Herodotus, with regard either to the name or the situation of the country.

Limits of the geogr phy of H rodotus.

Before concluding this short review of the travels of our author, it may not be improper to notice the information which he gives, or is supposed to give, on three subjects, which still continue to agitate the scientific world, we mean the Niger, the Nile, and the pretended circumnavigation of Africa by the Phœnicians. With regard to the Niger, the only passage in Herodotus that can possibly allude to this river, is the account which he gives on the authority of Etearchus, king of the Ammonians, of a journey into the interior of Africa, undertaken by five young Nasamons, a people situated at the extremity of the Gulf of Sydra. These travellers having, in the first part of their journey, passed through an inhabited country, came to an immense sandy desert, through which they continued their route westward, till they reached an extensive plain covered with vegetation. While they were enjoying the shade, and eating the fruit of the trees which they found there, they were fallen upon by men of a very diminutive size, who conducted them across a swampy country, till they came to a town inhabited by black people,

His accou of the Ni ger.

History.

and situated on the bank of a large river, running from west to east. Though the vague and indefinite nature of the account itself, the authority on which it rests, and the circumstance of its being obviously introduced for the purpose of proving that the Nile runs from the west, tend to throw considerable doubts on the truth, or at least the accuracy of this relation, yet some eminent geographers are of opinion, that the town mentioned above is no other than Tombuctoo on the banks of the Niger.

Of the Nile.

Of the Nile, Herodotus speaks with more precision; and, as his information on the subject appears to have been derived from personal observation, it is on this account entitled to more credit. After detailing at some length the manner of ascending the river, and describing minutely the nature and inhabitants of the countries through which it passes before entering Egypt, he concludes by affirming that it certainly runs from the west, though he acknowledges that beyond the country of the Automoles it had never been explored. The Automoles, otherwise called Asmach, were originally descended from a colony of Egyptian fugitives, but, at the time of Herodotus, inhabited a province subject to the king of Ethiopia, and lying as far to the south of his capital Meroe, as Meroe was from the great cataract. According to Eratosthenes, and other ancient geographers, this town was situated on an island formed by the junction of the Atbar or Tacazze with the Nile; and this account is farther confirmed by the testimony of Mr Bruce, who discovered magnificent ruins to the north of Chandi, opposite the island of Kurgos. If this opinion be correct, it fixes the situation of Meroe in 17 degrees of north latitude, about 6 degrees south of the cataract, and 6 north of the Automoles. Herodotus, therefore, must have been acquainted with the course of the *western* branch of the Nile, as far as the *eleventh* parallel; and of its course beyond this, no subsequent traveller has yet given any satisfactory information.

Of the circumnavigation of Africa by the Phœnicians. B. C. 604.

With regard to the circumnavigation of Africa by the Phœnicians, Herodotus relates the story apparently as he received it, without determining any thing as to its being true or false. When Neco king of Egypt had completed his famous canal between the Nile and the Arabian gulf, he dispatched vessels manned with Phœnician sailors, who, after navigating the ocean to the south of the Red Sea, were to return to Egypt by the pillars of Hercules and the Mediterranean. This they are said to have accomplished in less than three years, including their stay on the coast of Africa, while they sowed and reaped a crop of corn. On their return, they related among other wonders, that in sailing round Lybia, the sun appeared to be on their right. "This," says Herodotus, "appears to me altogether incredible, but it may not perhaps appear so to others." On this passage it has been remarked by those, who are disposed to admit the truth of the circumnavigation in question, that the very circumstance which the historian rejects as incredible, is one of the strongest arguments possible in favour of the tradition. The truth of this remark is too obvious to be disputed, and we are ready to admit the full force of the argument which it affords. At the same time we cannot by any means consider it as decisive. The Phœnicians we think might have sailed far enough to the south in the Indian Ocean to have observed the phenomenon of the sun to the north of the zenith, though they had never attempted, far less executed the circumnavigation of Africa; and we cannot avoid observing in passing, that they who are disposed on all occasions to magnify the discoveries, and exalt the merits of the ancients, would do well to be on their guard, lest they pull down with one hand what they have taken pains to erect with the other. May not the incredulity expressed by Herodotus with regard to the position of the sun, be brought forward with some plausibility, as presumptive evidence against the commonly received opinion with regard to the extent of his own travels up the Nile? It is difficult to conceive how he could possibly have advanced so far as to the eleventh parallel of latitude without having heard at least of the sun being observed towards the north. To say that such a journey as this would never be undertaken while the sun was advancing towards the tropic of Cancer, on account of the overflowing of the Nile, is hardly a satisfactory solution of the difficulty.

Discoveries of the Carthaginians.

It has already been observed, that before the time of Herodotus, the Carthaginians had established a commercial intercourse with some of the nations on the western coast of Africa, though it is not exactly known when this intercourse began, or how far it extended. There is reason, however, to believe, that the voyage of Hanno, which some say reached to the mouth of the Senegal, was not earlier than the end of the fifth, or beginning of the fourth century before Christ, and that it was about the same time that the Carthaginians first became acquainted with the Canaries, the northern provinces of Spain, and the British islands. The latter, indeed, had in all probability been visited at a much earlier period by the Phœnicians, who carried on a lucrative trade in *tin* with the inhabitants of Cornwall.

Hanno. B. C. 430.

During this same period, the Greeks continued to cultivate geography with ardour and success. Hippocrates, the celebrated physician of Cos, retracing the footsteps of Herodotus, and sometimes penetrating beyond his predecessor, collected many valuable observations on the temperature and humidity of different climates as affecting the human constitution, and may perhaps be justly styled the father of physical geography. The subject in all its bearings wanted only to be reduced to a regular and systematic form, to be placed on a footing with the other sciences, and fortunately the execution of this task fell to one who of all men perhaps was the best qualified to do it justice. Aristotle directing towards it the energies of his powerful mind, stamped a value on the discoveries and observations of others, which till his time they had never possessed. He collected and combined the whole of these facts into one system of geographical knowledge, deduced from them the spherical figure of the earth, (the fundamental principle of all geography), and in this simple form put the science, along with others, into the hand of his royal pupil, to smooth the march of conquest, and make some reparation for the violated liberties of mankind.

Hippocrates. B. C. 420.

Aristotle. B. C. 340.

Discoveries of Alexander and his followers. B. C. 333.

The expedition of Alexander constitutes an era in the history of ancient geography. As eager to be thought the patron of science as the conqueror of the world, he was careful on all occasions to blend the two characters, and judiciously left to posterity an accurate geographical account of his expeditions, as the most durable monument of his military glory. His successors indeed, however anxious they were to imitate him in other respects, did not shew the same predilection for literary fame. But from the school which he established in Alexandria, the light of science continued to emanate with increasing splendour; and even to one of his generals, Seleucus Nicanor, who carried his victo-

History.

Seleucus explores India. B. C. 312 to 291.

rious arms from the Indus, where Alexander's expedition terminated, to the mouth of the Ganges, geography was not a little indebted. His ambassadors Megasthenes and Daimachus, who were sent to Palibothra, the capital of a large kingdom on the Ganges, and thought to be the Allahabad, or according to others, Baliputra of modern India, collected a great deal of important information with regard to the natural history of the country, as well as the manners of the inhabitants. The spirit of commercial enterprise, which prevailed particularly in Greece during the century after Alexander's death, served not only to keep up a constant intercourse with the countries thus discovered, but also to extend the boundaries of geography to others before unknown. The Grecian kings of Egypt carried on a regular trade with India and Taprobane (Ceylon), while the Carthaginians extended their commerce along the western coast, as well as into the interior of Africa.

Expeditions of the Romans. B. C. 264 to 146.

The Romans also, having obtained possession of all Italy, began to aspire after foreign conquest. Their expeditions against Carthage made them acquainted with Africa, and what was of still greater consequence, taught them the construction and management of ships. In the Macedonian war they acquired a knowledge of Greece, and rendered themselves formidable in Asia Minor by the defeat of Antiochus. Their subsequent conquests were still more important in a geographical point of view. Julius Cæsar gave the earliest and the most accurate account of the interior of Gaul and the south of Britain, Germanicus penetrated as far as the Elbe, and Elius Gallus traversed the interior of Arabia.

Julius Cæsar. B. C. 50.

Thus by the commencement of the Christian æra, geography had received a vast accession, not merely in extent, but in point of accuracy. Countries that had only been heard of from the casual visit of a solitary traveller, or misrepresented by the selfish policy of the avaricious trader, were now familiarly known, from the march of victorious armies, whose leaders were as anxious to describe as to conquer, and by a happy combination of events, a Strabo arose to transmit an account of all these discoveries to posterity.

Strabo. B. C. 30.

Limits of his geography.

Of the elegant and learned work of this celebrated writer, we cannot pretend to give any thing like an analysis, ; and indeed no analysis could do it justice. We have only to observe, that the portion of the globe which he describes is bounded on the north by the Baltic, towards the east by the Ganges, and on the south nearly by the line joining the mouth of that river with the mouth of the Senegal. Of course his description of all the countries contained within these limits cannot be equally minute, nor is he always accurate in his delineation of those that were more perfectly known. He is frequently mistaken with regard to the situation of particular places, the course of rivers, and the direction of chains of mountains. These, however, are errors which will readily be overlooked, when we consider the period at which the work was composed, a period when the traveller had to struggle with difficulties in all inland expeditions, and the geographer laboured under disadvantages from the want or the imperfection of instruments, of which moderns can hardly form an idea.

Thule of the ancients according to Pytheas.

The only other subject which we would notice as connected with this period of ancient geography, is the situation of the much disputed Thule. Pytheas, a navigator of Marseilles, who lived a short time before Alexander the Great, after having explored the east, or as he thought the north east coast of Britain, continued his voyage, as he says, to the north, that is to the north-east, and after six days fell in with land which he calls Thule or Thyle, and which he states to be 46,300 stadia from the equator. The situation of this place has long been a disputed point both with ancient and modern writers, and the difficulty arises from not knowing, in the first place, which of the ancient stadia is here meant, and secondly, what was the precise length of the stadium. The different kinds of stadia in use among the ancients, are generally reduced, by modern geographers, to four, but the respective lengths of these have by no means been accurately determined. Without, however, entering into a detail of the various opinions which have been entertained on the subject, we shall merely state that of an eminent writer, which is perhaps as accurate as any other. This author (M. Gosselin) supposes, that of the longest stadia $666\frac{2}{3}$ were equal to one degree of the equator, of the second kind 700, of the third $833\frac{1}{3}$, and of the fourth or Egyptian $1111\frac{1}{9}$. Applying these different measures successively to Pytheas's account, we shall have for the latitude of Thule 69° 27′; 66° 8′; 55° 34′, and 41° 40′. Of these results the third appears to be the most probable, as it determines Thule to be on the west coast of Jutland, and as it is to Jutland only that Pytheas' description can at all apply. He says, for example, that there the sea, the earth, and the air, seem to be confounded in one element; a description strikingly applicable to the downs of Jutland, where the sand is frequently driven about with violent winds, and being scattered over the surface of the marshes, conceals from the unwary traveller the gulf beneath. His account of the produce of the country is equally applicable; and the whole is rendered more probable, from there being in Jutland, about a degree farther north than the situation of Thule, as now determined, a part of the coast still denominated Thy or Thyland, and in the ancient language of Scandinavia, Thiuland. Other arguments might be urged in favour of this opinion, notwithstanding the scepticism of Strabo, and other ancient geographers; but more, perhaps, has already been said on the subject than is consistent with the nature of our plan. See Foulah.

Supposed to be Jutland.

Circumstances that retarded the progress of geographical discovery after the commencement of the Christian æra.

For some time after the commencement of the Christian era, the progress of geographical discovery was neither rapid nor very extensive. The Romans had by this time, indeed, subdued the greater part of the known world, and had consequently a great deal in their power with regard to the advancement of science. But their attention was directed more to what they already knew, than what they might still have to discover. They soon began to perceive that conquests were more easily made than retained, and that, by attempting to gain more, they might eventually lose what they already possessed. They had therefore no longer any inducement to extend their researches into foreign countries for the purpose of conquest, scarcely even for military renown; and thus geography was deprived of the aid which it had formerly derived from a spirit of military adventure, and to which, more than any other circumstance, perhaps, it was indebted for its success. Nor had the Romans the same temptation as formerly to explore unknown regions, for the purpose of commerce. Asia continued long to supply them in abundance with every luxury which they could desire, through the ordinary channel; and while that supply kept pace with the demand, it was not to be expected that they would give themselves much trouble either about discovering new countries, or exploring new channels of communication with such as were already known to them. Add to all this, that geographical discovery was approaching that point when its farther extension could only be looked for in the event of some new and important improvement in the art of navigation, or some discovery in those sciences on which it chiefly depends. But though these circumstances were sufficient to prevent the Romans from extending in any great degree the sphere of geographical knowledge, they were by no means inattentive to the cultivation of the science in general. The civil and military establishments which they were obliged to maintain in all the conquered provinces, and the security which trade enjoyed under a regular and efficient government, gave rise to a closer and more regular intercourse among all the countries which composed the empire, than had ever been known at any former period. Were we indeed to point out the limits of Roman geography, we should probably not include a much greater extent than has been already assigned to that of Strabo. But in point of accuracy and minute detail, the difference is considerably in favour of the former. They were well acquainted with all the countries on the Danube and the Vistula, nor was the Rha or Wolga unknown to them, though sometimes confounded with the Tanais or Don. Of the intermediate space containing Scythia, Sarmatia, and Dacia, we have accounts from various Roman writers, though it is obvious that in many things they follow Herodotus. Their knowledge of the countries on the southern coasts of the Baltic, as well as Jutland, then called Cimbria Chersonesus, was tolerably accurate with regard to situation and extent; but the origin and names of the different nations were by no means well ascertained, and notwithstanding the labours of modern geographers and critics, they are still involved in darkness and confusion. The Romans little thought, in the meridian of their glory, that they were ultimately to fall a sacrifice to the ravages of nations so barbarous as to be without the limits of the civilized world, and so rude as to be incapable of communicating to others any account of their own origin or early history. Of the countries to the north of the Baltic, the Romans knew comparatively little. The southern part of Sweden was denominated Scandia, and was considered as an island of unknown extent. It seems, indeed, to have been the general opinion, that the Baltic was part of the northern ocean, containing an archipelago of large islands, and it may perhaps be inferred from this opinion, that their geographical knowledge, in this direction, did not extend beyond the large lakes in the south of Sweden, and the entrance of the gulf of Bothnia. Proceeding westward, the next country we meet with in the geography of the Romans is Britain, of which we have a very minute account, comprehending not only the mainland of England and Scotland, but also Ireland, the Isle of Man, the Western Islands, and the Orknies. Ptolemy speaks of Thule as situated to the north-east of Britain, by which he has been understood as meaning one of the Shetland islands. It cannot, however, be inferred from this, that the Romans were really acquainted with these islands. Of Gaul and the other western countries of Europe, it is hardly necessary to take any notice, the Roman accounts of these being familiar to every body.

From the west of Europe we naturally pass to Africa, and we find that the Romans were acquainted with about one-third of that continent. Pliny, from a statement by Agrippa, estimates the breadth from north to south, through Cyrenaïca and the country of the Garamantes, that is from Barca towards Bournu, at 910 Roman miles, a distance from the Mediterranean which falls considerably short of the Niger. It appears, however, that they were not altogether ignorant of that river in another direction. Pliny, on the authority of Juba, king of Mauritania, mentions that the Nile rises from a lake in the interior of that country, and that, after running under ground through a desert of twenty days journey in extent, it makes its appearance again on the confines of Ethiopia, where its source is called Nigris. From this modern geographers have concluded, that the desert here mentioned is the great desert of Sahara, that what Pliny calls the Nile is only a small river running along the south side of Mount Atlas, and that its pretended reappearance is no other than the source of the Niger or Joliba. In this our readers will recognise the opinion of Herodotus, expressed in a more detailed form, that the Niger and the Nile are the same river, and they will also observe, that the Roman geographers, in the time of Pliny, were not better acquainted with the western part of Africa, than their rivals the Carthaginians had been. Ptolemy, indeed, distinctly mentions the Niger, and enumerates some of the towns situated on its banks, as Tucabath, Nigira, Ta-Gana and Panagra, in which later geographers have discovered the modern towns of Tombuctoo, Cashnah, Ganah, and Wangara; but even his account of the interior is very partial and indistinct. Of the Canaries, the Romans undoubtedly knew more than the Carthaginians, though these islands were still regarded too much as the region of fiction. They were called in general the *Fortunate Isles,* a name famous with the poets, and perhaps too frequently employed in the more sober details of the historian. Among the particular names, we find Canaria and Nivaria, the former obviously the same with modern Canary, the latter, perhaps, denoting Teneriffe with its snowy summit. On the eastern side of Africa, the geography of the Romans was neither very distinct nor very extensive. They seem to have been acquainted with the Nile, as far as the Automales of Herodotus, but not to have penetrated farther. On the shores of the Indian ocean, their navigation terminated at the promontory of Prasum, a point which Ptolemy represents as lying to the south of the equator, but which, from a careful investigation of the measures employed by him, is found to correspond with Cape Brava, two degrees to the north of the line.

When we turn to Asia, we find the geographical improvements of the Romans much more interesting in a scientific point of view, as well as more important in regard to commerce. These improvements may be almost wholly ascribed to the discovery of the monsoons, by which the communication with India was completely altered, and the trade of that rich and luxurious country prodigiously extended. Embarking at the Egyptian ports on the Red Sea, and passing the straits of Babel-mandel, the merchant was carried by the south-west monsoon, or Hippalus, so called from its discoverer, directly to the peninsula of Hindostan, and back again by the Vulturnus, or north-east monsoon, in the course of the same year. This navigation was first undertaken during the reign of Augustus, till which time the route to India was either across the desert from Syria to the Euphrates, down the Persian gulf and along the northern coast of the Arabian sea to the mouth of the Indus; or farther to the north by the Caspian sea, and the Oxus or Jihon. Some ancient writers represent the latter as much more easily accomplished than it could possibly have been, by supposing that the Oxus fell into the Caspian Sea, or rather that Lake Aral was a gulf of that sea. But even if this had been the case, the conveyance of merchandise by such

The Niger.

The Canary islands.

The Nile.

In Asia.

Discovery of the monsoons in the reign of Augustus.

History.

a route, must have been exceedingly slow, expensive, and precarious, compared with the direct course across the Arabian Sea. By the latter, also, the western coast of the peninsula of India became better known, and opened the way for other discoveries in the interior as well as on the Bay of Bengal. The whole extent of country south of the line joining the mouth of the Indus and the mouth of the Ganges, was soon explored, and is described with considerable minuteness by Pliny and Ptolemy. Of the north of India, the accounts of these writers are extremely vague; but it appears that Thibet was pretty well known under the name of Serica. On this subject, indeed, there has been much learned disquisition among critics and geographers, some supposing, as we have now stated, that Serica included Thibet, with part of the north of India, while others consider it as denoting China. This last opinion is chiefly founded on the calculations of Ptolemy, by which Serica appears to be situated in the middle of the Pacific Ocean; but these calculations are obviously in direct contradiction, not only to Pliny, but to Ptolemy himself. According to the former, Asia terminated a little to the east of the Ganges and the north of the Caspian Sea; and he distinctly says that the Seres inhabit the middle of the eastern regions, of which the Scythians and Indians occupy the two extremes. The latter also describes Serica as bounded on the east by unexplored countries, and on the south by the mountains of Emondus, (the modern Emod, Hema, or Himmala), which separate it from India. It is unnecessary to observe, that neither of these accounts can possibly apply to China, while both are accurate if understood of Thibet. "Here, then," to use the words of a modern geographer, "among the Alps of Asia, and on the borders of the great desert of Shamo, expired the last ray of the geographical knowledge of the ancients."

Geography of Pliny and Ptolemy. A. D. 100 to 140.

A. D. 140 to 650.

To pursue the history of geography through the period on which we are now about to enter, would be to trace the decay of every thing dignified and ennobling, and to mark the progress of ignorance and barbarism, triumphing over science and civilization. We should find, in the course of a few centuries, the inhabitants of the whole civilized world completely extirpated, and succeeded by a race of men who knew nothing of themselves farther back than their recollection carried them, and nothing of the rest of mankind but what they learned during their career of victory and bloodshed. We should perceive the termination of all friendly intercourse among different countries, and wars carried on no longer with a view to conquer and civilize, but to extirpate and destroy. It is not consistent, however, either with the nature or the limits of the present article, to enter into a minute detail of the circumstances that conspired to accelerate the destruction of the Roman empire, or enumerate the various tribes that took possession of the different countries of Europe, and the revolutions that took place in their manners and form of government. We shall only observe, therefore, that during the latter period of the Roman history, literature and the fine arts had in a great measure banished the cultivation of science, and the ardour of curiosity, so necessary in all laborious researches, but particularly for geographical discovery, had degenerated into a love of indolence and ease. A great deal still remained to be done by active and enterprizing adventurers, before the science of geography could be successfully prosecuted in the retirement of an academy; but enterprize and adventure were no longer to be found among a people enervated by every species of luxury and dissipation. We find, accordingly, that from the time of Ptolemy, till the overthrow of the Roman empire, there is scarcely a single fact on record that deserves a place in the history of geographical discoveries. From that period, the progress of all knowledge was retrograde. The monuments of learning that had been reared by the persevering labours of many ages, were successively overthrown; till Alexandria itself, the last refuge of persecuted science, fell a sacrifice to the merciless fury of a barbarous fanatic. The work of devastation was now complete. The last faint glimmerings of intellectual light were extinguished, and the gross perversion of religious principle in Europe, with the establishment of a false system in Asia, threatened to perpetuate that darkness which had enveloped the civilized world.

Such was the state, and such the prospect, of literature and science about the middle of the seventh century. There was still one country, however, which had not yet felt the shock of revolution, and from which the light of science was again destined to emanate. Arabia, from time immemorial, had preserved its independence; and while the rest of the civilized world was hurrying into decay, it continued to enjoy its ancient laws and privileges, and made considerable progress in many of the useful arts. Even the establishment of Mahometanism, at first so fatal in its operation, and which, like every other false system of religion, might have been supposed inimical to the progress of science, eventually contributed to the advancement of geographical knowledge. The Arabians, possessing a great extent of sea-coast, had from a very early period carried on an extensive trade, which was considerably increased by the conquests of Mahomet and his immediate successors. In their eagerness to propagate the doctrines of Islamism, the Arabian caliphs extended their arms to the pillars of Hercules in the west, and the banks of the Ganges in the east, and thus geographical discovery was once more associated with its most powerful ally, a spirit of military and commercial adventure. By the middle of the ninth century, the Arabians had formed settlements in different parts of China, and established an intercourse with Madagascar, the Maldives, Ceylon, Sumatra, Java, and other oriental islands. Nor was it to geography, considered in a commercial point of view, that their attention was exclusively directed. Their generals had orders to procure geographical accounts of all the countries which they subdued; and we find the Caliph Al Mamon, as early as 833, obtaining the measurement of a degree of latitude in the desert of Sandgiar, for the purpose of ascertaining the magnitude of the earth.

While the followers of Mahomet were thus extending the boundaries of geography in Asia, a spirit of enterprise seemed for a time to break out in the north of Europe. The earliest account of Denmark, Norway, and Sweden, on which any reliance can be placed, is that given by Alfred king of England, towards the end of the 9th century. This account is chiefly founded on the information of certain Norman adventurers, who finding the southern parts of Europe already in possession of their own countrymen, were forced to betake themselves to maritime expeditions in quest of new settlements. These adventurers gradually extending their researches into the Northern Ocean, discovered Greenland and the Shetland isles, on both of which they planted colonies, about the end of the 10th century. In the year 1001, Biorn, a Norman navigator, while steering round the coast of Greenland in search of his father, was driven by a storm a considerable way to the south-west, where he fell in with land, afterwards called Vinland, and supposed to be part of North America. Subsequent voyages to the same place tend to confirm this opinion, particularly that of the Zeni, two noble Venetian brothers, who, in the account of their adventure in 1390, describe a country called by them Estotiland, corresponding in every respect with Vinland, and agreeing in many points also with Newfoundland in North America. From this circumstance it has been inferred, that Columbus, in his anticipations of a western continent, was guided by something more decisive than bare conjecture. But whatever truth there may be in this supposition, it seems to be generally admitted, that the Normans had at a very early period landed on the coast of America. The consequences of the discovery however, were neither interesting nor important. Europe still continued ignorant and inactive, or engaged in pursuits suited only to an age of ignorance and barbarism. Even when her energies were awakened by the crusading mania towards the end of the 11th century, they promised to be productive of little benefit to the cause of literature and science. The professed object of the crusades was in itself chimerical, and it is difficult to say what advantage would have resulted from them, had they been completely successful. But though the immediate effects of these fanatical expeditions are still somewhat problematical, there can be no doubt that they were ultimately beneficial in a commercial point of view. It was in order to supply the crusaders with stores and ammunition, that the Genoese were first tempted to cultivate the art of ship-building, which for many centuries had been almost totally neglected, and to extend their short coasting expeditions to the most distant extremity of the Mediterranean. The same enterprising people having afterwards succeeded in re-establishing the Greeks on the throne of Constantinople, were rewarded with certain exclusive privileges in the way of commerce. By this event, their rivals the Venetians, who had shared with them the advantages of a trade with India nearly by the same route as was formerly known to the Romans, were excluded from the navigation of the Black Sea. The monopoly, however, was in this case beneficial to the cause of commerce. The Venetians, by concluding a treaty with the Sultan of Egypt, opened a communication with India by the Red Sea; and Alexandria soon became the grand depot of commerce, as it had formerly been the retreat of literature and science.

While the consequences of the crusades were thus apparent in exciting a spirit of enterprise in the commercial world, there were not wanting men who, actuated by motives very different from those of avarice or even curiosity, contributed from time to time to extend the boundaries of geography in the East. These consisted of ecclesiastics, who, animated by a sincere though mistaken zeal for promoting the doctrines of a corrupted church, undertook long and painful journies into countries which European commerce had not yet reached, and endeavoured, by the more captivating method of persuasion, to propagate opinions, which the sword had in vain attempted to impose. From the accounts of these missionaries, scanty and unsatisfactory as they frequently were, a great deal of information was obtained respecting the interior of Asia, particularly the north of India and Tartary. Among those who chiefly distinguished themselves in these expeditions, the first place is due to Marc-Paul, a noble Venetian of the 13th century. This celebrated traveller set out with his father Nicolas Paul, who had already acquired considerable reputation as a missionary to the East, and some Dominican monks in 1271, and after 26 years spent in unremitted labour, during which time he not only traversed those countries that were already known, and explored many new regions on the continent of Asia, but also visited Borneo, Java, Sumatra, the Nicobar islands, Ceylon, Madagascar, and other islands in the Pacific and Indian Ocean, till then unknown to Europeans, returned to Italy, where he was soon after made prisoner in a war with the Genoese. It was during his captivity in Genoa, that he wrote the account of his travels; a work which, though composed in a very irregular and confused manner, continued long to be the guide of Europeans in all matters relating to oriental countries. Of himself and his writings it has been justly observed, that he was the father of the modern geography of Asia, the Humboldt of the 13th century, though the misfortunes of the latter part of his life, by preventing him from publishing a more accurate and systematic account of his travels, have thrown a shade over the glory of his own name, and robbed science of the advantages which she might otherwise have derived from his labours.

History. Travels of Marc-Paul. A. D. 1271 to 1297.

Passing over the other events of the 13th and 14th centuries, as presenting nothing very striking or important, we hasten forward to a period of all others the most brilliant and interesting in the history of geographical discovery. About the beginning of the 15th century, the Portuguese began to attract the notice of the other European states, by the glory of their military exploits, and the fame of their naval discoveries. Having succeeded in driving out their inveterate enemies and oppressors the Moors, they carried their arms into Africa, where their achievements were such as might have been expected from a combination of every motive that could lead to acts of fearless bravery. Religious zeal inflamed them with the desire of extirpating the enemies of the Christian faith; avarice inspired them with the hope of sharing the treasures of a rich and powerful people; and a spirit of chivalrous and romantic gallantry threw a charm over military enterprise, more powerful perhaps than either of the other principles. The youthful adventurer of every country ranged himself under the standard of Portugal, and courted the approbation of his mistress by deeds of valour on the shores of Africa. Success in such circumstances could be neither slow nor uncertain, and every new victory led the way to a new expedition. The coast of Africa as far as Cape Nun, had been formerly explored more than once; but all beyond that was still enveloped in impenetrable darkness. The art of navigation, however, from the discovery of the compass, was rapidly improving; and the daring spirit of enterprise that had just been awakened, could no longer be confined within the former limits. In attempting to extend their discoveries towards the south, the Portuguese fell in with, and took possession of Madeira in 1420; and in 1433, Cape Nun was doubled for the first time by Gilianez. It is generally supposed, that in the same year the Azores, or Western Islands, were discovered, though on this point geographers are by no means agreed.

Discoveries of the Portuguese after the beginning of the 15th century.

Madeira. A. D. 1420.

The discoveries of the Portuguese along the coast of Africa, though not very rapid, became after this period progressive. In 1445 they reached the Senegal; and in 1456 discovered the Cape Verd Islands. A short time after this, Pierre de Cintra penetrated as far as Cape Mesurada, where the coast of Africa stretching

Cape Verd islands. A. D. 1456.

towards the east, promised a speedy accomplishment of the great object of all their expeditions, the circumnavigation of Africa. It was just at the dawn of these hopes, that the death of Prince Henry, the author of all the grand projects of the Portuguese, threatened to put an end to exertions equally honourable to his country, and beneficial to the interests of science. The spirit of the prince, however, had by this time been communicated to the nation, and the progress of discovery scarcely suffered any interruption. Prince's Island, St Thomas, and Annobon, were discovered in 1471; in 1484, Diego Cam entered the river Zaire, or Barbela, in the kingdom of Congo; and finally in 1486, fifty-three years after Gilianez had first doubled Cape Nun, Barthelemy Diaz reached the southern point of Africa, which he named the *Stormy Cape*, but which King John II. afterwards more properly denominated the *Cape of Good Hope*.

Cape of Good Hope. A. D. 1486.

Slow progress of the Portuguese not a conclusive argument against the circumnavigation of Africa by the Phœnicians.

While the slow progress of the Portuguese in exploring the west coast of Africa, has generally been accounted for from the imperfect state of navigation at that period, it has also been considered by some geographers, as a conclusive argument against the pretended circumnavigation of Africa by the Phœnicians, it being quite incredible, in their opinion, that the latter should have been able to accomplish in three years, twice as much as the Portuguese, with the assistance of the compass, could effect in half a century. Without at all entering again into the merits of the question, we would observe, that the conclusion drawn from the preceding fact is by no means legitimate. The Portuguese, in all their expeditions, seem to have confined themselves chiefly to the coast, where the compass could be of comparatively little use; and there can be no doubt, we think, that in every thing connected with coasting navigation, the Phœnicians had acquired much greater skill and dexterity than the Portuguese could possibly have at the commencement of their African expeditions. But to proceed with their discoveries.

Portuguese reach India. A. D. 1498.

In 1497, Vasco de Gama was dispatched for the purpose of exploring a passage to India by the Cape of Good Hope, at the same time invested with a commission to conclude a treaty with Prester John, whom the Portuguese supposed to be the prince of Abyssinia, or some other country on the eastern coast of Africa. That celebrated navigator, after touching successively at Port Natal, Mozambique, and Melinda, obtained pilots at the last of these places, and traversing the Arabian sea, in 1498, landed at Calicut, on the Malabar coast, the whole of which he soon after explored. About 1506, succeeding navigators pushed their discoveries along the eastern coast of Africa, as far as the straits of Babelmandel, and thus completed the circumnavigation of that continent. In the same year they discovered Ceylon, and in 1511 established themselves in Malacca. Their discoveries after this period are too numerous to be particularized. It is enough to observe, that by 1520 they had visited the Sunda islands, the Moluccas, Philippines, and indeed almost all the islands to the south-east and east of Asia, as far north as the thirtieth degree of latitude. Their being prohibited from entering China, probably led to the discovery of many islands in the Pacific at a much earlier period than would have happened, had the Portuguese been permitted to open a commercial intercourse with that country.

Ceylon. A. D. 1511.

Discovery of America by Columbus. A. D. 1492.

While geographical discovery was making such rapid progress in the East, the West also had become the scene of very interesting and important events, by the vast and daring projects of Columbus. Hitherto the course of navigators, in all voyages of discovery, had been determined by the direction of the coast, and was probably, for the most part, within sight of land; but Columbus, leaving the guidance of the shore, and trusting to the compass alone, ventured across an ocean of unknown extent, in search of a continent whose existence was extremely doubtful. In order still further to excite our admiration of this extraordinary man, it has been said, that he was strongly impressed with the idea of there being a great western continent, and attempts have even been made to point out the train of reasoning by which a man of genius might be naturally led to form such an opinion. We do not think, however, that the character and merits of Columbus require any adventitious support of this kind. If the circumstances to which we have already alluded respecting the adventure of the Zeni, in 1390, be well founded, it proves, that Columbus was not less distinguished for prudence than for intrepidity; and if it be false, we apprehend that his adventure is to be ascribed to an error common to him with Aristotle and many of the ancients, that the eastern extremity of Asia was not far distant from the shores of Spain. But whatever was the origin or the nature of the opinion formed by Columbus on this subject, it is certain that he undertook his voyage under a strong conviction of his ultimate success; and it is a curious coincidence, that at the very time when Vasco de Gama was taking possession of the peninsula of Hindostan in the name of the King of Portugal, Columbus was adding a new continent to the kingdom of Spain. It is unnecessary here to detail the circumstances connected with the discovery of America, as we have already done so in another part of our work, (See America and Columbus.) We cannot, however, avoid noticing the striking contrast which the history of that period exhibits, between the speculations of a few bold and aspiring individuals, and the childish prejudices which still enslaved the great bulk of mankind. While Columbus supposed that the nearest route to the eastern shores of Asia was by the western ocean, the Pope imagined, that, by a line of demarcation drawn on one side of the globe, he had completely separated the discoveries of the Spaniards and Portuguese!

Though Spain, in exploring a nearer passage to the East Indies, had discovered and taken possession of a new continent, she did not relax her endeavours to effect her first object. Accordingly, in 1520, Magellan was sent out on another voyage of discovery, when he succeeded in passing the extremity of South America by the strait which still bears his name, and, pursuing his voyage westward, reached the islands on the east coast of Asia. After his death, which happened at one of the Philippines, his companions continued their course, and, after touching at the Moluccas, returned by the Cape of Good Hope, having accomplished the first navigation of the globe in 1124 days. The attempts of the Spaniards to discover a passage by the north of America were not so successful. Some indeed have imagined, from their description of the Strait of Anian, that it was Bhering's Straits which they had reached by the north-west; but it is obvious that this strait was no other than Hudson's Strait, about the position of which the navigators of that period had formed some erroneous notions.

The success that had hitherto attended the adventures of the Spaniards and Portuguese, soon stimulated other nations, particularly such as had thrown off the

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Papal yoke, to undertake similar expeditions. In 1578, Sir Francis Drake discovered the southern extremity of Terra del Fuego, with some parts on the western coast of America, and completed the circumnavigation of the globe in 1051 days. In 1556, some English navigators, in seeking a north-east passage to India, fell in with Nova Zembla, and about the same time the Dutch discovered Spitzbergen. Of the discovery of New Holland, or Australasia, various opinions have been entertained, some ascribing it to Gonneville in 1503, others to Menezes, a Portuguese navigator, in 1527; but the first authentic account of a landing on the coast is by Captain Dirk Hartigh, a Dutchman, in 1616, (See Australasia.) It would be tedious to enumerate the various voyages of discovery, as well as land travels, that have been undertaken by different nations since the commencement of the 17th century, and still more so to give a catalogue of the islands and countries with which their labours have made us acquainted. We cannot conclude this sketch, however, without mentioning the names of Cook, Flinders, and Park, who may all be justly denominated martyrs in the cause of geographical discovery. With Captain Cook's discoveries in the South Sea, Captain Flinders' expedition to the south of Australasia, and Mr Park's interesting travels in Africa, our readers cannot fail to be acquainted. Cook, indeed, has been accused, by some French writers, of having entertained a mean jealousy of other navigators, unbecoming in any man, but particularly unworthy of one who had deserved so well, and enjoyed so much, of the grateful admiration of mankind. But the history of his successor proves, that even those who are loudest in their praises of liberality, and the most strenuous advocates for the maxim *palmam qui meruit ferat*, are not always proof against the pitiful and degrading vanity of attributing to themselves the discoveries made by another. At the very moment that the accusation above alluded to was brought against Cook, the accusers themselves were joining a *national* league to deprive the deeply injured Captain Flinders of his hard earned glory, as they had before done of his freedom and his property. Accident and misfortune threw him into their hands in the isle of France, where he was, in violation of every law, both of hospitality and humanity, detained a prisoner, and treated as a criminal for more than six years, obviously for no other purpose but to afford time to the French navigators who had followed his track under the protection of British passports, to publish the account of discoveries which had been stolen from another. Justice indeed has at length extorted an acknowledgment of the fraud, and the geographers of other countries are erasing from their charts the names, by which the authors of this infamous plot thought to immortalise themselves at the expence of an individual. This much was due to the merits and memory of Captain Flinders, and a triumph more honourable or more complete, the friends and admirers of that lamented navigator can neither desire nor expect. But what expiation will ever wipe away from the character of a great nation, the blot which it has sustained, by permitting itself to be either deluded or wilfully drawn into a participation of such baseness, as to lend its sanction to an imposition, the most abominable in the annals of science? See Strabonis *Rerum Geograph.* libri xvii. &c. Oxon. 1807; Rennel's *Geography of Herodotus*; Malte Brun *Precis de la Geographie Universelle*, tom. i.; Flinders' *Voyage to Terra Australis*, 1801, 1802, 1803: also our articles Africa, Cook, and Park.

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...s, Flinders, and Park.

History.

Unjust treatment of Captain Flinders by the French. 1803.

MATHEMATICAL GEOGRAPHY.

Mathematical Geography.

CHAP. I.

Of the Sphere.

Sect. I. *Of the Figure of the Earth, and of the Sphere in General.*

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The fundamental principle of all mathematical geography, and what of course naturally claims our first attention, is the spherical figure of the earth. The proof of this, however, is neither elaborate nor abstruse, the various phenomena from which it is inferred being so obvious and so conclusive, as to require only to be mentioned. The first, and perhaps the most simple of these which we shall notice, is the appearance of a ship at sea, either approaching to, or receding from, an observer on the shore. In the former case the vessel seems to rise out of the water, and in the latter to sink beneath it, a phenomenon that can only be accounted for from the convexity of the earth's surface; and as the same appearance is observed at all times and in all situations, this convexity must also hold in every direction, that is, the earth must be spherical. The same conclusion may also be drawn from other phenomena; as the change which takes place in the visible part of the earth's surface, as well as of the heavens, to an observer who changes his situation—from the circular form of the earth's shadow, as observed in eclipses of the moon—and, finally, from the actual circumnavigation of the globe. Our readers will find these appearances illustrated at greater length under the article Astronomy, at p. 658 of the second volume of our work. Without, therefore, attempting any farther proof of the fact, we shall proceed on the supposition that the earth is a perfect sphere. This, indeed, is not exactly the case, the globe being flattened or compressed at two opposite points, forming what mathematicians call an oblate spheroid, and at the same time having its surface diversified with numerous elevations and depressions. But to the geographer, these inequalities are of no importance, as they are too inconsiderable to affect any of the problems that he may have occasion to solve. The longest diameter of the earth is to the shortest nearly as 1 to .9968, or as 301 to 300, and the highest mountain on the earth, if represented on a sphere of six feet nine inches diameter, would not project from its surface farther than $\frac{1}{11}$th of an inch. In a system of geography, therefore, we may safely omit the consideration of such minute irregularities, and regard the globe as really a perfect sphere.

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Not affected by the inequalities of its surface.

General properties of the sphere.

As our chief object in the present article is to render the principles of geography intelligible to our readers in general, we shall endeavour, as much as possible, to exhibit a popular view of the subject, referring the scientific reader to those articles of our work, where the propositions that we may assume, and the phenomena that we shall have occasion to explain, are examined and illustrated on the most rigid principles. Agreeably to this plan, we shall here throw into the form of definitions, some of the properties of the sphere in ge-

Mathematical Geography.

neral, referring for a demonstration of these properties to the article Trigonometry.

Definition of a sphere. *A sphere* is an uniformly round body, every point of whose surface, is equally distant from a point within the body, called the centre. Hence,

If a circle is made to revolve about its diameter, which remains fixed, its circumference will describe or trace out the surface of a sphere. The circle thus revolving is called the *generating circle.*

Diameter. *The diameter* of a sphere is a straight line passing through the centre, and terminated both ways by the surface.

Axis. *The axis* of a sphere is that diameter about which the generating circle, or sphere itself, is supposed to revolve.

Circle of the sphere. If an indefinitely thin plane or flat surface cut or pass through a sphere, the part of the plane that lies within the sphere will be a circle, whose circumference appears on the surface, and is called a *circle of the sphere.*

Pole of a circle. *The pole* of a circle of the sphere, is a point on the surface, from which every point in the circle is equally distant. Hence

Every circle of the sphere has two poles, diametrically opposite to one another.

Great circle. *A great circle* of the sphere, is that whose plane passes through the centre, and consequently divides the sphere into two equal parts or hemispheres.

Small circle. *A small circle* of the sphere is that whose plane does not pass through the centre, but divides the sphere into two unequal parts.

Division of a circle. Every circle is supposed to be divided into 360 equal parts, called *degrees;* each degree into 60 equal parts, called *minutes;* and each minute into 60 equal parts called *seconds.* These different subdivisions are denoted by the signs ° ′ ″, thus 12° 15′ 10″ mean 12 degrees, 15 minutes, and 10 seconds.

Length of an arch. *The length of an arch* is expressed by the number of degrees, minutes, and seconds which it contains; thus the fourth part of a circle, or a quadrant, is said to be equal to 90°.

Distance between two points. *The distance between two points,* on the surface of a sphere, is measured by an arch of a great circle intercepted between them.

Great circles equal. All great circles of a sphere are equal, and intersect one another in two points diametrically opposite.

Measure of an angle formed by two great circles. The angle formed by the intersection of two great circles, is measured by the arch of another great circle, cutting the other two at the distance of 90° from the point of intersection in each.

When two great circles make with one another an angle of 90°, that is, when their planes are at right angles to one another, they pass through each others poles, the poles of a great circle being 90° distant from its circumference.

Sect. II. *Of the Celestial Sphere.*

General view of the celestial sphere. The heavenly bodies as seen from the earth, appear to be placed in the concave surface of a hollow sphere, having the earth in its centre, and seem to describe circles every 24 hours of a greater or less circumference, according as they are farther from, or nearer to a certain point, that appears fixed. Diametrically opposite to this point is another, about which also the heavenly bodies seem to describe circles, thus exhibiting the same appearance, as if the whole celestial sphere revolved about a diameter from east to west. In this motion, which is called the *diurnal revolution* of the sphere, all the heavenly bodies seem to participate, but the sun, with others of them called planets, have also a proper motion of their own in a contrary direction, by which, in a certain time, they perform a complete revolution of the sphere, though this is generally a very long period compared with that of their diurnal revolution. Thus the sun, by his proper motion from west to east, describes a circle of the celestial sphere in 365 days, the moon in 27, and the other planets in different periods between 87 and 30689 days. In order to illustrate these motions, as well as to determine the relative positions of the bodies themselves, certain imaginary points and lines are supposed to be marked or traced out on the surface of the celestial sphere. The most important of these we now proceed to explain.

(Margin note: Diurnal revolution.)

Definition. Poles of the world. *The north and south poles* of the world, are those points in the celestial sphere that appear to be fixed. The poles are also termed *arctic* and *antarctic*; the arctic or north pole being that which is visible in this as well as in every other country of Europe.

Axis. *The axis* of the world is that diameter of the sphere which connects the poles, and about which the whole sphere seems to revolve.

Zenith. *The zenith* of any place on the earth, is that point in the celestial sphere which is directly over the place, or it is the point in which the plumb-line at that place, if produced upwards, would meet the celestial sphere. When the sun or any other heavenly body is in the zenith of a place, it is said to be *vertical* to that place.

Nadir. *The nadir* is a point in the sphere diametrically opposite to the zenith.

Equinoctial. *The equinoctial* is a great circle of the sphere whose poles coincide with the poles of the world.

Horizon. *The horizon* is a great circle whose poles are the zenith and nadir.

Cardinal points of the horizon. *The cardinal points* of the horizon are its north, south, east, and west points, which divide it into four quadrants, the two first being opposite to each other, as also the two last. The point of the horizon nearest the north pole is called the north point.

Meridians. *Meridians,* called also *hour circles* and *circles of right ascension,* are great circles perpendicular to the equinoctial, and consequently passing through the poles of the world.

Meridian of the place. *The meridian of the place,* or the *twelve o'clock hour circle,* is the meridian that cuts the horizon in the north and south points.

Six o'clock hour circle. *The six o'clock hour circle,* is the meridian at right angles to the meridian of the place.

Azimuth. *An azimuth or vertical circle,* is a great circle perpendicular to the horizon, and consequently passing through the zenith and nadir.

Prime vertical. *The prime vertical,* is a vertical circle passing through the east and west points of the horizon, and consequently cutting the meridian of the place at right angles.

Ecliptic. *The ecliptic* is a great circle representing the sun's annual path, and cutting the equinoctial at an angle of about 23° 28′. Hence the poles of the ecliptic are about 23° 28′ distant from the corresponding poles of the world.

Signs. *The signs* are the twelve equal parts into which the ecliptic is divided, each consisting of 30°. They are written and named as follows:

♈ Aries.	♎ Libra.
♉ Taurus.	♏ Scorpio.
♊ Gemini.	♐ Sagittarius.
♋ Cancer.	♑ Capricornus.
♌ Leo.	♒ Aquarius.
♍ Virgo.	♓ Pisces.

Mathematical Geography. Equinoxes.

The cardinal points of the ecliptic are the two *equinoctial* and two *solstitial* points.

The equinoctial points or *equinoxes*, are those points of the ecliptic where it intercepts the equinoctial, viz. the beginning of Aries and the beginning of Libra 180° distant from each other. The sun enters Aries about the middle of spring, and Libra about the middle of autumn; hence the former is called the *vernal*, and the latter the *autumnal equinox*.

Solstices. *The solstitial points* or *solstices*, are those points of the ecliptic that are at the greatest distance from the equinoctial, viz. the beginning of Cancer and the beginning of Capricorn, also 180° distant from each other. The sun enters the former about the middle of summer, and the latter at the middle of winter; hence the one is called the *summer*, and the other the *winter solstice*.

Colures. *The equinoctial colure* is a meridian passing through the equinoctial points.

The solstitial colure is a meridian passing through the solstitial points.

Circles of longitude. *Circles of celestial longitude* are great circles perpendicular to the ecliptic, and consequently passing through its poles.

Parallels of declination. *Parallels of declination* are small circles parallel to the equinoctial.

Every point in the celestial sphere between the equinoctial and the poles appears to describe a parallel of declination in 24 hours. When part of this parallel is above, and part below the horizon, the former is called the *diurnal*, and the latter the *nocturnal arch*.

Diurnal and nocturnal arches. Tropics. *The tropics of Cancer and Capricorn* are parallels of declination passing, the one through the summer solstice 23° 28′ to the north, and the other through the winter solstice 23° 28′ to the south of the equinoctial. They are so called from a Greek word signifying to *turn*, because the sun in his annual course appears to recede from the equinoctial till he reaches the tropics, after which he returns towards it.

Polar circles. *The arctic and antarctic polar circles* are parallels of declination, 23° 28′ from their corresponding poles.

Parallels of latitude. *Parallels of celestial latitude* are small circles parallel to the ecliptic.

Declination. *The declination* of a heavenly body is its distance from the equinoctial measured on a meridian; or it is the arch of a meridian intercepted between the equinoctial, and a parallel of declination passing through the body. It is called north or south according as it is to the north or south of the equinoctial.

The declination of a body cannot exceed 90°.

Right ascension. *The right ascension* of a heavenly body is its distance from the vernal equinox measured on the equinoctial; or it is the arch of the equinoctial intercepted between the vernal equinox and a meridian passing through the body, reckoning in the order of the signs.

Latitude. *The latitude* of a heavenly body is its distance north or south from the ecliptic, measured on a circle of longitude; or it is the arch of a circle of longitude intercepted between the ecliptic and a parallel of latitude passing through the body.

Longitude. *The longitude* of a heavenly body is its distance from the vernal equinox measured on the ecliptic; or it is the arch of the ecliptic intercepted between the vernal equinox, and a circle of longitude passing through the body.

Altitude. *The altitude* of a heavenly body is its height above the horizon measured on a vertical circle; or it is the arch of a vertical circle intercepted between the horizon and the body. The arch of the same circle between the body and the zenith, is called its *zenith distance*. The altitude and zenith distance are together equal to 90°. The former is greatest when the body is on the meridian of the place, which is then called its *meridian altitude*, and at equal distances on either side of the meridian, the altitude is the same.

Zenith distance. Meridian altitude. Azimuth. *The azimuth* of a body is its distance from the meridian of the place measured on the horizon, or it is the arch of the horizon intercepted between the meridian of the place, and the vertical circle passing through the body. It is called *eastern* or *western* azimuth, according as the body is on the east or west side of the meridian.

Rising, &c. of a heavenly body. A body is said to *rise*, *culminate*, and *set* when its centre is in the eastern side of the horizon, the meridian of the place, and the western side of the horizon respectively.

Amplitude. *The eastern* and *western amplitude* of a body is the arch of the horizon intercepted between the point where the body rises or sets, and the east or west point of the horizon.

Zodiac. *The zodiac* is a zone or circular space of the celestial sphere, extending about 9° on each side of the ecliptic.

Illustration of the preceding definitions. PLATE CCLXV. Fig. 1. The preceding definitions will be rendered more intelligible perhaps, by referring to Plate CCLXV. Fig. 1. where HZRN represents the celestial sphere, and *hzrn* the earth, situated in its centre. Then if Z be the zenith of a place *z*, P and S the north and south poles of the world, and C the vernal equinox, HR will be the horizon, ÆQ the equinoctial, EL the ecliptic, and P′ its pole, PS the equinoctial colure, HZRN the solstitial colure, TL the tropic of Cancer, and ED the tropic of Capricorn. Also, since the circle HZRN passes through Z, P and P′ the poles of the horizon, equinoctial and ecliptic, it represents a vertical circle, a meridian, and a circle of celestial longitude. If, therefore, A be a given star, the arch RA will be its altitude, and ZA its zenith distance to an observer at *z*, or rather at the centre of the earth, QA will be its declination, LA its latitude, CQ its right ascension, and CL its longitude. In this case, its azimuth is nothing, the star being on the meridian of the place. It is hardly necessary to observe, that though CL and CQ, as represented in the Figure, appear to be straight lines, they are nevertheless arches of great circles, the point C being the pole of the hemisphere HZRN. The same is true of all the other straight lines passing through the point C.

Heavenly bodies. Having thus explained some of the principal points and lines, which geographers have imagined to be traced out on the celestial sphere, we shall briefly mention the different classes and characters of the heavenly bodies themselves. These are all comprehended under three heads, *Fixed Stars, Planets*, and *Comets*.

Fixed stars. The *fixed stars* are those heavenly bodies, that have always the same situation relatively to one another, having no other motion than what they derive from the apparent diurnal revolution of the celestial sphere from east to west. In order to distinguish them more easily from one another, they are divided into classes, according to their brilliancy and apparent magnitude, the brightest and largest being denominated stars of the first magnitude, the next largest of the second magnitude, and so on to the sixth. Stars less than those of the sixth magnitude, are not in general visible by the naked eye, and are called *telescopic stars*. Besides this classification, the fixed stars are also divided into groups called *Constellations*, each being named after some animal, or other object, to which the stars, in their arrangement, bear a fancied resemblance. There are twelve

Magnitudes. Telescopic stars. Constellations.

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such constellations in the zodiac, and it is from them that the signs of the ecliptic take their names. The stars in each constellation are distinguished by the letters of the Greek alphabet, the first letter denoting the largest star of the constellation, whatever may be its magnitude. Stars not included in any of the constellations, are called *Unformed Stars.*

Unformed stars.

Planets.

The *planets*, as we have already observed, are bodies which, besides their diurnal revolution, have also a motion of their own in a direction contrary to the other. They are *eleven* in number, and are found to revolve about the sun as a centre, in different periods, and at different distances. These eleven are denominated *Primary Planets*, to distinguish them from the *Secondary* or *Satellites*, with which some of them are accompanied, and to which they serve as centres of revolution. The path which a planet describes about its centre is called its *Orbit*. The primary planets are written and expressed as follows:

Primary and secondary orbit of a planet.

☿	♀	⊙	♂	⚵	⚶
Mercury	Venus.	Earth.	Mars.	Juno.	Vesta.

⚳	⚴	♃	♄	♅
Ceres.	Pallas.	Jupiter.	Saturn.	Georgium Sidus, Herschel, or Uranus.

For the distances of the planets from the sun, the periods of their revolutions, magnitudes, &c. see ASTRONOMY *Index.*

Comets.

Comets are luminous bodies, which appear in the heavens only occasionally, and for a limited period, generally consisting of a nucleus surrounded by a luminous vapour, sometimes shooting out into a long train or *tail.* Comets, besides the diurnal revolution common to all the heavenly bodies, have also a motion peculiar to themselves. In some, this motion is in the same direction with that of the planets, and in others it is in the contrary direction. See ASTRONOMY and COMETS.

SECT. III. *Of the Earth, or Terrestrial Sphere.*

Revolution of the earth the cause of the apparent revolution of the sun and celestial sphere.

IF all the inequalities of the earth's surface were removed, it would appear to its inhabitants to be a circular plane, fixed in the centre of the celestial sphere. There are two deceptions, however, in this appearance. The earth is not a plane, neither is it at rest. Its true figure, as we have already shown, is spherical, and it is continually in motion, revolving both daily on its own axis, and annually in an orbit round the sun. It must be obvious, on a moment's reflection, that the apparent diurnal motion of the heavenly bodies may be produced, either by the revolution of the celestial sphere from east to west, or by the rotation of the earth on its axis from west to east. Of the two explanations of the phenomenon, therefore, we are bound to adopt that which is liable to fewest objections, and this will be found to be the rotation of the earth. The revolution of the heavens, indeed, presents difficulties both physical and mechanical, which it is impossible to remove, while the other hypothesis is perfectly simple in itself, and in unison with the other phenomena of the universe. The same observations will apply, with perhaps still more force, to the annual revolution of the earth round the sun, which is the true cause of the sun's apparent motion in the heavens from west to east. The earth, therefore, is to be ranked among the planets, revolving about the sun in a year from west to east, having the ecliptic for its orbit, and accompanied by the moon as a satellite or secondary planet. But though we have thus noticed the real motions of the earth, as the causes of the apparent revolution of the sun and the celestial sphere, we shall not, in the remaining part of the present article, always confine ourselves to this view of the subject. In the solution of geographical problems, it is often much simpler to consider the apparent revolution of the celestial sphere, and the motion of the sun in the ecliptic, as real, than as produced by the combined motions of the earth, while the solution is the same in both cases. We shall not hesitate, therefore, to assume the first of these, whenever by doing so we can render the subject more intelligible or concise.

Circles of the terrestrial sphere. PLATE CCLXV. Fig. 1.

It is obvious from Plate CCLXV. Fig. 1. that the planes of all great circles of the celestial sphere form, by their intersections with the surface of the earth, corresponding great circles on the latter. Thus *hr*, *zn*, *ps*, *æq*, &c. on the earth, correspond to HR, ZN, PS, ÆQ, &c. in the heavens. This transference of the circles from one sphere to the other, may be still more clearly understood, by conceiving the celestial sphere uniformly contracted in its dimensions, without any change in the relative position of its parts, till it be just sufficient to cover the terrestrial sphere. By this method, the small as well as the great circles of the heavens may be transferred to the same positions on the earth; thus TL would coincide with *tl*, and ED with *ed*.

Poles. Equator. Rational horizon. Sensible horizon. Meridians. Parallels of latitude.

The points *p* and *s* on the earth, immediately under the poles of the world, are called the *north* and *south poles of the earth*; *æq* the *equator* or *equinoctial*; *hr* or HR the *rational horizon*, to distinguish it from H′R′, the limit of an observer's vision at *z*, and which is called the *sensible horizon*; *ps* and *hzrn meridians*, or *circles of longitude*; and *tl*, *ec*, *parallels of latitude*. In general, all parallels of declination on the celestial sphere become parallels of latitude on the earth, retaining however their proper or individual names. Thus the tropic of Cancer in the celestial sphere, is a parallel of declination 23° 28″ to the north of the equinoctial, and on the earth it is a parallel of latitude at the same distance from the equator.

Besides the terms already defined in the account of the celestial sphere, there are others peculiar to the earth, which require to be explained.

First meridian.

The first meridian of any country, in modern systems of geography, is the meridian passing through the capital of that country, from which the position of other meridians is determined. The ancients chose for their first meridian that of the Fortunate Isles, which they conceived to be the limit of the habitable world. In later times, the meridian passing through Ferro, one of the Canary Islands, and nearly the same with that of the ancients, was used as the first meridian by geographers of many countries; but now every nation generally reckons from the meridian of its own metropolis.

Terrestrial longitude.

The longitude of any place on the earth is its distance from the first meridian, measured on the equator; or it is the arch of the equator intercepted between the first meridian and the meridian of the place. It is called *east* or *west* longitude, according as the place lies to the east or west of the first meridian. Longitude on the earth corresponds, not to longitude, but to right ascension, on the celestial sphere. As the longitude of places on the earth is reckoned in two directions, it never can exceed 180°, whereas the right ascension of a heavenly body may be any thing between 0 and 360°, being always reckoned in one direction only, viz. in the order of the signs.

Difference of longitude.

The difference of longitude between two places, is the distance between them measured on the equator; or it is the arch of the equator intercepted between the meridians

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of the places. When the places are on different sides of the first meridian, the sum of their longitudes gives their difference of longitude.

Longitude, difference of longitude, expressed in time.

As the sun in his apparent diurnal revolution round the earth moves over 360° in 24 hours, or 15° in one hour, he is on the meridian of any given place, or it is noon at that place one hour sooner than at any other place 15° farther west. Hence longitude, and difference of longitude, may be expressed in time, allowing 15° to one hour, or 1° to four minutes. As the degree and hour are similarly subdivided, any number of degrees, minutes, and seconds, divided by 15, will give the corresponding number of hours, minutes, and seconds; and, on the contrary, hours, minutes, and seconds of time, multiplied by 15, give the corresponding number of degrees, minutes, and seconds.

Terrestrial latitude.

The latitude of a place on the earth is its distance from the equator measured on a meridian, or it is the arch of a meridian intercepted between the equator, and a parallel of latitude passing through the place. It is called *north* or *south* latitude, according as the place lies to the north or south of the equator. The distance of the place from the nearest pole measured on the meridian is called the *co-latitude* of the place, or the complement of the latitude. Latitude on the earth, corresponds to declination on the celestial sphere.

Co-latitude.

Difference of latitude.

The difference of latitude between two places, is the distance between them measured on a meridian; or it is the arch of a meridian intercepted between the parallels of latitude passing through the places. If they lie on opposite sides of the equator, the sum of their latitudes gives their difference of latitude.

A zone.

A zone is any portion of the earth's surface, included between two parallels of latitude. There are, however, usually reckoned five zones; the *Torrid*, the two *Temperate*, and the two *Frigid*.

Earth divided into five zones.

The torrid zone is the space included between the two tropics: the temperate zones extend from the tropics to the polar circles; and the frigid from the polar circles to the poles. To explain this division of the globe mathematically, we may observe, that whatever be the position of the sun, he always illuminates one half of the terrestrial sphere at once, and that the great circle which separates the light from the dark hemisphere, and which is called the *circle of illumination*, has for its pole that point on the surface of the earth, to which the sun is vertical. Now, as the sun appears to be always in some point or other of the ecliptic, moving over EL, (Fig. 1.), between the middle of winter and the middle of summer, and from L to E on the opposite side of the sphere in the next half year, the phenomenon is precisely the same as if he vibrated along the arch DL, viz. from D to L during the first of these periods, and from L to D during the next; the earth, in the mean time, revolving daily on its axis. When the sun is at Q, he is vertical to q; that is, the circle of illumination corresponds with a meridian ps; and every point of the earth's surface is successively 12 hours above and 12 hours below that circle. When the sun advances 1° towards L, he becomes vertical to a point 1° to the north of q, or the circle of illumination falls 1° below p towards p', and rises 1° above s towards r; that is, while the sun's declination is 1° north, the circular space about the north pole to the distance of 1° from it, never sinks below the circle of illumination, and a similar space around the south pole never rises above it. As the sun approaches L, a greater space about P continues to be permanently within the circle of illumination, and a corresponding space about s to be permanently without it. When the sun reaches L, or is vertical to l, the circle of illumination falls 23° 28′ below P, and rises as far above s, and may be represented by $p'g$; that is, on the day of the summer solstice, the whole of the north frigid zone is within the circle of illumination, and the whole of the south frigid zone is without it for 24 hours. From this period the sun again returns towards the south, when the circle of illumination also begins to move backwards, till at the autumnal equinox, three months after the summer solstice, it again occupies the position ps, so that for six months the north pole is above, and the south pole is below the circle of illumination. The sun still continuing his motion southward, reaches D by the middle of winter, when the circle of illumination occupies the position bf, and the circumstances of the frigid zones are just reversed. Hence, to every place within the torrid zone, the sun is vertical twice a year, which it never is to any other part of the earth. In the temperate zones, no place is either above or below the circle of illumination for 24 hours together. And in the frigid zones, a place may be in the dark or light hemisphere for any period, between 24 hours and six months. The zones might also be distinguished from each other physically, by the difference in the intensity of the sun's rays, as indicated in the difference of mean temperature in different latitudes. But for the investigation of this subject, we refer to PHYSICAL *Geography*.

Limits of the zones.

Circle of illumination.

Illustration. PLATE CCLXV. Fig. 1.

A Climate.

A climate is also a portion of the earth's surface, included between two parallels of latitude, and of such a breadth, that the longest day under the parallel nearest the pole, is half an hour longer than under the other. There are twenty-four such climates between the equator and either of the polar circles. Between the polar circle and the pole, there are six climates of such a breadth, that the longest day under the two parallels varies by a month. There are thus thirty climates in all on each side of the equator.

Each hemisphere divided into thirty climates.

Illustration. PLATE CCLXV. Fig. 2.

The principle that has already been employed, in explaining the division of the earth into zones, may serve also to illustrate the nature of climates. When the sun is vertical to Q, (Fig. 2.), the circle of illumination coinciding with the meridian NS, divides the equator ÆQ, and every parallel of latitude into two equal parts, or the day and night are equal all over the globe. When the sun passes to either side of Q, as northward towards L, the equator is still divided into two equal parts by the circle of illumination, as it must always be by a great circle; but the parallels of latitude are divided unequally, the greater arch of the northern parallels being above, and of the southern below, the circle of illumination; that is, the day and night are still equal at the equator, but in northern latitudes the day is longer than the night, and in southern the night is longer than the day. This inequality continues to increase in all latitudes, as the sun approaches L; and of two given parallels, as cd, el at any time, the inequality is greatest at that which is nearest the pole. When the sun reaches L, or at the summer solstice, the day is longest in all northern, and shortest in all southern, latitudes. At the polar circle it is 24 hours, the whole of the parallel ab being above the circle of illumination. At the parallel cd, the day is to the night as twice pd to twice pc, or as pd to pc; at eL it is as qL to qe, &c.; and at the equator they are equal. It is obvious, therefore, that between the equator and the polar circle, the length of the longest day varies from 12 to 24 hours, and that consequently 24 parallels may be found at such distances from each other, that

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the longest day under the one, shall exceed that under the other, by half an hour. With regard to places within the polar circle, it is evident that the parallel which comes to be wholly above the circle of illumination, half a month before the sun reaches the summer solstice L, or two months and a half after he passes Q, will continue to be a month above the circle, viz. half a month before the sun reaches L, and half a month till he returns to the same position. In like manner, the parallel that begins to be wholly illuminated one month before the sun reaches the solstice, or two months after the vernal equinox, will continue to be so for two months, and so of others. As the pole rises above the circle of illumination at the equinox, or three months before the solstice, it continues, as was formerly observed, to be illuminated for six months. Hence, between the polar circles and the poles, six parallels may be found such, that the longest day under the one, shall be a month longer than under the other. The same reasoning will apply to the southern hemisphere during the sun's progress from Q to *h*; and, in general, it is to be observed, that at any time, the length of the day, at a given latitude in one hemisphere, is always equal to the night, at the same latitude in the opposite hemisphere. The climates, as above defined, are contained in the following Table, where the first column shews the number of the climate, the second the length of the day under the highest parallel, or that nearest the pole, the third the latitude of that parallel, and the fourth the breadth of the climate.

Table of Climates.

Table of Climates.

Between the Equator and Polar Circle.	Longest Day under the highest Parallel.		Latitude of the highest Parallel.		Breadth of the Climate.	
	Hours.	Min.	Deg.	Min.	Deg.	Min.
1	12	30	8	34	8	34
2	13	0	16	43	8	9
3	13	30	24	10	7	27
4	14	0	30	46	6	36
5	14	30	36	28	5	42
6	15	0	41	21	4	53
7	15	30	45	29	4	8
8	16	0	48	59	3	30
9	16	30	51	57	2	58
10	17	0	54	28	2	31
11	17	30	56	36	2	8
12	18	0	58	25	1	49
13	18	30	59	57	1	32
14	19	0	61	16	1	19
15	19	30	62	24	1	8
16	20	0	63	20	0	56
17	20	30	64	8	0	48
18	21	0	64	48	0	40
19	21	30	65	20	0	32
20	22	0	65	46	0	26
21	22	30	66	6	0	20
22	23	0	66	20	0	14
23	23	30	66	28	0	8
24	24	0	66	32	0	4

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Between the Polar Circle and the Pole.	Longest Day under the highest Parallel.	Latitude of the highest Parallel.		Breadth of the Climate.	
	Months.	Deg.	Min.	Deg.	Min.
1	1	67	23	0	51
2	2	69	50	2	27
3	3	73	39	3	49
4	4	78	31	4	52
5	5	84	5	5	34
6	6	90	0	5	55

Other divisions of the earth.

Besides dividing the earth into different climates, the ancients also employed certain terms to distinguish the inhabitants of particular countries, which it may be useful to notice. Those who live under the same meridian and parallel of latitude, but on opposite sides of the equator, were called relatively to one another *Antœcii*, from αντι, *opposite to*; and οικια, *a habitation*. They have always the same hour of the day, but opposite seasons of the year. Those who live on the same side of the equator, and under the same parallel of latitude, but differ 180° in longitude, were called *Periœcii*, from περι, *about*; and οικια, *a habitation*. They have always the same seasons, but opposite hours of the day. The inhabitants of places under the same parallel of latitude, but on opposite sides of the equator, and differing in longitude 180°, were called the *Antipodes* of each other, from αντι, *opposite to*, and πους, *the foot*. They have always opposite hours of the day, as well as contrary seasons of the year. The inhabitants of the different zones were also distinguished according to the projection of their shadows. Thus the inhabitants of the torrid zone were called *Amphiscii*, from αμφι, *around*; and σκια, *a shadow*; because their shadow is projected sometimes towards the north, and at other times towards the south; or *Ascii*, from α, *without*; and σκια; because they sometimes have no shadow. The inhabitants of the temperate zones were called *Heteroscii*, from ἑτερος, *different*, and σκια; because their shadows are always projected in opposite directions, or towards the poles. And the inhabitants of the frigid zones were named *Periscii*, from περι, *about*, and σκια; because during their longest day, their shadows describe a circle round them.

Different positions of the sphere.

As the celestial sphere, in its apparent revolution, may present itself under three different aspects, according to the situation of the observer, it becomes necessary to distinguish them by particular names. Accordingly, to an observer at the equator, the celestial sphere is said to be *right*, because the equinoctial and parallels of declination, or circles described by the heavenly bodies, are at right angles to the horizon, and divided by it into two equal parts. To an observer between the equator and the pole, the sphere is *oblique*, because the equinoctial and parallels of declination are inclined to the horizon, so that all heavenly bodies not in the equator, are above and below the horizon during unequal periods. And from the pole the sphere appears *parallel*, the equinoctial coinciding with the horizon, and the heavenly bodies revolving in circles parallel to it.

Dimensions of the earth.

In the view that we have hitherto taken of the earth, we have considered it merely as a spherical body, without any regard to its actual magnitude and dimensions. All the phenomena, indeed, which we have yet noticed, depend entirely on the figure and situation of the hemati- Geogra- phy.

earth; and therefore, in the explanation of these phenomena, it is not necessary to take the volume of the globe into the account. In practical geography, however, it is frequently an important question to express the distance between different points on the surface of the earth, in terms of some known measure, as miles, yards, feet, &c.; and as these distances cannot always be subjected to actual measurement, it becomes necessary to determine the dimensions of the globe itself. Various attempts have accordingly been made by astronomers to solve this problem, though it is only from the perfection of modern instruments, that they have been able to accomplish it with any degree of accuracy.

isure- t of the h by tos- es.

If the earth were perfectly spherical, it is obvious that, to determine its circumference, nothing more would be necessary, than to find the length of a degree of the terrestrial meridian, that is, the distance between two places lying under the same meridian, but differing 1° in latitude, and multiply that distance by 360. It was upon this principle that Eratosthenes, computing the difference of latitude between Alexandria and Syene to be 7° 8′ 45″, and estimating the distance between them at 5000 stadia, determined the circumference of the earth to be about 252,000 stadia. This estimate is valuable, as being the result of the first attempt to ascertain the dimensions of the globe en correct principles. In point of accuracy, however, as might be expected, it is very deficient. Independent of the uncertainty with regard to the length of the stadium which Eratosthenes employed, he committed a considerable error in supposing Alexandria and Syene to be under the same meridian, and his calculation was also affected by an irregularity of which he was not perhaps aware. It has been found, from actual measurement, that the degrees of a meridian on the earth increase in length from the equator towards the poles; that is, if two points be taken in a terrestrial meridian, at such a distance from each other that perpendiculars at these points, or lines in the direction of gravity, when produced to the heavens, include between them 1° of a celestial meridian; and if other two points be taken on the same meridian, but nearer the pole, such that perpendiculars from them also include between them 1° of the celestial meridian, then it is found, that the distance between the two first points, measured on the surface of the earth, is less than the distance between the two last. This difference, indeed, is the necessary consequence of the spheroidal figure of the earth, which we formerly mentioned; and though, in geographical problems in general, the irregularity may be safely neglected, yet it is of importance to take it into account, in determining the dimensions of the earth. At the equator, a degree of latitude has been found to measure 60480.247 fathoms; at the parallel of 45°, 60759.473; and in latitude 66° 20′ 10″, 60952.374. Taking the second of these as nearly a mean for all latitudes, and multiplying by 360, we have for the whole circumference of the meridian 21873410.28 fathoms, or 24856.148 English miles. The circumference of the equator is found to be 24896.16 miles, or 40 miles greater than that of the meridian.

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As all the meridians on the globe intersect one another in the poles, the distance between any two of them diminishes as the latitude increases. In many cases, it is of importance to know the law of this diminution, that is to determine the length of a degree of longitude on any parallel of latitude, the degree on the equator being given. In order to solve this problem with the greatest possible accuracy, it is necessary to make allowances for the spheroidal figure of the earth, or the difference in the length of degrees of latitude at different distances from the equator. But as there are irregularities in these differences, that have led to doubt whether the earth be a regular spheroid, and as for ordinary purposes it is not necessary to aim at a degree of accuracy, which is after all perhaps a mere waste of calculation, we shall suppose the earth to be a sphere, and on this principle exhibit in a Table the diminution of the degrees of longitude for every degree of latitude. In such tables, it is usual to express the degree of the equator in terms of English miles; but as the length of this degree is estimated differently by different writers, we shall, in the following Table, assume it equal to unity, and exhibit the corresponding arches of the parallels in decimal fractions.

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Table of the Diminution of a Degree of Longitude for every Degree of Latitude, that of the Equator being reckoned Unity.

Table of the Diminution of the Degrees of Longitude.

Latitude.	Degree of Longitude.	Latitude.	Degree of Longitude.	Latitude.	Degree of Longitude.
1	.99985	31	.85717	61	.48481
2	.99939	32	.84805	62	.46947
3	.99863	33	.83867	63	.45399
4	.99756	34	.82904	64	.43837
5	.99619	35	.81915	65	.42262
6	.99452	36	.80902	66	.40674
7	.99255	37	.79864	67	.39073
8	.99027	38	.78801	68	.37461
9	.98769	39	.77715	69	.35837
10	.98481	40	.76604	70	.34202
11	.98163	41	.75471	71	.32557
12	.97815	42	.74314	72	.30902
13	.97436	43	.73135	73	.29237
14	.97030	44	.71934	74	.27564
15	.96593	45	.70711	75	.25882
16	.96126	46	.69466	76	.24192
17	.95630	47	.68200	77	.22495
18	.95106	48	.66913	78	.20791
19	.94552	49	.65606	79	.19081
20	.93970	50	.64279	80	.17365
21	.93358	51	.62932	81	.15643
22	.92718	52	.61566	82	.13917
23	.92050	53	.60181	83	.12187
24	.91355	54	.58779	84	.10453
25	.90631	55	.57358	85	.08716
26	.89879	56	.55919	86	.06976
27	.89101	57	.54464	87	.05234
28	.88295	58	.52992	88	.03490
29	.87462	59	.51504	89	.01745
30	.86603	60	.50000	90	.00000

Construction of the preceding table.

Since the circumferences of circles are to one another as their radii, if the radius of the equator be taken to express a degree of the equator, a degree of any parallel will be expressed by the radius of that parallel. But the radius *e* D (Fig. 2.) of any parallel *e* L, is the sine of *e* N the colatitude, or the cosine of Æ *e*, the latitude of that parallel to the radius ÆC. Hence to construct the above Table, we have only to take the natural cosines of the different parallels to radius 1, or the natural numbers corresponding to the logarithmic cosines, removing the decimal point ten places towards the left hand in each. Thus, let it be required to

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find a degree of longitude on the parallel of 25°. The natural cosine of 25° is 90,631 to radius 100,000, and making radius 1, the cosine becomes .90631, the length of the degree required. Thus also the logarithmic cosine of 25° = 9.957276, and the number corresponding to this logarithm is 9,063,100,000, which is the length of the degree required, that of the equator being 10,000,000,000, or radius of the trigonometrical table. But as it would be inconvenient to operate with these numbers, they may both be divided by 10,000,000,000, or the decimal point may be removed ten places to the left hand in each, which will give 1 for the degree of the equator, and .90631, as in the preceding Table, for that of the parallel of 25°. This number may also be found at once from the logarithmic Tables, by subtracting 10 from the cosine, and finding the natural number corresponding to the remaining logarithm. Thus the cosine of 25° becomes $\bar{1}.957276$, and the number corresponding in the Table of logarithms is .90631.

The application of the above Table for finding the length of a degree of longitude under any parallel, consists in simply multiplying the fraction opposite to the given latitude, by the length of a degree of the equator. Thus, to find the length of a degree on the parallel of 25°, that of the equator being 60 geographic miles, multiply .90,631 by 60, and the product 54.3786, or 54.38 nearly, gives the degree required in geographic miles. If the earth be considered as spherical, a degree of the equator may be assumed equal to the degree of the meridian bisected by the parallel of 45°, or 60759.473 fathoms, which gives for the geographical mile 6075.947 feet.

Method of finding the area of a given zone of the earth.

Before concluding this account of the dimensions of the globe, it may perhaps be of use to some of our readers, to point out a simple and expeditious method, of finding the superficial contents of any given zone of the earth. By geometry, the superficies of a sphere, is equal to the product of the circumference, multiplied by the diameter, and that of a zone to the product of the circumference multiplied by that part of the diameter, intercepted between the planes of the two parallels containing the zone; that is, the area of the zone is to the area of the whole sphere, as the perpendicular distance of the two parallels of the zone is to the diameter. But the distance B D (Fig. 2.) between any two parallels *fg*, *e* L, is the difference of the sines of Æ*e* and Æ*f*, the latitudes of *e* and *f*; therefore the area of the zone *fe* L *g* : area of the globe : : sin. Æ*e* — sin. Æ*f* : diameter : : $\frac{\text{sin. Æ}e - \text{sin. Æ}f}{2}$: radius. If, therefore, the radius of the sphere be taken to express the whole area; half the difference of the natural sines, or of the natural numbers corresponding to the logarithmic sines of any two latitudes, will express the area of the zone included between these latitudes, the radius of the sphere being equal to the radius of the respective Tables. If the radius be reduced to unity, the area of the zone will be a decimal fraction. In the common logarithmic Tables, this is done by removing the decimal point ten places towards the left hand, or the fraction may be found at once, thus: From the trigonometrical tables, take the sines of the latitudes, subtract ten from the index of each, and find the numbers corresponding to the remaining logarithms; half the difference of these numbers will express the area of the zone, that of the sphere itself being unity.

Example. It is required to find the area of the zone contained between the parallels of 56° and 57°, that of the globe being 1.

First, by a Table of natural sines.

sin. 57° = 83867
sin. 56. = 82904

963

and $\frac{963}{2} = 481.5$ is the area required, the radius of the Table being 100,000, and removing the decimal point five places towards the left, the radius becomes 1, and the area of the zone .004815.

Secondly, by a Table of logarithmic sines.

sin. 57° (subtracting 10 from index) = $\bar{1}.923591$
sin. 56. . . . . = $\bar{1}.918574$

The natural numbers corresponding to these logarithms are,

.83867
.82904

Difference .00963

and $\frac{.00963}{2} = .004815$ is the area required.

Table of zones.

Upon this principle, the following Table is constructed, exhibiting the area of every zone of 1° from the equator to the pole, that of the globe being unity.

Latitude.	Area.	Latitude.	Area.	Latitude.	Area.
0° to 1°	.008725	30° to 31°	.007520	60° to 61°	.004295
1 — 2	.008725	31 — 32	.007440	61 — 62	.004165
2 — 3	.008720	32 — 33	.007360	62 — 63	.004030
3 — 4	.008710	33 — 34	.007275	63 — 64	.003890
4 — 5	.008700	34 — 35	.007195	64 — 65	.003760
5 — 6	.008685	35 — 36	.007105	65 — 66	.003620
6 — 7	.008670	36 — 37	007010	66 — 67	.003475
7 — 8	.008650	37 — 38	.006925	67 — 68	.003340
8 — 9	.008630	38 — 39	.006830	68 — 69	.003200
9 — 10	.008610	39 — 40	.006735	69 — 70	.003055
10 — 11	.008580	40 — 41	.006635	70 — 71	.002915
11 — 12	.008550	41 — 42	.006535	71 — 72	.002770
12 — 13	.008520	42 — 43	.006435	72 — 73	.002620
13 — 14	.008485	43 — 44	.006330	73 — 74	.002480
14 — 15	.008450	44 — 45	.006225	74 — 75	.002335
15 — 16	.008410	45 — 46	.006115	75 — 76	.002185
16 — 17	.008365	46 — 47	.006005	76 — 77	.002035
17 — 18	.008325	47 — 48	.005895	77 — 78	.001890
18 — 19	.008275	48 — 49	.005785	78 — 79	.001740
19 — 20	.008225	49 — 50	.005665	79 — 80	.001590
20 — 21	.008175	50 — 51	.005555	80 — 81	.001440
21 — 22	.008120	51 — 52	.005430	81 — 82	.001290
22 — 23	.008060	52 — 53	.005315	82 — 83	.001140
23 — 24	.008005	53 — 54	.005190	83 — 84	.000985
24 — 25	.007940	54 — 55	.005065	84 — 85	.000835
25 — 26	.007875	55 — 56	.004945	85 — 86	.000685
26 — 27	.007810	56 — 57	.004815	86 — 87	.000535
27 — 28	.007740	57 — 58	.004690	87 — 88	.000380
28 — 29	.007670	58 — 59	.004560	88 — 89	.000230
29 — 30	.007595	59 — 60	.004430	89 — 90	.000075

Area of zone than

To find from the preceding Table the area of a zone, less than 1° in breadth, take a proportional part of the zone of 1° of which the other forms a part. Thus to find the area of a zone between 43° and 43° 35′, take from the Table the area of the zone between 43° and 44°, which is .00633 and say 60′ : 35′ : : .00633 ; area athemati- Geogra- phy.

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required nearly $= \frac{35}{60} \times .00633 = .0036925$. The true area, as found from the Table of sines, is .003705.

rea of a gment of zone.

To find the area of a segment of a zone, terminated at both extremities by meridians; multiply the area of the whole zone, by the length of the segment, and divide by 360. Thus, to find the area of a segment of the zone between 43° and 43° 35′, terminated by two meridians 6° 20′ distant from one another, multiply .0036925 by 6° 20′, and divide by 360, that is the area of the segment $= \frac{6°20'}{360°}$ or $\frac{380}{21600} \times .0036925 = .000065$.

ea of any ven coun- y.

To find the area of any particular country or district, divide the country into segments of zones, by parallels of latitude, and find the area of each segment separately; the sum of these areas will be the area required.

In some cases, this operation may be considerably abbreviated without affecting, in any great degree, the accuracy of the result. Let it be required, for example, to find the area of Portugal. Instead of dividing the whole surface into segments of zones of different lengths, according to the difference in the extent of the country from west to east, we may suppose the whole to consist of one segment, of a uniform length and breadth, viz. between 37° and 42° north latitude, and between 7° and 9° west longitude. By this arrangement, indeed, the eastern boundary cuts off a part of Tralos Montes and Beira, and the western a part of Estremadura; but, in lieu of these, the former includes a portion of Andalusia in Spain, and the latter a part of the Atlantic ocean. Supposing, therefore, these exchanges to be nearly equivalent, the area may be found thus:—

Take the sum of the areas of the zones between 37° and 42°, which is .03366, multiply by 2 the length of the segment, and divide by 360, that is,

$$\text{Area} = \frac{2}{360} \times .03366 = \frac{.03366}{180} = .000187.$$

Taking the circumference of the globe at 24856.148 English miles, the radius is 7911.964, or, making the circumference 21600 geographical miles, the radius becomes 6875.499. By the former the area of the globe is 196660948 English square miles, and by the latter 148510778.4 geographical square miles. The area of a zone is found by multiplying these numbers by the fractional value of the zone. Thus the zone included between the parallels of 56° and 57° is equal to 196660948 × .004815 = 946922.46 English square miles, or 148510778.4 × .004815 = 715079.39 geographical square miles. Thus also the area of Portugal is equal to 196660948 × .000187 = 36775.6 English square miles, or 148510778.4 × .000187 = 27771.5 geographical square miles.

deter- ne the ent of visible izon.

There is another problem connected with the figure and dimensions of the earth, which, though properly belonging to trigonometry, may, from its application to the present subject, and the facility with which it can be solved, be properly introduced here, viz. to find the most distant point of the globe visible to the eye at any elevation; or to determine the extent of the visible horizon from any given point.

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Let ABG (Fig. 3.) represent the circumference of the globe, and GB a diameter produced to E a given elevation above B, it is required to find the most distant point visible to the eye at E, supposing the eminence BE to be in a level country, or on the sea coast.

Through E draw EF a tangent to ABG in D, then D is the limit of the horizon as seen from E; the arch BD is the measure of the distance required in degrees, minutes, or seconds, and DE the tangent of that arch to the radius CB or CD. But in very small arches, as BD must always be, even though E were the summit of the highest mountain on the globe, the tangent hardly differs from the arch itself; therefore ED may, without any sensible error, be considered as the distance required. Now $ED^2 = GE.BE$ (see GEOMETRY) = (since BE is very small compared to GB) GB.BE nearly, and therefore $ED = \sqrt{GB.BE}$. Hence, if d represent the diameter of the globe in English miles, f the given height of the eye in feet, that is $\frac{f}{5280}$ the height in miles, and d' the distance required in miles, we have $d' = \sqrt{d \times \frac{f}{5280}} = \sqrt{\frac{d}{5280}} \times f$. If the diameter of the globe be assumed = 7912 English miles, the formula becomes

$$d' = \sqrt{\frac{7912}{5280}} \times f = \sqrt{1.49,84,} \times f = 1.224126 \times \sqrt{f}.$$

In every case, therefore, the square root of the height in feet multiplied by 1.224126 will give the radius of the visible horizon in English miles, supposing the ray of light to come from the verge of the horizon to the eye in a straight line, viz. in the direction of the tangent DE. This, however, is not exactly the case, the ray by the refractive power of the atmosphere, being bent downwards, so as to meet BE at a point below E; that is the point D is visible to the eye at an elevation less than BE. From E therefore, the horizon extends to a greater distance than D, and consequently the value of d', as found by the preceding formula, is too little by a quantity corresponding to the refraction, and which is found to vary from $\frac{1}{7}$ to $\frac{1}{14}$ of the whole distance, according to the state of the atmosphere with regard to weight and humidity. In a medium state, the refraction is about $\frac{1}{14}$, or .0714, which may therefore be considered as a near approximation to the truth in all ordinary cases. With this correction the preceding formula becomes $d' = 1.224126 \times 1.0714 \times \sqrt{f} = 1.3115\sqrt{f}$; and reduced to the form of a rule, it may be stated thus: *Multiply the square root of the height of the eye, in feet, by 1.3115, and the quotient will be the radius of the visible horizon in English miles.*

Example 1. Required the distance or radius of the visible horizon to the eye, situated six feet above the surface of the sea.

Here $d' = 1.3115\sqrt{6} = 1.3115 \times 2.449 = 3.2118$ English miles, the distance required.

Example 2. At what distance may a mountain 21440 feet in height be seen, the eye being on the surface of the sea.

In this case $d' = 1.3115\sqrt{21440} = 1.3115 \times 146.42 = 192$ English miles. Hence the summit of Chimborazo, the highest of the Andes, ought to be seen at a distance of 192 miles, if its height be as it is stated, 21,440 feet.

CHAP. II.

OF THE GLOBES.

SECT. I. *Construction of the Globes.*

As soon as geographers had discovered the spherical figure and diurnal revolution of the earth, they would naturally be led to a very simple method, of representing

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Properties of the globe as illustrative of mathematical geography.

its motion and various positions, by means of an artificial sphere. We find, accordingly, that from a very early period, the globe, with certain modifications, has been made use of for this purpose, and notwithstanding all the discoveries and improvements in the astronomical apparatus of modern times, it still continues to afford the simplest, and at the same time a correct illustration, of the principles of mathematical geography. We have already seen in what way, and to what extent, the earth differs in figure from a true sphere, and how imperceptibly small the irregularities of its surface become, when represented on a sphere six or seven feet in diameter. If the sphere be reduced to one-third of this, which is more nearly the size of ordinary globes, these irregularities will totally disappear, and the difference between the polar and equatorial diameters, or between the meridian and equator, be itself inappreciable. The earth therefore, with all its inequalities, can alone be represented by a sphere; and the only remaining question is, how can the instrument be accurately constructed, and most extensively applied?

General description of the terrestrial globe.

In constructing an artificial sphere or globe, the first operation is to prepare a spherical body of wood, metal, ivory, or such other substance as may be found most convenient. The materials commonly employed, and perhaps upon the whole best adapted for this purpose, are paper and plaster, prepared and combined by the following process: On a spherical block or mould of wood, somewhat less than the size of the intended globe, are laid successive coverings of paper or pasteboard, attached to one another by glue or paste, till the whole is about the thickness of $\frac{1}{10}$th or $\frac{2}{10}$ths of an inch. When completely dry, this covering is cut into two hemispheres, by which it is separated from the mould; and the hemispheres being again placed on a wooden axis, previously prepared for the polar diameter of the globe, they are stitched together in the same position, as when attached to the block or mould. In the extremities of the wooden axis, are fixed pins of iron or other metal, which represent the poles, and by which the globe is suspended in a metallic semicircle, whose diameter is exactly equal to that of the intended globe. In this state, a composition of whiting and glue is applied to the surface of the paper, the globe in the mean time being made to revolve, so that the interior edge of the semicircle, which is prepared for the purpose, pares off the superfluous plaster from the projecting parts of the surface. The whole being thus made perfectly smooth and spherical, and at the same time equally balanced on its axis, so as to remain in any position in which it may be placed while suspended by the poles, it is set aside to dry and harden, when it is ready to receive the various circles which geographers have imagined to be described on the surface of the earth, and which we have already explained, viz. the equator, ecliptic, meridians, the tropics, polar circles, and other parallels of latitude. These circles being described by some of the methods afterwards to be explained, the various parts of the surface of the earth are then delineated, according to their actual situation, the position of every place being determined by the intersection of its meridian and parallel of latitude. The iron pins in the extremities of the axis, formerly used for fixing the globe in the metallic semicircle, for the purpose of applying the plaster, are now employed to suspend it in a brass circle, of such a diameter that the globe may revolve easily without coming in contact with any part of its interior edge. This ring is called the *universal meridian*, because by the revolution of the globe, it may be made to represent the meridian of any place. The frame in which the globe is placed is variously constructed, according to the taste and fancy of the workman; but its top or upper part always consists of a broad horizontal circle of wood or metal WNES, (Fig. 4.) of which the interior diameter WE is equal to the interior diameter of the brazen meridian. The latter, with the globe suspended in it, passes through notches at N and S, and rests by its under edge in a groove in which it may be made to slide, so as to elevate or depress the pole at pleasure. In every position, however, one half of the globe is above, and another below the surface of WNES, which is therefore taken to represent the rational horizon. On the surface of this horizontal rim are described several concentric circles, variously divided, according to the purposes which they are intended to serve. The largest, or that towards the outer edge, is named the calendar, being divided into 365 parts, representing the days of the year, classed under their respective months. The next represents the ecliptic divided into signs and degrees, and so arranged that each point of the ecliptic stands opposite to the day on which the sun is at that point. The names or characters of the different signs are placed at the beginning, or opposite the middle of each. The innermost circle represents the horizon divided into quadrants, two of these being reckoned from W the west point, and the other two from E the east point, towards N and S, the north and south points. This circle, or rather another concentric with it, but larger, is divided into 32 equal parts, representing the points or rhumbs of the mariner's compass. The side of the brazen meridian facing the west is divided into degrees, or if the size of the circle will admit into degrees and minutes, reckoning from the equator towards both poles on two quadrants, and from the poles towards the equator on the other two, each quadrant being numbered from 1 to 90. The circle representing the equator is also divided into degrees in two directions, on each side of the first meridian, which, on British globes, is that of Greenwich. The 15th, 30th, 45th, &c. degrees towards the west are marked I. II. III. &c. to facilitate the conversion of longitude, and difference of longitude into time, and the contrary. The ecliptic, which is generally made to intersect the equator and first meridian in the same point, is divided into 12 signs, each sign being again subdivided into 30 degrees, and reckoned from the first meridian eastward. The characters of the signs are placed at the beginning, or opposite the middle of each, as on the horizon.

Plate CCLXV. Fig. 4.

Such is a general view of the artificial sphere usually employed to represent the earth. It is called the *terrestrial globe*, to distinguish it from that used to represent the heavens, and which is denominated the *celestial globe*. The latter, like the terrestrial globe, is suspended by the poles in a brazen or universal meridian, and mounted in the same way in a horizon. On its surface are described the equinoctial, the ecliptic, the tropics, the polar circles, the equinoctial and solstitial colures, circles of celestial longitude, and parallels of celestial latitude. As the celestial sphere revolves from east to west, the graduation of the brazen meridian is towards the east, but, in other respects it is the same as that of the terrestrial globe. The ecliptic is divided in the same way as on the other globe, but opposite each degree is a dot, representing the day on which the sun is at that point. The degrees of the equator are reckoned in one direction only, viz. towards the east, and the equinoctial and solstitial points are determined from

Celestial globe.

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actual observation of the heavens. On the surface of the celestial globe are represented the fixed stars, in their true relative positions, distinguished according to their magnitudes, and arranged in constellations.

Instruments belonging to the globes.

Besides the parts already described, there are other appendages common to both globes, which yet remain to be explained. The principal of these are the *horary* or *hour circle*, the *quadrant of altitude*, and the *compass*.

Horary.

The *horary* is a small brass circle, generally fixed on the north pole of the globe, and divided into 24 equal parts, representing the hours of the day. The divisions are numbered from 1 to 12 along the first semicircle, and again from 1 to 12 along the next, in the contrary direction to that in which the globe naturally revolves. The circle is moveable separately by the hand, so that any given hour may be brought to the brazen meridian; but when left to itself, it turns with the globe, and thus serves to measure the whole, or any part of a revolution.

Quadrant of altitude.

The *quadrant of altitude* is a graduated slip of brass, so thin and flexible, as to be easily applied to the surface of the globe. It is furnished at one extremity with a nut and screw, by which it may be fastened to any part of the meridian. When this extremity is fixed on the zenith of the globe, the zero, or commencement of the graduation, coincides with the horizon, thus forming the fourth part of a vertical circle. The graduation is also continued to the other extremity of the quadrant, which is generally about 18 or 20 degrees. It takes its name from being applied to measure the altitude of heavenly bodies.

Compass.

The *compass* consists of a magnetic needle, suspended over the centre of a circle, on the circumference of which are marked the 32 points or rhumbs of the horizon. It is, in fact, the simplest form of the mariner's compass, fixed in the under part of the frame or mounting, and used for placing the brazen meridian in the meridian of the place.

It would be tedious, even to enumerate the various improvements and alterations, that have been from time to time recommended, in the construction and use of the globes, as well as of their appendages. Such an enumeration, however, is we conceive unnecessary, because any body who understands the general principle of the globes, as we have now explained it, will find no difficulty in using any of the instruments, with which they may be accompanied; and because more information will be acquired, in half an hour, from inspecting the globe itself, than we could communicate in a whole volume of descriptions and drawings. While, therefore, we have endeavoured, in the preceding short sketch, and by help of the representations, Figs. 5 and 6. Plate CCLXV. to convey some idea of the nature of the globes, we would conclude, by recommending to such of our readers as wish to become thoroughly acquainted with the subject, to draw their information from the instrument itself.

Plate CCLXV. Figs. 5, 6.

Method of describing the circles on the globe.

The most natural, as well as the most correct method of tracing out the circles of a globe, may easily be deduced from the preceding description. Suppose, for example, it is required to delineate on the surface of a spherical body, the various lines and figures of the terrestrial globe. From either of the points that represent the poles, with a radius equal to half the distance between them, a circle is described to represent the equator, and divided into degrees. From the 90th degree of the equator with the same radius, another circle is described, passing through the poles, and representing the first meridian. Other meridians are described in a similar manner, by taking for a centre every fifth, tenth, or fifteenth degree of the equator, according to the number required. The first, or any other meridian, being divided into degrees, from the equator towards the poles, the tropics and polar circles may be described from the poles as centres, with radii extending to $23\frac{1}{2}°$ and $66\frac{1}{2}°$ respectively. Other parallels of latitude are described in a similar manner. The ecliptic is described, by taking as a centre the point which is in 90° west longitude, and $66\frac{1}{2}°$ north latitude, and for a radius one-fourth of the circumference of the globe. Having thus described all the circles, it only remains to lay down the different places of the earth, according to their respective longitudes and latitudes, as determined by observation, and described in books of geography.

Method commonly adopted.

But though this method of delineating globes is in itself simple, and capable of being carried to almost any degree of exactness, those whose business it is to construct them for sale, have found it necessary, in order to furnish them at a moderate price, to adopt another method, less accurate perhaps, but much more expeditious. This method consists in delineating, on separate pieces of paper of the form ÆNQS, (Fig. 7.) called *gores*, separate portions of the earth or the heavens, according as they are intended for a terrestrial or celestial globe, and afterwards fixing them in order on the surface of the sphere, when N and S coincide with the poles, NÆS, NMS, and NQS become meridians, and ÆMQ an arch of the equator. Strictly speaking, indeed, no portion of paper can be accurately fitted to a spherical surface; but if ÆQ be very small compared to the whole circumference, the portion of the sphere, covered by the segment ÆNQS, will not sensibly differ from a plane in the direction ÆQ; that is, the arches of the equator ÆM, QM, and of the parallel of latitude *ab*, *cb*, may be considered as straight lines perpendicular to NS. The number of segments necessary to cover the globe, will depend on the length of the arch ÆQ; but when the whole have been once carefully designed and accurately fitted to the sphere, it is only necessary to make correct engravings of the originals, in order to construct, with comparatively little labour, any number of globes of the same dimension. Sometimes the segments are truncated at each extremity AB, CD, so as to leave a small circular space about the poles. These spaces are considered as plane surfaces, and are accordingly covered with one circular piece of paper, on which the portions of the meridians form radii of a circle. The method of delineating the gores will be explained when we come to the projection of maps.

Plate CCLXV. Fig. 7.

Having thus shortly noticed the different methods of constructing globes, we should now proceed to what more properly constitutes the object of this Chapter, the application of these instruments to the solution of problems. Before concluding this Section, however, we would observe, that in perusing the terrestrial globe, the eye of the observer is in its natural position; but in the case of the celestial globe, he must conceive himself situated in the centre, and looking towards the concave surface. This will perhaps be better understood by referring to the *armillary sphere*, as represented Fig. 8. Plate CCLXV. This instrument consists of a number of metallic rings, so connected as to represent the circles of the sphere, and at the same time to exhibit the apparent relative positions of the earth and heavens. As delineated in the figure, N and S represent the poles, and the line NS the axis of the world, with the earth G in the centre; HR the horizon, ÆQ the equinoctial, EL the ecliptic, ÆNQS the solstitial colure, KM the equinoctial co-

Armillary sphere.

Plate CCLXV. Fig. 8.

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ture, TC the tropic of Cancer, T′C′ the tropic of Capricorn, AP the arctic circle, and A′P′ the antarctic circle. The meridian ÆNQS is graduated in the same way, as the brazen meridian of the celestial globe, viz. from Æ towards N and S, and from N and S towards Q; and the horizon is moveable, so that by raising or depressing it at the north and south points, it may be made to intersect the meridian ÆNQS, in any two opposite points. The whole instrument rests on the southern extremity S of the axis, and is generally so constructed that the earth G, with the meridian ÆNQS, and horizon HR, may be made to revolve from west to east, while the other circles remain at rest; or the latter may be made to revolve from east to west, while the former remain fixed. By means of the joint B, the sphere may be placed so as that the north pole N may have any elevation, the angle of that elevation being measured by the graduated arch F, attached to BS, and passing through a slit in BD. In using the celestial globe, then, the eye is supposed to be situated on G, and viewing the circles of the armillary sphere, the latter in all cases being placed in the same situation with the globe.

Sect. II. *Solution of Problems by the Globes.*

I. *By the Celestial Globe.*

To rectify the globe.

Prob. I.—To rectify the globe for any place, that is, to give the globe the same position, as the celestial sphere has, to a spectator at any place on the earth's surface.

Elevate the north or south pole, according as the place is north or south of the equator, till its altitude be equal to the latitude of the place.

To find the sun's place.

Prob. II.—To find the sun's longitude, or place in the ecliptic, for any given day.

Find the day under the ecliptic on the globe, and opposite to it will be the *sign* and *degree* required. The problem may also be solved, by finding the day in the calendar on the wooden horizon, marking the sign and degree opposite to it, and finding the same sign and degree in the ecliptic on the globe. As the sun is always in the ecliptic, he has no latitude.

To find the sun's right ascension, &c.

Prob. III.—To find the sun's right ascension and declination for any given day.

Bring the sun's place in the ecliptic to the graduated edge of the brazen meridian, then the degree of the equator under the meridian will shew his right ascension, and the degree of the meridian over his place will be his declination. When the sun's declination is less than 23° 28′, there are two corresponding places in the ecliptic, which may be found by marking those two points on the ecliptic, which pass successively under the given declination on the meridian.

To exhibit the appearance of the heavens.

Prob. IV.—To dispose the celestial globe, so as to exhibit the actual appearance of the heavens at any given time and place.

Rectify the globe for the latitude of the place, and bring the sun's place in the ecliptic, and the 12th hour of the horary to the brazen meridian. Turn the globe towards the east or west, according as the time is before or after noon, till the given hour on the hour circle comes to the meridian, and the globe will represent the actual appearance of the heavens, at that time and place.

To find the stars that never rise, &c.

Prob. V.—To find those stars that never rise, and those that never set, at a given place not under the equator.

Rectify the globe for the latitude, and make it revolve. The stars that do not sink below the wooden horizon, are those that never set, and the stars that do not appear above it, are those that never rise in that latitude. If the place be under the equator, every star is 12 hours above and 12 hours below the horizon.

To find right ascension, &c. of a star.

Prob. VI.—To find the right ascension and declination of a fixed star.

Bring the star to the brazen meridian, and its right ascension and declination will be found, as in Problem III.

To find star from its right ascension, &c.

Prob. VII.—The right ascension and declination of a star being given, to find the star on the globe.

Bring the degree of the equinoctial denoting the right ascension to the meridian, and the degree of the meridian, denoting the declination, will be over the star.

To find longitude, &c. of a star.

Prob. VIII.—To find the longitude and latitude of a given star.

Place the upper extremity, or 90th degree of the quadrant of altitude, on the north or south pole of the ecliptic, according as the star is north or south of the ecliptic, and let its graduated edge fall upon the star; then the degree of the ecliptic, intersected by the quadrant, will be the longitude of the star, and the degree of the quadrant over the star, its latitude.

To find star from its longitude, &c.

Prob. IX.—The longitude and latitude of a star being given, to find the star upon the globe.

Place the extremity of the quadrant of altitude on the pole of the ecliptic, and make its graduated edge intersect the ecliptic, in the longitude of the star; then the star will be found, under the degree of the quadrant denoting its latitude.

To find what stars are rising, &c.

Prob. X.—To find what stars are rising, setting, or culminating, at any given time and place, and also the altitude and azimuth of any star, at the same time and place.

Dispose the globe as in Prob. IV. then the stars under the eastern side of the horizon are rising, those under the western side are setting, and those under the meridian are culminating.

To find the altitude, &c. of a star.

If the quadrant of altitude be fixed on the zenith, and its graduated edge made to fall on a given star, the degree of the quadrant over the star, will be its altitude, and the degree of the horizon intersected by the quadrant its azimuth.

To find when a star rises, &c.

Prob. XI.—To find when a given star rises, sets, or culminates at any place on any given day.

Dispose the globe and hour circle as in the first part of Prob. IV. then bring the star successively to the eastern side of the horizon, the meridian, and western side of the horizon, and the times of its rising, culminating, and setting on the hour circle, will come to the meridian respectively.

To find angular distance between two stars.

Prob. XII.—To find the apparent angular distance between two stars; that is, the arch of the great circle intercepted between them.

Apply the quadrant of altitude to the globe, so that its graduated edge may fall on both the stars, the zero, or commencement of the graduation, being on one of them; then the degree of the quadrant over the other will be the angular distance required.

To find when a planet rises, &c.

Prob. XIII.—To find when a planet rises, sets, or culminates on any day at a given place.

Find the planet's place on the globe, from its longitude and latitude, or right ascension and declination, as given in the Nautical Almanack, or any other ephemeris, and fix on that place the name or character of the planet; then its rising, setting, or culminating, also its altitude, azimuth, &c. may be found in the same way as if it were a fixed star. In general, all the problems relative to the fixed stars are applicable to the planets,

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the places of the latter being determined from the ephemeris.

To illustrate the harvest moon.

Prob. XIV.—To illustrate, generally, the phenomena of the harvest and hunter's moons.

The moon's orbit forms with the ecliptic an angle of $5\frac{1}{3}°$, and advances about 13° daily from west to east. But to simplify the problem, let it be supposed, in the first instance, that her orbit coincides with the ecliptic, and that her place and hour of rising being given for one day, it is required to find her hour of rising for the next.

Rectify the globe for the latitude, bring the moon's place to the east side of the horizon, and the hour to the brazen meridian, then turn the globe westward till the point of the ecliptic, 13° from the given point, come to the horizon, and the hour required will be under the meridian.

By solving this problem for various points of the ecliptic, assumed as the moon's places, it will appear, that the difference in the time of her rising on any two consecutive days, to a place not under the equator, is always considerably less when the moon is in Pisces and Aries, and greater in the opposite signs, than in any other point of the ecliptic, and that this difference increases with the latitude of the place of observation. Thus if the globe be rectified for the latitude of 56° north, and the above problem solved, supposing the moon's place to be the beginning of Libra, it will be found, that the time of her rising one day, will be upwards of $1\frac{1}{4}$ hour later than on the preceding; but if her place be the beginning of Aries, her time of rising will be little more than one quarter of an hour later, so that she rises for several days nearly at the same time. This phenomenon, though it must obviously happen every month, was long considered as peculiar to the autumnal months, when the sun is in Virgo and Libra, because it is only then that the moon is in Pisces and Aries, at the time of her being full.

Such is a brief illustration of the harvest and hunter's moon, on the supposition that the moon revolves in the ecliptic. As her orbit, however, is inclined to that circle at an angle of $5\frac{1}{3}°$, and as her nodes, or points where her orbit intersects the ecliptic, are constantly shifting, it may easily be shewn by describing several great circles, inclined to the ecliptic at an angle of $5\frac{1}{3}°$, but cutting it at different points, and solving the above problem, that the difference of time in the moon's rising during these months, is sometimes greater, and sometimes less than it would be if she revolved in the ecliptic. See Astronomy, Vol. ii. Page 668.

To find the path of a comet.

Prob. XV.—To trace the apparent path of a comet on the celestial globe.

If the right ascension and declination of the comet be known, at two different periods, find its position at each by Prob. VII. lay the quadrant of altitude through both, and join them with a pencil line, which will represent the intermediate path. If the longitude and latitude of the comet be observed, its places may be determined by Prob. IX. and if its azimuth and altitude be known at any hour, the latitude of the place of observation being also given, its place may be found thus: Dispose the globe as in Prob. IV. fix the quadrant of altitude on the zenith, and make its graduated edge intersect the horizon in the azimuth of the comet; then the degree of the quadrant denoting its altitude will be over the comet's place. If the positions of the comet, as determined in any of these ways, be at a greater distance from each other, than the length of the quadrant of altitude, they may be both brought to coincide with the horizon, and the path traced accordingly.

The preceding examples, though only a few of the problems that may be solved by the celestial globe, will be sufficient to shew the general principle of such solutions, and if that principle be well understood, the reader will find no difficulty in applying it to any particular case. The problems relating to the sun, and which are frequently solved by the celestial globe, we consider as bearing more directly on the subject of this article. We have therefore reserved them for the second class of problems, viz, those solved by the terrestrial globe, to which we now proceed.

II. *By the Terrestrial Globe.*

To find the latitude and longitude of a place on the earth.

Prob. XVI.—To find the latitude and longitude of a given place on the earth's surface.

Set the twelfth hour of the horary circle to the first meridian, bring both to the brazen meridian, and turn the globe till the given place be under the brazen meridian; then the degree of the meridian over the place will be its latitude, the point of the equator intersected by the meridian its longitude in degrees, and the hours of the horary that pass under the meridian the longitude in time.

If the equator be divided into hours as well as degrees, the problem may be solved without any previous adjustment of the hour circle, by simply bringing the place to the brazen meridian.

To find a place from its latitude and longitude.

Prob. XVII.—The latitude and longitude of a place being given, to find the place on the globe.

Find the longitude on the equator, and bring it to the brazen meridian, then the degree of the meridian denoting the latitude will be over the place.

To find the difference of latitude, &c. between places.

Prob. XVIII.—To find the difference of latitude and the difference of longitude between two given places.

Find the latitudes of both places by Prob. XVI. and take the difference or sum of these according as they lie on the same side, or on different sides of the equator. The difference of longitude is found in the same way, by taking the difference or sum of the longitudes according as they lie on the same side, or on opposite sides of the first meridian.

To find the hour at any place.

Prob. XIX.—The hour being given at one place, to find the hour at any other place at the same time.

Bring the given place and hour to the meridian, then turn the globe till the other place comes to the meridian, and the hours that pass under the meridian added to, or subtracted from the first given hour, according as the second place, is to the east or west of the first, will give the hour required.

To find when it is any given hour.

Prob. XX.—The hour being given at any place, to find the places where it is any other given hour at the same time.

Bring the given place, with the hour at that place, to the meridian, then turn the globe towards the east or west, according as the second given hour is earlier or later than the first, till the difference between them pass under the meridian, and the places required will be under the meridian.

To find the distance between two places.

Prob. XXI.—To find the distance between two given places on the earth.

Find the number of degrees, of a great circle, intercepted between them; these degrees multiplied by 60, or by 69.045, will give the distance in geographical and English miles respectively. The number of degrees may be found from the brazen meridian, if the places are under the same meridian; from the equator, if they are both under the equator; and from the quadrant of altitude applied to them, if they are neither under the equator, nor on the same meridian.

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To find the angles of position between two places.

Prob. XXII.—Given two places, it is required to find the angle which a great circle passing through them, makes with the meridian of each.

When the places are under the same meridian, the angles are 0, and when they are under the equator the angles are 90°.

When the places are neither on the same meridian, nor under the equator, place the globe in such a position, that both the places may be in the horizon together, and a line drawn with a pencil along the horizon will be a great circle passing through the places; the globe being then rectified for both places successively, as in Prob. I. and the places themselves brought to the brazen meridian, the arches of the horizon, intercepted between the meridian and the circle passing through the places, will be the measures of the angles required.

Solution of questions in navigation.

This and the preceding problem may be very conveniently applied to the solution of questions in globular sailing. Thus, if the ship be steered on an arch of a great circle, the distance sailed is found by Prob. XXI. and the rhumbs on which the ship must leave the one place and arrive at the other, by Prob. XXII.

Given difference of longitude and latitude, to find the course and distance sailed.

Example 1. A ship leaves A, Lat. 16° south, Long. 5° 50′ west, and sailing on a great circle arrives at B, Lat. 32° 30′ north, Long. 63° 30′ west, required the distance sailed, and the rhumbs on which she left A and arrived at B?

1. Describe on the globe with a pencil a great circle passing through A and B, and find the length of the intersected arch by Prob. XX. which in this case will be about 73° 30′, or 4410 geographical miles.

2. Rectify the globe for the latitude of A, bring it to the meridian, and mark the point where the great circle passing through B intersects the horizon, which will be about 48° from the north point towards the west.

3. Rectify the globe for the latitude of B; bring it to the meridian, and mark the point of the horizon again intersected by the great circle, and which will now be found to be nearly 58° from the north towards the west. It appears, therefore, that a ship sailing from A to B, upon a great circle, must leave A on the rhumb N. 48° W., and gradually changing her course, must arrive at B on the rhumb N. 58° W. having run a distance of about 4410 geographical miles.

Given difference of latitude and course, to find difference of longitude and distance.

Example 2. A ship leaves A, Lat. 16° S. on a course N. 48° W. and sailing on a great circle arrives at B, Lat. 32° 30′ N.; required the difference of longitude and distance between A and B?

Rectify the globe for the latitude of A, and bring it to the meridian. Fix the quadrant of altitude on A, and make its graduated edge intersect the horizon in the given course (N. 48° W.); then the point where the quadrant of altitude intersects the parallel of 32° 30′, is the position of B. The place being thus determined, the difference of longitude may be found by Prob. XVIII. and the distance by Prob. XXI. In this example the former is about 57° 40′, and the latter 4410 geographical miles.

Given difference of longitude and course, to find the difference of latitude and distance.

Example 3. A ship sails from B, Lat. 32° 30′ N. on a course S. 58° E. and when she reaches A, her difference of longitude is 57° 40′; required the difference of latitude, and distanee between A and B, the ship having sailed on a great circle?

Bring B to the meridian, and rectify the globe for its latitude. Place the quadrant of altitude on B, and let its graduated edge intersect the horizon in the given course (S. 58° E.); then the point where the quadrant intersects a meridian, 57° 40′ E. of the meridian of B, will give the position of A, and A being determined, the difference of latitude and distance may be found by Probs. XVIII. and XXI. The former in this example is 48° 30′, and the latter 4410 geographical miles.

Examples of this kind might be multiplied, but the preceding are sufficient to illustrate the general principle. See Navigation.

To find where the sun is vertical for a day.

Prob. XXIII. To find those places in the torrid zone, to which the sun will be vertical, on any given day.

Find the sun's place in the ecliptic by Prob. II. solution 2d, bring that place to the meridian, and mark the degree of the meridian over it; all the places that pass under that degree while the globe revolves, will have the sun vertical that day.

To find where the sun is vertical at an hour.

Prob. XXIV.—The day and hour being given at any place, to find where the sun is then vertical.

Find the sun's declination, or the parallel to which he is vertical that day, and bring the given place and hour to the meridian; then turn the globe, till the 12th hour at noon come to the meridian, and the intersection of the meridian, with the parallel of latitude to which the sun is vertical, will be the place required.

To find when the sun is vertical at a given place.

Prob. XXV.—A place being given in the torrid zone, to find on what days the sun will be vertical there.

Find the latitude of the place, and the points of the ecliptic which have the same latitude; the days in the calendar, opposite to these points, will be the days required.

To find the sun's altitude, &c.

Prob. XXVI.—To find the sun's altitude and azimuth at any given time and place.

Rectify the globe for the given latitude, and bring the sun's place in the ecliptic and the 12th hour of the horary to the brazen meridian. Turn the globe towards the east or west, according as the time is before or after mid-day, till the difference between the given hour and 12 is under the meridian. Fix the quadrant of altitude on the zenith, and make its graduated edge fall on the sun's place in the ecliptic; then the degree of the quadrant over the sun's place will be his altitude, and the point of the horizon intersected by the quadrant his azimuth.

If the sun's meridian altitude be required, it is found by rectifying the globe for the latitude, and bringing the sun's place to the meridian, when the arch of the meridian intercepted between the sun's place and the horizon will be the altitude required. In this case the azimuth is nothing.

To find the circle of illumination.

Prob. XXVII.—To find the circle of illumination for any day, and the places that are above or below it at any hour of that day, reckoning the time at a given place.

Rectify the globe for the latitude to which the sun is vertical, and the horizon will represent the circle of illumination. Bring the given place and hour to the meridian, and turn the globe towards the west or east, according as the hour is before or after mid-day, till 12 of the hour circle be under the meridian; then the horizon will represent the circle of illumination at the given hour. To the places in the western side of the horizon, the sun is rising, to those in the eastern side, he is setting, and to those under the meridian, he is culminating.

To find the hour of the sun rising, &c.

Prob. XXVIII.—To find the hour of the sun's rising or setting, as well as his amplitude, on any day, at any place, whose latitude does not exceed 66° 32′.

Rectify the globe for the latitude of the place, and bring the sun's place in the ecliptic, and the 12th hour of the horary, to the brazen meridian. Then turning the globe eastward till the sun's place be in the horizon, the hour under the meridian subtracted from 12 will be the hour of his rising, and the point of the horizon coinciding with his place will be his eastern amplitude. In like manner, turning the globe westward, till the sun's place be again in the horizon, the hour under the meridian subtracted from 12, will be the hour of his setting, and the point of the horizon, coinciding with his place, will be his western amplitude.

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In solving this problem by the celestial globe, the method now shewn, is the most obvious and natural; because in using the celestial globe, the heavens are supposed to revolve, every point rising above the horizon in the east, and sinking beneath it in the west, while the earth itself remains fixed, and the hour circle is graduated accordingly. But in solving the problem by the terrestrial globe, when the sun is supposed to be stationary at his place in the ecliptic for that day, and the time of his rising or setting to any place, is the time when that place, by the revolution of the earth from west to east, is on the west or east side of the circle of illumination, the following method, when the hours of rising and setting only are wanted, is perhaps more natural.

Find the circle of illumination for the day; bring the given place and the 12th hour of the horary to the meridian; then turning the globe westward till the place is in the horizon, the hour under the meridian will shew the time of the sun's rising, and turning it eastward till the place is again in the horizon, the hour under the meridian will shew the time of his setting. It is an advantage attending this method of solution, that the horary shews the time at once, and by one rectification of the globe, may be found the length of the day, in any latitude between the polar circles, as well as those places within the polar circles where the sun never rises or never sets on that day.

Find the length of the day, &c.

PROB. XXIX.—To find the length of any day or night, at any given place.

Find the hour of sun rising and sun setting by Prob. XXVIII. double the latter will be the length of the day, and double the former the length of the night.

Find how long the sun is present to, or absent from the frigid zone.

PROB. XXX.—To find when, and how long, the sun is present to, or absent from, a given place within the frigid zone.

Rectify the globe for the latitude of the place, and while it revolves on its axis, mark the points of the ecliptic, which coincide with the north or south point of the horizon, according as the place is in the north or south frigid zone. Find the days in the calendar corresponding to these points, and they will be the limits of the time, during which the sun never sets at the given place. If the points of the ecliptic intersected by the opposite point of the horizon be marked, the days corresponding to these points, will be the limits of the time, during which the sun never rises at the place.

The problem may be solved without rectifying the globe thus.

Find the sun's places in the ecliptic when his declination is equal to the co-latitude of the place, and on the same side of the equator; the days, corresponding to these points, will be the limits of the time during which the sun is present to the place. In like manner, find his places when his declination is equal to the co-latitude of the given place, but on the opposite side of the equator; and the days, corresponding to these points, will be the limits of his absence from the place.

Find the latitude where a day is of a given length, &c.

PROB. XXXI.—To find in what latitude any given day, not one of the equinoxes, is of any given length less than 24 hours.

Rectify the globe for the sun's place in the ecliptic, and bring the first, or any other meridian, with 12 of the hour circle, to the brazen meridian; then turning the globe eastward, till the hour denoting half the given length of the day, be under the brazen meridian, the point of the first meridian, intersected by the eastern side of the horizon, will be the latitude required.

The problems, for finding in what latitudes the longest day is of any given length, and for determining the boundaries of the different climates, between the polar circles, are only particular cases of the preceding general problem.

To find the hour of the day, &c.

PROB. XXXII.—To find the hour of the day by exposing the globe to the sun's rays.

Place the globe so that the wooden horizon may be level, and the brazen meridian may coincide with the meridian of the place. Rectify the globe for the latitude, and bring the sun's place in the ecliptic, and 12 of the hour circle, to the brazen meridian. In the sun's place fix a small pin or needle perpendicular to that place, and turn the globe till the pin has no shadow, that is, till it point directly towards the sun; then the hour under the brazen meridian, subtracted from 12, will be the hour of the day.

For various other methods of solving the preceding problem, see Adam's *Astronomical and Geographical Essays.*

To find the beginning, &c. of twilight.

PROB. XXXIII.—To find when the twilight begins in the morning, and ends at night on any day.

Rectify the globe for the latitude of the place: bring the 12th hour of the horary and the sun's place in the ecliptic to the brazen meridian, and fix the quadrant of altitude on the zenith. Turn the globe westward, till the point of the ecliptic diametrically opposite to the sun's place cut the quadrant of altitude 18° above the eastern side of the horizon, and the hour denoting the beginning of twilight in the morning, will be under the brazen meridian. By turning the globe in the opposite direction, till the point opposite the sun's place, be 18° above the western side of the horizon, the hour circle will shew the end of twilight in the evening. In those latitudes where the sun does not sink more than 18° beneath the horizon, the twilight continues all night. See ASTRONOMY, vol. ii. p. 660.

To construct a dial.

PROB. XXXIV.—To construct a horizontal dial by the globe.

Rectify the globe for the latitude of the place, and bring the first meridian to the brazen meridian; the arches of the horizon, intercepted between the first meridian, and the meridians passing through every fifteenth degree of the equator, will be the measures of the angles, which the hour lines must make, with the meridian line.

Example. It is required to construct a horizontal dial for Edinburgh, supposing its latitude to be 56°.

Elevate the north pole 56° above the horizon, and bring the meridian of London to the brazen meridian. While the globe remains fixed in this position, the meridians on each side of the first meridian, and 15° distant from it, will intersect the horizon 77½°, or more accurately 77° 28′ from the east and west points, that is 12° 32′ from the south point, therefore the hour lines for 11 forenoon, and 1 afternoon, must make with the meridian line, each an angle of 12° 32′. The meridians on each side of the first meridian, and 30° distant from it, will intersect the horizon in 64° 25′, that is 25° 35′ from the south point, which is therefore the angle that the hour lines, of 10 and 2, must make with the meridian. In the same manner may be found the angles

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made by the other hour lines, after which the dial is to be constructed according to the directions given under the article DIALLING, § 40. vol. vii. p. 697.

The lines for half hours and quarters may be found in the same way as the hour lines, if meridians be described on the globe, dividing every 15° of the equator, into four equal parts, that is at the distance of 3° 45′ from each other. But as globes have seldom so many meridians, the half hours and quarters may be found thus:

Having disposed the globe as directed above, turn it in either direction, till the brazen meridian intersect the equator in 3° 45′, and the arch of the horizon, intercepted between the brazen meridian, and the first meridian, will be the measure of the angle, which the line of three quarters past 11, or a quarter past 12 must make with the meridian line. Turn the globe in the same direction, till the brazen meridian intersect the equator in 7° 30′, and the arch of the horizon intercepted between the brazen meridian, and the first meridian, will measure the angle which the line of half past 11, or half past 12, must make with the meridian line, and thus every other quarter and half hour line may be found, by bringing successively to the brazen meridian every 3° 45′ of the equator. If the globe is moved only 1° 15′ at once, the successive arches of the horizon, intercepted between the brazen meridian and first meridian, will measure the angles which the lines of every 5 minutes must make with the meridian line, and so of any other subdivision.

To construct a vertical south or north dial, rectify the globe for the co-latitude of the place, and proceed as in the case of a horizontal dial. See DIALLING, § 51, vol. vii. p. 700.—The application of the armillary sphere to the solution of problems, is the same in principle with that of the globes.

CHAP. III.

OF MAPS.

SECT. I. *Of Maps in General.*

General definition.

THOUGH the representation of the terrestrial sphere, by means of a globe, is the simplest as well as the most accurate, it has been found in many respects deficient for the purposes of geography. If the globe be made very large, it becomes expensive and incommodious; if small, the places which it ought to represent are either too much crowded, or altogether omitted. To remedy these defects, geographers have contrived to delineate the earth's surface on a plane, by which means the whole or any portion may be easily represented, on a greater or less scale, according to circumstances. Such representations are in general denominated *maps*, and are also distinguished by particular names, according to their nature or use. Thus a map representing the whole world is called a *planisphere*; if it represent a considerable portion of the globe, it is called a *general map*, and a *particular map* if it contains only a country. When a portion of a country is represented on a large scale, with the direction of roads, the course of small rivulets, and the position of villages and single houses, it is called a *topographical map*. Hence also *mineralogical maps*, intended to illustrate the geological structure of a country; and *nautical maps or charts*, used for the purposes of navigation. With regard to the position of maps, it may be observed, that whatever be

Different kinds of maps.

Planisphere.

Topographical.

Mineralogical.

Nautical.

their nature or use, the north is generally at the top, the east on the right hand, the south at the bottom, and the west on the left hand. The graduation of the equator, or degrees of longitude, are marked at the top and bottom, and the graduations of the meridian, or degrees of latitude, on the right and left sides.

Methods of describing maps.

The various methods adopted by geographers in the construction of maps, may be referred to two principles, PROJECTION and DEVELOPEMENT. By *projection* is meant, a representation of the surface of the sphere on a plane, as it appears to the eye situated at a particular point; and by *developement* is to be understood the unfolding, or spreading out, of a spherical surface on a plane. We are now to explain briefly, the construction of maps according to both of these principles; but as we shall frequently have occasion to employ lines of chords, sines, tangents, secants, &c. we shall here show the method of constructing these lines, and explain so much of their nature and use, as may be necessary for our present purpose.

PLATE CCLX. Fig. 9.

From any point C, (Fig. 9.) draw CA, CD at right angles to one another, and with any convenient radius CA, describe a quadrant ABD. Join AD, and from A as a centre, through every degree of the arch ABD, describe arches intersecting AD, marking these intersections with the corresponding degrees of the quadrant. Then AD will be a *line of chords*. From each degree of the quadrant let fall perpendiculars on AC, and it will be a *line of sines*. Produce CD indefinitely towards E, and through A draw AF parallel to CE. Through the centre C, and each degree of the quadrant, draw lines intersecting AF, and it will become a *line of tangents*. From C as a centre through every intersection of AF, describe arches intersecting DE, and CE will be a *line of secants*. And lastly, through every half degree in the line of tangents, draw parallels to CD, and it will be a *line of semitangents*.

For practical purposes, the lines, after being divided in this manner, are transferred to flat rulers of different sizes, where they are drawn parallel to one another, generally in the following order, chords, sines and secants in one line, tangents, and semitangents. In using them, nothing more is necessary, than to extend the compasses from the extremity of the line, to the number denoting the degrees of the given arch: thus the distances from A to 40 on AD, from C to 40 on AC, from A to 40 on AF, from C to 40 on DF, and from C to 40 on CD, will give respectively the chord, sine, tangent, secant, and semi-tangent of an arch of 40°, the radius of the arch being equal to AC. In any set of lines, the chord of 60°, is always equal to the radius of the quadrant, from which the lines are constructed.

SECT. II. *Construction of Maps by Projection.*

General principles of projection.

IN projecting an object upon a plane, according to the rules of perspective, the *plane of projection*, or that on which the object is to be delineated, is generally supposed to be transparent, and situated between the eye and the object to be projected. The position of the eye is called the *projecting point*, and the straight line drawn from this point, perpendicular to the plane of projection, is termed the axis of that plane. The projection of any point of the object, is the point which it is to occupy, when transferred to the plane of projection, and is always determined from the intersection of that plane, by the ray of light coming from the given point to the eye.

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Different methods of projecting the sphere.

Gnomonic.

Orthographic.

Stereographic.

Globular.

Varieties arising from the position of the sphere.

Polar.

Equatorial.

Horizontal.

The different methods of projecting the sphere, arising from the different distances of the projecting point, are generally reckoned four, the *gnomonic* or *central*, the *orthographic*, the *stereographic*, and the *globular*. In the gnomonic projection, the eye is supposed to be placed in the centre, and the plane of projection is tangent to the pole of the hemisphere to be projected. In the orthographic, the eye is supposed to be at an infinite distance from the sphere, so that the rays of light coming from every point of the hemisphere, may be considered as parallel to one another. In the stereographic projection, the eye is situated on the surface of the sphere, in the pole of the circle of projection. And in the globular, its distance from the sphere is equal to the sine of 45°. In each of these methods of projection as applied to the globe, there may be three different cases, according to the position of the sphere, with regard to the projecting point. These are called the *polar, equatorial*, and *horizontal* projections. In the first, the plane of projection or *primitive circle*, coincides with the equator, and one of the poles is in the centre of the map. In the second, the primitive is a meridian, and a point of the equator is in the centre; and in the last, the horizon is the primitive, of which the given place occupies the centre. We shall now proceed to the mechanical construction of a planisphere or map of the world, according to these different methods, referring to the article PROJECTION, for the investigation of the principles of each.

I. *By Gnomonic Projection.*

General properties.

This method, as its name implies, constitutes the foundation of dialling, but is very seldom used in the construction of maps. The disadvantages with which it is attended in its application to the latter, are the distorted appearance which it gives to countries at a distance from the centre of projection, and the difficulty of describing parallels of latitude, which in the *equatorial* and *horizontal* projections are parabolas, ellipses, or hyperbolas. In the *polar* projection, however, where the primitive is parallel to the equator, this difficulty is removed, the parallels of latitude being projected into concentric circles, while the meridians, which in every case of this method are represented by straight lines, intersect one another in the centre of the projection, forming at that point, the same angles that they do on the surface of the sphere. By this method, therefore, we obtain a very simple and expeditious projection, of the northern or southern parts of the globe, and at the same time a tolerably accurate representation, at least of the polar regions. This projection is shewn in Fig. 10. which is constructed thus.

Construction of a gnomonic polar map.

From the centre P, with 60 from the line of chords, describe the circle WLEM for the primitive, and draw the diameter LM to represent the first meridian. From M set off successively towards E and W the chord of 5, 10, or 15 degrees, according to the number of meridians wanted; and through these points, draw diameters for the meridians required. To find the parallels of latitude, take the tangents of their respective co-latitudes, or distances from the pole, and with these radii, describe concentric circles about the centre P. Thus the tangent of 10°, is the radius of the parallel of 80°, the tangent of 20°, is the radius of the parallel of 70°, &c.; that is, PM is converted by the intersections of the parallels into a line of tangents to radius PM. The parallel of 45° corresponds with the primitive WLEM, after which the radii increase with great rapidity as they approach the equator, which becomes infinite. Hence, a whole hemisphere cannot be projected by this method, and it is obvious from inspection, that of what *can* be projected, the countries farther from the pole than the 60th parallel of latitude, must be very inaccurately represented.

Having drawn the meridians, and described the parallels of latitude as above, the continents, seas, islands, &c. which it is intended to represent, are to be delineated according to their relative situations and extent, the position of every point being determined by the intersection of its meridian and parallel of latitude. This may be considered as a general rule for determining the position of places in all projections; but as meridians and parallels of latitude cannot be described through every degree, the position of any intermediate point in the preceding method, may be found readily thus: Transfer to the edge of a flat ruler the divisions of the line of tangents, then by laying the commencement of this scale on P, and the graduated edge on the degree of the primitive denoting the longitude, the division of the scale corresponding to the co-latitude of the place, will shew the position required.

II. *By Orthographic Projection.*

General properties.

Though this method of projection is more frequently employed in geography than the preceding, it affords but a very imperfect and inaccurate representation of the whole hemisphere. From the position of the eye, the parts of the sphere are seen more and more obliquely as they approach the primitive, and consequently the countries at a distance from the centre of projection are contracted far below their natural limits. The orthographic projection, therefore, though the reverse of the gnomonic as to its defects, is like the latter best adapted for representing countries at a moderate distance from the centre of projection. The representations of the hemisphere on orthographic principles, usually employed in geography, are the polar and equatorial, which are constructed as follows:

Construction of an orthographic polar map. PLATE CCLXV. Fig. 11.

1. *The Polar.* From the centre P, (Fig. 11.) with 60° from the line of chords, describe the primitive WLEM, which will represent the equator, and draw the meridians as in Fig. 10. To find the parallels of latitude, take the sines of their respective co-latitudes, and with these radii describe circles about the centre P. Thus the sine of 10° is the radius of the parallel of 80°, the sine of 20° is the radius of the parallel of 70°, &c. or PM is converted by the intersections of the parallels into a line of sines to radius PM. Hence, to find the radii of the parallels without the help of lines previously constructed, divide ME into as many equal parts as the parallels wanted, and let fall perpendiculars from these divisions on MP; the distances between P and these perpendiculars will be the radii required.

In this projection, the whole hemisphere is represented within the primitive, which in the gnomonic is occupied by the zone of 45° round the pole; but the countries near the equator are very much distorted from their true dimensions.

An orthographic equatorial map. PLATE CCLXVI. Fig. 1.

2. *The Equatorial.* From Æ (Fig. 1. Plate CCLXVI.), with the chord of 60°, describe the meridian WNES for the primitive, and draw the diameters WE, NS at right angles to one another; the former to represent the equator, and the latter a meridian at right angles to the primitive. From Æ towards E, set off Æ*h*, Æ*g*, Æ*f*, &c. equal to the sines of 5°, 10°, 15°, or of 10°, 20°, 30°,

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&c. according to the number of meridians wanted; then elliptic arches described through N *a* S, N *b* S, N *c* S, &c. will represent the meridians, in this case, 10° distant from each other, or whose angles of inclination to the primitive, measured by the arches of the equator intercepted between them, are 10°, 20°, 30°, &c. respectively. Of these ellipses, NS is always the transverse axis, and Æ *a*, Æ *b*, Æ *c*, &c. the semiconjugates. Hence, to find the foci of any given arch N*f*S; from *f* the extremity of the semiconjugate, as a centre, with the radius ÆN, half the transverse, describe an arch intersecting NS in F and F′: these points will be the foci required. The foci being found, the ellipse may be described according to the method explained under CONIC SECTIONS, vol. vii. p. 137, or by any of the elliptic instruments described under the article DRAWING INSTRUMENTS, vol. viii. p. 130. If the whole ellipse N*f*S be described, the other semicircumference will represent the corresponding meridian on the opposite side of NS. The points *a*, *b*, *c*, *d*, &c. may also be found by dividing EN or ES into nine equal parts, and letting fall perpendiculars from every division on EÆ. Straight lines drawn through the divisions of EN, and parallel to EW, will represent parallels of latitude.

PLATE CCLXVI. Fig. 1.

Analemma.

When this projection is made upon the solstitial colure, the planisphere is distinguished by the name of *Analemma*, and is the foundation of a simple instrument of the same name used for the solution of various astronomical problems. See ANALEMMA, and PROJECTION OF THE SPHERE.

The orthographical projection of the sphere on the plane of the horizon, is seldom used in constructing maps, partly from the inaccuracy of representation common to it with the preceding methods, but chiefly from the difficulty of construction, both meridians and parallels of latitude being projected into ellipses. It is applied to the projection of solar eclipses. See ASTRONOMY, vol. ii. p. 744.

III. *By Stereographic Projection.*

General properties.

In delineating maps according to the principles of this projection, the defects of the other methods are in a great measure avoided, both as to the accuracy of representation, and the facility of construction. These advantages are chiefly owing to the two following properties, by which the stereographic projection is distinguished from every other. 1*st*, All circles are projected into circles or straight lines; and, 2*dly*, The projections of any two circles intersect one another in the plane of projection, at the same angle that the circles themselves do on the surface of the sphere.

In maps of the world constructed on stereographic principles, the projection is generally made on the plane of a meridian, the eye being successively placed in the poles of that meridian, opposite the hemisphere to be projected. As the method, however, is of very extensive application, we shall give an example of all the three cases.

Construction of a stereographic polar map.

PLATE CCLXVI. Fig. 2.

1. *The Polar.* From P (Fig. 2.) with 60° from the line of chords, describe the primitive WLEM, in this case the equator, and draw diameters for meridians as in the gnomonic polar projection. To project the parallels of latitude, take from the scale the semitangents of their complements of latitude, or distances from the pole, and with these radii describe concentric circles about P. Thus the semitangent of 10° will be the radius of the parallel of 80°, the semitangent of 20° will be the radius of the parallel of 70°, &c. that is, PM by the intersections of the parallels, is converted into a line of semitangents to radius PM. The radii of the parallels may also be found thus: From W draw straight lines to every tenth degree of the quadrant ME, intersecting the line MP in 10°, 20°, 30°, &c. then the distances between P and these intersections will be the radii of parallels for every tenth degree of latitude.

2. *The Equatorial.* In this method, which is most frequently used in constructing terrestrial maps, the meridian of any place may be taken for the primitive, or plane of projection; but for the more convenient representation of the earth in two hemispheres, it is usual to take one of those meridians, which nearly separate the eastern and western continents. In British maps, the projection is generally made on the plane of the meridian 20° west from the meridian of London, that is, the projecting points are in the equator 70° east and 110° west from the first meridian. The projection of meridians and parallels of latitude, according to this method, is represented in Fig. 3. which is constructed thus.

A stereographic equatorial map.

PLATE CCLXVI. Fig. 3.

From Æ with the chord of 60° describe the meridian WNES for the primitive, and through the centre draw WE and NS at right angles to one another, the former representing the equator, and the latter a meridian at right angles to the primitive. From Æ, set off on Æ, Æ *a*, Æ *b*, Æ *c*, &c. the tangents of 5°, 10°, 15°, &c.; or of 10°, 20°, 30°, &c. according to the number of meridians wanted, and from these divisions as centres, describe arches of circles passing through the poles P and S; these arches will be the projections of meridians between Æ and W. In the same manner may be described meridians on the other side of NS. In Fig. 3. Æ *a*, Æ *b*, &c. are the tangents of 10°, 20°, &c. therefore the arch described from *a*, viz. N *m* S next to W, is 80° from N Æ S, the meridian passing through the projecting point, that described from *b*, viz. the second from W is 70° from the same meridian, and so of the others, always measuring the distance between two meridians, or the angle which they make with each other, by the arch of the equator intercepted between them. If the second from W be taken to represent the meridian of London, the primitive WNES will embrace the whole of the eastern continent, or old world, except a small part of the north-east point of Asia, without including any part of America, and the other meridians will be reckoned both ways towards the east and west. In the present case, however, as our object is not to exhibit an actual map of the earth's surface, but only the imaginary lines with which it is supposed to be intersected, we shall assume NÆS as the first meridian, by which means our references to the Figure will be more obvious and distinct.

Before proceeding to the projection of the parallels of latitude, it may be proper to notice another method, besides that already explained, of describing meridians, viz. by determining the points in which these circles must intersect the equator WE (Fig. 4.) This is done by setting off from Æ towards W and E, Æ 10, Æ 20, Æ 30, &c. equal to the semitangents of these arches respectively. Then three points being given, viz. N, S, and 10, 20, or 30, in the equator WE, a fourth may be found, which shall be the centre of a circle passing through the other three. To determine this fourth point or centre, draw lines from N and S to the point in the equator through which the meridian is to pass, bisect these lines, and erect perpendiculars at the points of bisection; these perpendiculars will meet WE in the point required. See GEOMETRY, SECT. II. PROB. XI.

Fig. 4.

Though both these methods of describing meridians imply the use of lines of tangents, or semitangents,

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yet the projection may be performed without the assistance of these lines. Thus, in the first method, divide the quadrants WN and ES, Fig. 3. into degrees, and from S, through every tenth degree of each, draw straight lines intersecting WE on both sides of Æ; then the parts of WE contained between every two corresponding points of intersection, will be the projected diameters of the meridians, whose distance from the first meridian, is equal to the distance of the points in the quadrants from the poles. Thus the straight line drawn from S to 10 in the quadrant WN, will intersect ÆW in *m*, and the line joining S and 10 in the quadrant ES, will intersect ÆE produced in *e*, wherefore *m e* is the projected diameter of the meridian, 80° distant from NÆS. If then *m e* be bisected, the point of bisection will be the centre, and half the line bisected will be the radius of the meridian N *m* S. In the same manner may be described the other meridians on either side of NÆS.

Plate CCLXVI. Fig. 3.

In the second method, where it is required to find the points of the equator through which any given meridian is to pass, draw a straight line from S, Fig. 4. to the point of the quadrant WN, or EN, whose distance from N is equal to the distance of the given meridian from the first meridian, and it will intersect ÆW or ÆE in the point required. Thus the line joining S and 10 in the quadrant WN will intersect ÆW in 80, the point through which the meridian must pass, whose distance from the first meridian is 80°. This point being determined, the centre may be found as before.

Instrument for describing meridians.

In projecting maps on a large scale, it becomes extremely difficult to determine the centres, and still more so to describe, with accuracy, the arches of meridians at small distances from the first meridian. To remedy this inconvenience, an instrument has been invented of a very simple construction, by which these arches may readily be described, the extremities and one intermediate point being given.* When this intermediate point is determined, as in the preceding paragraph, and the circle described by means of the instrument now mentioned, the operation is perhaps as much simplified as the nature of the subject will admit of.

To describe the parallels of latitude in this projection, set off from Æ (Fig. 3.) on ÆN produced, the secants of the co-latitudes of the parallels, and from these points as centres, with radii equal to the distances between them and the points in the quadrants WN, EN, denoting the latitudes, describe arches, and they will be the parallels required. Thus the secant of 30° set off from Æ to *f*, on ÆN produced, will be the centre of the parallel of 60° north latitude, and the distance between that point and 60 in the quadrant WN, or EN will be the radius of the parallel.

The centre of any given parallel, as 60, may also be determined thus: From E, draw straight lines through 60 in each of the quadrants EN, WN, intersecting ÆN, and ÆN produced, in the points *g* and *h*, then the part of ÆN contained between these points will be the projected diameter of the parallel of 60. If, therefore, this line be bisected, the point of bisection will be *f*, the centre; and half the line bisected will be the radius of the parallel.

If the semi-tangents of 10°, 20°, 30°, &c. be set off from Æ towards N, they will give the points in which the parallels of 10°, 20°, 30°, must intersect ÆN. Thus the semitangent of 60° set off from Æ towards N, gives the point *g*. In every parallel, there will thus be given three points, viz. the extremities in the quadrants WN and EN, and an intermediate point in ÆN; and consequently the parallel may be described either by finding its centre, or applying the instrument formerly mentioned, in the projection of meridians. The intermediate points in ÆN may also be found without a line of semitangents, as in the last paragraph, viz. by drawing lines from E to every tenth degree of WN. In the same manner may be described the parallels on the other side of the equator.

3. *The Horizontal.* Though this projection is not so frequently used as the preceding in constructing a map of the world, it is more convenient, as we shall afterwards shew, for some particular purposes, and is therefore not to be omitted in a system of mathematical geography. The projection of the equator, meridians, and parallels of latitude on the horizon of any given place, as Edinburgh, Lat. 56° N. is as follows.

A stereographic horizontal map.

Plate CCLXVI. Fig. 5.

From C (Fig. 5.) with 60 from the line of chords, describe the circle WNES for the primitive or horizon of the place C, and draw NCS, WCE at right angles to each other, the former representing the meridian of the place, and the other a great circle 90° distant from it, and which, on the celestial sphere, is called the Prime vertical. From C set off on CN, the semitangent CP of the co-latitude, in this case 34°, and P will be the projection of the north pole. From the same point set off on CN and CS, CÆ equal to the tangent of the co-latitude (34°), and CQ equal to the semitangent of the latitude (56°); then a circle described from Æ as a centre with the radius ÆQ will pass through W, E, and represent the equator. To project the meridians, set off from C on CS, or CS produced, CA equal to the tangent of the latitude (56°), and through A draw BD at right angles to CA. From P, with 60 from the line of chords, describe the quadrant *v w*, and from *v* set off on this arch the chords of 10, 20, 30, &c.; then a ruler laid between P and each of these divisions, will intersect AD in *a*, *b*, *c*, *d*, &c. the centres of the meridians between S and W. Thus AP will be the radius of the meridian WPE, 90° distant from the first meridian NPS; *a* P will be the radius of 80 P 100, the meridian 10° distant from the last, or 80° from the first meridian, and so of the others. In the same manner may be described the meridians on the other side of NS from centres in the line AB. In determining the centres of the meridian, it is convenient to describe the quadrant *v w* with 60 from the line of chords, because the chords of 10, 20, 30, &c. may be set off from the same line, without the trouble of dividing the quadrant. It is not necessary, however, nor indeed is it always proper, to take that particular radius, as any other will answer the same purpose; and the greater it is, the more accurately will the points in BD be determined, particularly such as are at a great distance from A.

In the preceding method, the points P, Q, Æ, A, are determined by the lines of tangents and semitangents; but they may also be found without the help of these lines thus: Having described WNES, and drawn NS, WE as before, set off from N towards E, the arch NP′ equal to the latitude of the place (56°), and join P′W; the line P′W will intersect CN in P, the projec-

* This instrument consists of two rulers AB, CB (Fig. 12. Plate CCLXV.) fastened together by a joint B, so as to form any required angle ABC, a pen or pencil being fixed in the angular point B. In using the instrument, this pen is placed on the intermediate point of the arch to be described, and pins being fixed, or weights laid at the extremities of the arch, the limbs AB, CB are extended so as to touch these pins or weights. In this state the whole instrument is moved round, the two sides being always pressed against the pins or weights, and the point at B describes the arch required. The principle of the instrument depends on the property of the circle, that all angles in the same segment are equal to one another. See Geometry, Sect. II. Prop. XVII. and Drawing Instruments.

tion of the north pole. From P′ draw the diameter P′C p′, and at right angles to this diameter draw another æ′ C q. From W through the extremities of this diameter, draw W q and W æ, intersecting CS in Q and CN produced in æ, and bisect æ Q; the point of bisection will be Æ the centre, and half the line bisected will be ÆQ the radius of the equator WQE. To find the centres of the meridians, join W p′, and produce the line till it meet CS produced in p; bisect P p, and the point of bisection will be A the centre; and half the line bisected will be AP, the radius of the meridian WPE at right angles to the first meridian NPS. The centres of the other meridians are found as before in BD, drawn through A, at right angles to AN.

In this, as in the equatorial projection, it becomes difficult to describe the meridians that make small angles with the first meridian, their centres being at a great distance from the point A. This inconvenience, however, will be in a great measure remedied by the following construction.

Plate CCLXVI. Fig. 6.

From C, (Fig. 6.) describe WNES, find Æ, P, Q and A, and draw P′ p′ and BD, all as in Fig. 5. From A draw A f perpendicular to P′p′, and on AC set off Ag, equal to A f. From g as a centre, with any radius as gA, describe a quadrant AG, and divide it into degrees from A towards G. Through g, and every tenth degree of AG, draw straight lines intersecting AD in a, b, c, d, &c. and from these points draw straight lines through C: these lines will intersect the primitive in the points through which the corresponding meridian is to pass. Now, as every meridian must pass through P, there will be given three points in each, viz. 10, P, 170 in the meridian 10° from NS, 20, P, 160 in the next, and so on; the circle may therefore be described by the instrument formerly mentioned in the equatorial projection. In this construction, the point in AD, next to A, gives the intersections of the meridian nearest to NS, and in the method explained in last paragraph the point next to A is the centre of the meridian farthest from NS. By a combination of the two methods therefore, all the meridians may be determined by means of points at a moderate distance from A.

To project the parallels of latitude, set off from C, (Fig. 5.) on NS, the semitangents of the greatest and least distances of the parallel from C, and bisect the part of NS contained between these points; the point of bisection will be the centre, and half the line bisected will be the radius of the parallel. Thus let it be required first to project a parallel to the north of the given place, as of 70° north latitude. Since the parallel extends 20° on each side of the pole P, and C is 34° distant from P, the nearest point of the parallel to C is between C and P $34°—20°=14°$ from the former, and the opposite or most distant $34°+20°=54°$. From C therefore, set off towards N the semitangents of 14° and 54° to r and s, and bisect r s; then the middle point of r s will be the centre, and half the line will be the radius of the parallel required. Secondly, let the parallel to be projected be the 56th, or that whose distance from the pole is equal to the co-latitude of the place. In this case it is obvious, that the circle must pass through C on the one side, and on the opposite it will cut CN in Æ, at the distance of the semitangent of $34°+34°=68°$. The distance therefore between C and that point being bisected, it will give the centre of the parallel. Lastly, let the parallel be to the south of the given place, as, for example, that of 30°. Here the distance of the circle from P is greater than PC by $60°—34°=26°$, or its nearest distance from C is 26° towards S, while its greatest distance is $60°+34°=94°$. From C therefore, set off towards S the semitangent of 26° C f, and from C towards N the semitangent of 94° C g, and bisect the distance between these points as before.

Parallels of latitude may also be projected, without the line of semitangents, thus: Divide the primitive into degrees from P′ (Fig. 6.) in both directions, and through the degree denoting the co-latitude of the parallel to be projected, draw lines to W, intersecting NS or NS produced in two points. Bisect the portion of NS contained between these intersections, and the circle described from the point of bisection with a radius equal to half the line bisected, will be the parallel required. Thus, if straight lines be drawn from the 20th degree on each side of P′ to W, the intersection of these lines with NS, will give the points r and s, as in Fig. 5.

IV. *By Globular Projection.*

General properties.

Plate CCLXV. Fig. 7.

Though we have classed this method of projection under a separate head, it is, strictly speaking, to be considered as a modification of the stereographic. As originally proposed by its inventor De Lahire, it is not indeed very frequently employed, but it has given rise to a mechanical method, which, from the facility of construction, is likely to become more and more common in projecting maps of the world, on the plane of a meridian. According to Lahire's method, the projecting point, as was formerly observed, is distant from the surface of the sphere, the sine of 45°, that is, if the diameter or meridian NS (Fig. 7.) be equal to 200, the distance NP of the projecting point P is equal to 70. Having determined P, divide SW, SE into degrees, and from P draw straight lines to every tenth division, intersecting ÆW and ÆE. Through these points of intersection, and the two poles N, S, describe ellipses, and they will be projections of meridians. By this construction, it is found, that the straight line from P to 45 in the quadrant SW or SE divides the radius ÆW or ÆE into two equal parts; but to render the other division of these radii nearly equal, the projecting point P must be only at the distance of 59½ from N, NS being equal to 200. This equality, however, may be obtained mechanically thus, without regard to the position of the projecting point.

Construction of a globular quatorial map. Fig. 8.

From C, (Fig. 8.) with 60 from the line of chords, describe the primitive WNES representing a meridian, and draw the diameters NS, WE at right angles to one another, the former representing a meridian at right angles to the primitive, and the latter the equator. From W and E set off in both directions towards N and S, the chords of 10°, 20°, 30°, &c. and divide each of the semidiameters CN, CE, CS, CW into 9 equal parts, in the points 10, 20, 30, &c. then circles passing through the poles N, S, and the divisions of the semidiameters CW, CE, will be meridians 10° distant from each other, and circles passing through the divisions of the quadrants WN, EN, and the semidiameter CN, or through the divisions of WS, ES, and the semidiameter CS, will be parallels, the former of north and the latter of south latitude, 10° distant from one another. These circles may be described, either by finding the centres, which will always be in the diameters WE, NS, or in these diameters produced, and which may be determined from the three given points in the circumference; or if the centres be at a great distance from C, by employing the instrument formerly mentioned in the stereographic projection. Upon this principle is constructed the planisphere, Plate CCLXVIII.

Plate CCLXV

Having thus briefly explained the various methods usually employed by geographers, for delineating on a plane the imaginary lines with which they suppose the surface of the earth to be intersected, we might go on to apply the same principles to the projection of the celestial sphere, or the construction of a map of the heavens. As this, however, does not properly apply to geography, we shall proceed to take a short view of the comparative defects and merits of the projections now explained, as applicable to the construction of terrestrial maps.

As the principal object of a planisphere, or map of the world, is to determine the longitude and latitude of particular places, with their distances and bearings from each other, and to exhibit a view of the figure, extent, and relative positions of the different countries, that projection is to be preferred, which determines all these particulars most accurately, and with the greatest facility. In none of the preceding methods, however, nor indeed in any other method, are all these properties united. In the gnomonic polar projection, as we formerly observed, the position of any place to be projected, and consequently the situation of a place after it has been projected, is easily determined, by applying a line of tangents to the centre, and making its graduated edge fall on the degree of the primitive denoting the longitude. The distance between two places that are in the same meridian, or under the same parallel of latitude, may also be easily and accurately determined from this projection. In the former case, lay the extremity of the line of tangents on the centre, and make its graduated edge pass through the two places, then the difference of the numbers on the scale between the two places will shew their difference of latitude in degrees, or the arch of a great circle intercepted between them, from which their distance in miles may be easily ascertained. In the second case, when the places are under the same parallel of latitude, by laying the ruler successively over each, and referring to the divisions in the primitive, the arch of the parallel of latitude intercepted between them will be determined, and the latitude being known, the length of that arch may be found in miles by means of the Table, at page 151. Of the latter, indeed, it is to be observed, that the rule holds only in the case of short distances, when the arch of a parallel of latitude intercepted between two points does not sensibly differ from an arch of a great circle intercepted between the same points. With these advantages, however, the projection is in other respects very defective. The distance between two places, not under the same meridian or parallel of latitude, can only be found by an operation far too tedious and complicated for ordinary use, while countries at a distance from the pole are very much extended beyond their true figure and dimensions.

In the orthographic polar projection, the advantages and disadvantages are nearly the same as in the gnomonic. The situation of places, and their distance from each other, when under the same meridian or parallel of latitude, are found by means of a line of sines instead of tangents; but the figure and dimensions of countries at a distance from the pole, are as much contracted below the truth, as in the former case they were extended beyond it. In the equatorial projection, it is more difficult than in the preceding methods to determine the longitude of any given point, the circles of longitude or meridians being ellipses. To the young geographer, however, this method will be found extremely useful, as calculated to convey a very distinct idea of the earth's sphericity.

The stereographic polar projection affords the same facility of finding the positions of places, by means of a line of semitangents, that the gnomonic and orthographic polar projections do, by means of tangents and sines. By the former may also be readily found the distance between places under the same meridian, or if they are not far from each other, under the same parallel of latitude, and it possesses the additional advantage of representing the different countries more nearly, according to their true figure and dimensions. In other respects, it does not materially differ from the other polar projections.

Equatorial. In the stereographic projection on the plane of a meridian, the principal advantages compared with the corresponding orthographic projection, are the simplicity of its construction, and greater accuracy of its representations. In neither, however, is it easy to find the distance between places not under the same meridian; nor is it possible to exhibit exactly the different portions of the globe according to their true figure and dimensions. In the orthographic, the countries at a distance from the centre of the map are very much contracted, and in the stereographic they are considerably, though not in the same proportion, expanded. The convenience formerly mentioned regarding the division of the globe into the eastern and western hemispheres, is common to both; and, indeed, to all projections in which the primitive coincides with the plane of a meridian.

Horizontal. The principal recommendation of the stereographic projection on the plane of the horizon, is the facility it affords of solving a problem which, in all the preceding methods, can only be effected by an operation too abstruse for the purposes of practical geography. The problem alluded to is, to find the distance between any two places on the surface of the globe, whatever may be their positions relatively to one another. Thus, if it were required to find the distance between Edinburgh and any other place, project the sphere on the horizon of Edinburgh, and construct a line of semitangents to the radius of the projection; then laying the extremity of the scale on the centre of the map, with its graduated edge on the given place, the number of the scale over the place will be the distance required in degrees of a great circle. If the place does not lie within the primitive, that is if it be more than 90° distant from Edinburgh, the map may be extended beyond the primitive so far as to include it; or, what is perhaps better, the opposite hemisphere may be projected, and the distance of the place from the centre of this hemisphere subtracted from 180, will give the distance required. By this projection may also be found the angle of position which any given place makes with the place in the centre, thus: Divide the primitive or horizon into degrees from the north and south points towards the east and west; then applying the scale as before, its graduated edge will cut the horizon in the angle required. But though the solution of these problems may in some cases be very desirable, the horizontal projection is, upon the whole, very inconvenient for a map of the world, particularly from the difficulty of determining, on such a map, the longitude and latitude of places which do not happen to lie under any of the meridians or parallels of latitude. This defect, indeed, is common to it with the equatorial projections, and it may be observed of them all in general, that as it is impossible to combine in one the whole, or even the principal properties of each, we must be satisfied with gaining one advantage by the sacrifice of another. *Globular.* For ordinary purposes, the globular projection is, after all, perhaps the best in constructing a map of the world. Simplicity of construction, tolerable accuracy in the

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representation of different countries, and facility in finding the longitude and latitude of any given place, are the characteristic properties of this projection; and, to the majority of those who have most occasion to consult such maps, these properties are by far the most important.

SECT. III. *Construction of Maps by Developement.*

Developement of different bodies.

IN the various methods of projecting the sphere, as explained in the preceding Section, the reader cannot fail to observe, that, besides the inaccurate representation of different portions of the earth's surface, common in some measure to them all, they are also attended in practice with considerable difficulty and inconvenience. This difficulty increases with the scale of the projection; and, in the delineation of small portions of the earth's surface, it becomes so great as almost to prevent the application of any of them, to the construction of such maps. To remedy this defect, geographers have had recourse to the method of *developement*, or that which supposes the earth's surface to be spread out on a plane. But as a sphere or spheroid is a body that does not admit of its surface being so extended, it must be supposed to be converted into some other body, as much as possible resembling the sphere, and whose surface is at the same time susceptible of such a developement. The only bodies of this kind with which the sphere can be at all compared, are the *cone* and *cylinder;* and accordingly, both have been employed for this purpose.

I. *Of the Cone.*

General principle. PLATE CCLXVI. Fig. 9.

The principle of this developement, or projection as it is sometimes called, may be shortly explained thus. Let WNES (Fig. 9.) be the sphere of which it is proposed to develope any portion, as the fourth part WNE, WE the equator, SN the meridian at right angles to WNES, and ML the radius of the middle parallel, or that which divides the part to be developed into two equal parts in the direction of latitude, in this case 45°. Draw MA and M′A at right angles to the radii CM and CM′, and meeting SN produced in A; that is, make MA and M′A the cotangents of the latitude of the middle parallel; then AM and AM′ will be the sides of a cone, tangent to the sphere at M and M′, and of which any zone, extending to a moderate distance on each side of MM′, may, without any sensible error, be considered as equal to the corresponding zone of the sphere. From A with the radius AM describe the arch M *m* M′; then, if the radius CN and the arch M *m* M′ be both divided into equal parts, arches described from A through the former will be the projected parallels of latitude, and straight lines drawn from the same point through the latter will represent meridians, both at greater or less distances from one another, according to the number of divisions. The arch M *m* M′ will be the parallel of 45°.

By this projection may be obtained a tolerably accurate representation of a small portion of the globe; but when it is extended to a considerable space, as the fourth part of the whole sphere, the countries towards the pole and the equator are extended a great deal beyond their true limits, in the direction of their latitude. Various methods of remedying this defect have been adopted or recommended by different geographers; but the simplest, as well as the most successful, is that known by the name of *Flamstead's projection.* It was so denominated at first from its inventor, and it still retains the name, though since his time it has undergone various alterations. In its most improved form, the construction is as follows.

Flamstead's projection. Fig. 10.

Draw an indefinite straight line NS (Fig. 10.) to represent the middle meridian of the map, and from the point M, near the middle of the line, set off on both sides towards N and S equal distances of any convenient length, to represent degrees of latitude. Suppose, for example, that the map is to contain 60 degrees of latitude, viz. from the 20th to the 80th parallel, and that this extent is to be equal to three inches; then each degree will be equal to $\frac{1}{20}$ or .05 *in.*; the point M will be in the parallel of 50°, and the distance of $\frac{1}{2}$ or .5 *in.* set off towards N and S will give the points through which the parallels of 40°, 30° and 20° must pass on the one side, and those of 60°, 70° and 80° on the other. The centre C of these parallels will be in the line NS towards N, and may be found thus.

Let d be the length of the assumed degree of latitude,
l the latitude of the middle parallel, or M, and
d' the length of an arch of 1° to radius 1; then

$$d' : \text{cotan. } l :: d : \text{MC} = \frac{\text{cot. } l \times d}{d'}.$$

Now, in this example, $d = .05$ *in.*, $l = 50°$, and $d' = \frac{3.14159}{180} = .01745329$; therefore,

$$\text{MC} = \frac{.05 \times \text{cotan. } 50}{.01745329} \text{ inches.}$$

The computation is performed most conveniently by logarithms, thus:

Log. .05	$\bar{2}.698970$
Log. cot. 50° to Rad. 1	$\bar{1}.923813$
	$\bar{2}.622783$
Log. .01745329	$\bar{2}.241876$
Log. MC	0.380907

and MC = 2.4038 inches.

From M, therefore, set off towards N, MC = 2.4 *in.* and from C as a centre through each of the divisions in NS, describe arches for the parallels of latitude.

To find the meridians, take any parallel, as the middle one passing through M, and from the table of degrees of longitude, p. 151, take the length corresponding to the latitude of the parallel, multiply it by the length of the assumed degree, and that product again by the number of degrees to which the map is to extend on each side of the middle meridian; the last product will express the distance from M at which the extreme meridian will intersect the middle parallel. Thus, in the present example, let the map extend 40° on each side of NS; that is, let it include 80° of longitude, and the calculation becomes—

Degree of longitude in lat. 50	.64279
Length of the assumed degree in inches .	.05
	.0321395
Half longitude of the map	40
	1.2855800

From M, therefore, set off on the middle parallel both ways, 1.285 *in.* and it will give the limits of the map on that parallel. Corresponding points being determined, in the same way, on each of the other parallels, the curves passing through these points will be the meridians bounding the map on the east and west. To find the other meridians, divide the arch of each parallel between the middle and extreme meridians, into as hemati- Geogra- phy.

many equal parts as the number of meridians wanted on each side of NS, and curves drawn through the corresponding points will be the meridians required. In the above example, each of the arches being divided into four equal parts, will give a meridian for every tenth degree. If the parallels are at such a distance from one another as to render it difficult to describe the meridian curves with sufficient accuracy, intermediate parallels may be described with a pencil point, and afterwards erased.

eding nod not accu-

It may be proper to observe, that the preceding method of determining the limits of the map on each parallel, gives the extent somewhat too great, the chord of the arch M*m*, instead of the arch itself, being assumed equal to 1.285 *in.* In ordinary cases, indeed, this difference is too small to affect the accuracy of the map, and therefore an expeditious and convenient method of construction is not to be abandoned, on account of an error which is scarcely, if at all, sensible. The truth of this remark will be obvious from the following method of determining the arch of the middle parallel, by which the length of the chord is obtained with perfect accuracy.

ount of rror de- ined.

As the arch of the middle parallel of latitude M*m*, (Fig. 9.) is terminated on the sphere, and in the projection by the same points, but has for a radius, in the former case the cosine, and in the latter the cotangent of the latitude, the number of degrees which the arch contains in the projection, will be less than the number which it contained on the globe, or which it represents in the projection, in the same proportion as the cosine of the latitude is less than the cotangent. Hence, if a denote the amplitude of the arch of the middle parallel l on the sphere, or the number of degrees to be represented between the middle and extreme meridian of the map, and a' the amplitude of the same arch in the projection, as described from the centre of the parallel, or the angle which a straight line, drawn from the extremity of the parallel to the centre, makes with the middle meridian, we have

$$\text{cotan.}\, l : \cos.\, l :: a : a' = a \times \frac{\cos.\, l}{\cot.\, l}.$$

But $\frac{\cos.\, l}{\cot.\, l} = \sin.\, l$ to radius $1 = \frac{\sin.\, l}{r}$ to radius r; therefore $a' = \frac{a \times \sin.\, l}{r}$, and by logarithms,

$$\log.\, a' = \log.\, a + \log.\, \sin.\, l - \log.\, r.$$

Let now half the longitude of the map be as above 40°, and let it be required to find the extremity of the middle parallel M*m*, (Fig. 10.)

In this case $a = 40$ and $l = 50°$, therefore

$$\log.\, a' = \log.\, 40 + \log.\, \sin.\, 50° - \log.\, r.$$

Log. 40	1.602060
Log. sin. 50°	9.884254
	11.486314
Log. r	10.000000
Log. a'	1.486314
a'	30°.641 = 30° 38′ 27″

therefore a straight line drawn from C, and making an angle with MC = 30° 38′ 27″, will intersect M*m* in the point through which the meridian must pass, whose distance from NS = 40°. By a similar, though a more tedious calculation, the amplitudes of the other parallels may be determined: but without entering upon these calculations, we shall proceed to find what is the real difference between the two methods in point of accuracy. In the case of the middle parallel, it has been shewn, that the angle MC*m* = 30° 38′ 27″, and joining *m*M, we have in the isosceles triangle CM*m* an angle C, and a side *m*C. If the triangle therefore be resolved, the base *m* M, or the chord of the arch *m* M, will be found to be 1.27 *in.* which gives for the excess of the former method .015 *in.*: an error which in almost all cases may be safely overlooked.

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The characteristic property of this projection is, that all the quadrilaterals formed by meridians and parallels of latitude have nearly the same ratio to one another on the map, that the corresponding quadrilaterals have to each other on the sphere. It is also a consequence of this property, that distances on the map may be readily and correctly measured by a scale of equal parts. This scale may be constructed as follows.

Scale of the map. PLATE CCLXVI. Fig. 11.

From any point A (Fig. 11.), draw a straight line AB, equal to any number of the assumed degrees of latitude, as for example 60, and from the same point draw an indefinite straight line AC, making any angle with AB. Then, suppose the scale is to be divided so as to represent English miles, the whole will contain 69.045 × 60 = 4142.7, or nearly 4140. From any scale of equal parts, set off from A towards C 4 divisions, and .14 of another division, and let them terminate at D. Join DB, and through the divisions of AD draw straight lines parallel to DB, and intersecting AB in the points 1, 2, 3, 4; each of these divisions will represent 1000 English miles, except the last, which will be 140, and the distance between two places on the map applied to this scale will give their distance in miles.

II. *Of the Cylinder.*

General principle. PLATE CCLXVII. Fig. 1.

The principle of this developement may be explained in a manner analogous to that of the cone. Let WNC, (Fig. 1. Plate CCLXVII.) be the eighth part of a sphere, a portion of which it is proposed to develope, and let M*m* be the radius of the middle parallel of that portion. Then if a cylinder ABCN, equal in diameter to the radius of the middle parallel, be partly inscribed in the sphere, and partly circumscribed about it, a zone of the cylinder to a short distance, on each side of M*m*, may be considered as very nearly coinciding with the corresponding zone of the sphere. If the former, therefore, be developed, or spread out, the parallels of latitude will be straight lines parallel and equal to M*m*, and the meridians will also be straight lines, cutting the parallels of latitude at right angles; that is, they will be parallel to one another, and equal in length to the breadth of the zone. Upon this principle is constructed the *Plane Chart*, as follows.

Plane chart.

Suppose the chart is required to extend from 40° to 60° north latitude, and from 10° west to 10° east longitude; that is, to contain 20° of latitude and 20° of longitude. Describe a parallelogram ABCD, (Fig. 2,) making BC of any convenient length, and AB : BC :: cos. of the middle latitude (50°) : radius. Divide AB and BC each into four equal parts, and straight lines drawn through these points parallel to BC and AB, will be meridians and parallels of latitude five degrees distant from one another. If necessary, intermediate parallels and meridians may be drawn in the same way.

Fig. 2.

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Mercator's chart.

It is obvious, from inspecting Fig. 1, that a chart constructed on this principle may, for a few degrees on each side of the equator, be tolerably correct; but that the inaccuracy increases with the distance from the equator, and in high latitudes becomes excessive. To obviate this inconvenience, another method of develepement has been invented, known by the name of *Mercator's projection.* In this method, as in the former, meridians and parallels of latitude are straight lines cutting one another at right angles, the degrees of longitude being of course the same in all latitudes; but in order that the degrees of latitude and longitude may preserve their true proportions to one another, the former are made to increase on the map, in the same ratio that the latter diminish on the sphere. The distances from the equator, or from one another, at which the parallels of latitude ought to be drawn according to this principle, can only be determined accurately by the application of the fluxional calculus: (see FLUXIONS, vol. ix. p. 463); but an approximation to these distances may be found as follows:

General principle of Wright's method.

PLATE CCLXVIII. Fig. 3.

Let PE (Fig. 3.) represent the quadrant of a meridian, CE the equator, and DE any arch of PE; then DG will be the sine, CG or DH the cosine, EF the tangent, and CF the secant of the arch DE. Now by similar triangles (see GEOMETRY) CG : CD : : CE : CF, or taking l for the latitude of D, cos. l : rad. : : rad. : sec. l. But since circles, or arches of circles, are to one another as their radii, rad. : cos. l : : an arch of the equator : a corresponding arch of the parallel l; or supposing the earth to be a sphere, rad. : cos. l : : an arch of the meridian : a corresponding arch of the parallel l. Hence if d represent the length of a degree of the meridian, and d' the length of a degree of the parallel l on the globe,

$$\text{sec. } l : \text{rad.} :: d : d'.$$

But on the map, the natural degree of the meridian d, must be increased in the same ratio as d' is diminished on the sphere; that is, taking ∂ to denote the lengthened degree of the meridian.

$$\text{rad.} : \text{sec. } l :: d : \partial = \frac{d \times \text{sec. } l}{\text{rad.}}.$$

When d and rad. are both $=1$, the formula becomes $\partial = \text{sec. } l$; that is, when the natural degree of the meridian and radius are both assumed $=1$, the length of any degree of latitude will be expressed by the secant of that latitude. But no degree of the meridian, nor indeed any arch of a definite length, can have all the same latitude l, and therefore in the equation $\partial = \text{sec. } l$ ∂ is to be understood as the projection of an indefinitely small arch d, assumed equal to unity. Now any arch of the meridian DE, is made up of an indefinite number of such arches, and therefore the projection of DE, or the distance of the parallel l from the equator, is equal to the sum of the secants of an indefinite number of arches, each of which is assumed equal to unity. This distance, as was formerly observed, can only be found accurately by fluxions, but an approximation is obtained by dividing DE into a number of small arches, each being reckoned unity, and finding the sum of their secants. The greater the number of parts, the greater also will be the accuracy of the approximation. This principle was first explained, and applied to the construction of charts, by Mr Wright in 1599, who determined the distance of each parallel to 1 minute of the quadrant, by finding the sum of the secants, of all the arches of 1 minute, from the equator to that parallel. These distances he arranged in a table which is denominated a table of *meridional parts,* and which is still employed in constructing charts, as in the following examples.

Chart of the world on Mercator's projection.

1. Let it be required to construct a chart of the world, according to Mercator's projection.

Through the point C (Fig. 4.) intended to be the centre of the map, draw two indefinite straight lines WE, NS at right angles to one another, the former representing the equator, and the latter the first meridian. From C by means of any convenient scale of equal parts, set off towards W and E, 18 equal parts, each representing 10 degrees of longitude. Find then, in the Table, the meridional parts, corresponding to 10°, 20°, 30°, &c. divide each by 60, and taking the quotients from the same scale of equal parts, set them from C towards N and S; then straight lines drawn through the divisions of WE parallel to NS will be meridians, and straight lines through the divisions of NS parallel to WE will be parallels of latitude, 10° distant from one another. Upon this principle is constructed the chart of the world, Plate CCLXIX.

PLATE CCLX[...]

Chart of a portion of the earth.

2. Let it be required to represent only a portion of the earth's surface, as for example from 0° to 50° W. longitude, and from 30° to 60° N. latitude.

Draw AB (Fig. 5.) to represent the parallel of 30°, and from the extremity, erect the perpendicular BC for the first meridian. From B, by means of any convenient scale of equal parts, set off five divisions, towards A, and from these points erect perpendiculars for the other meridians, 10° distant from each other. Take then from the Table the meridional parts corresponding to 40°, 50°, and 60°, subtract from each the meridional parts corresponding to 30°, the lowest parallel of the chart, and divide the remainders by 60°; the quotients taken from the same scale of equal parts, and set from B to C, will give the distances of the respective parallels. Thus, to find the distance of the parallel of 40°:

Meridional parts of 40°	2622.7
Meridional parts of 30°	1888.4
	734.3

and $\frac{734.3}{60} = 12,24$ parts of the scale from which the divisions of AB were taken.

To facilitate the construction of charts according to this projection, the flat rulers commonly called Gunter's scales, are provided with two lines adjacent and parallel to one another marked Mer. and E : P, the first being meridional parts, previously divided by 60, so as to reduce them to degrees, and the second a scale of equal parts, or degrees of longitude, corresponding to the latitudes on the other. Hence, if the longitude of a chart be taken from the line E : P, the distance of any parallel from the equator is found by extending the compasses from the extremity of the line Mer. to the number denoting the latitude, and applying that distance from the commencement of the line E : P. In like manner to find the distance between any two parallels, take the distance between the latitudes on Mer. and apply it to E : P. Thus the distance between the parallels of 30° and 40° on Mer. will be equal to 12.24 on E : P, the same as in the preceding example.

Improvement of Gregory, Halley, &c.

Such is the principle of the method, originally invented by Wright, and still frequently employed, in constructing a chart, according to Mercator's projection. It was soon discovered, however, and subsequently demonstrated by Gregory and Halley, that the meridian line, divided according to this principle, becomes a line of logarithmic cotangents, to half the co-

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latitudes of the different parallels, deducting radius from each; that is, C 20 (Fig. 4.) reckoning from C towards N, is the log. cot. $\frac{90^\circ - 20^\circ}{2}$ or 35°, = log. tan. 55°;

C 40 = log. cot. $\frac{90^\circ - 40^\circ}{2}$ or 25°, = log. tan. 65°, &c.

always deducting radius. Advantage has accordingly been taken of this principle, by adapting a line of such tangents to the construction of charts. This line is to be found on the common Gunter's scale, adjacent to the line Mer. and marked Tan. Like the former, it commences on the right hand, and is constructed on the following principle.

Construction of the line of logarithmic tangents.

As radius is to be deducted from each tangent, before transferring it to the scale, and as all tangents below 45° are less than the radius, none less than that of 45° can be exhibited on the line. Nor, indeed, is any less tangent necessary, as half the colatitude never can be greater, or, which is the same thing, the complement of half the colatitude, never can be less than 45°. From the extremity of the line, therefore, which is marked 45°, the logarithmic tangents of all the arches greater than 45°, deducting radius, are set off towards the left hand, and numbered at every tenth division, 50, 60, 70, &c. But the logarithmic tangent of any arch, as 50° = log. cot. $90^\circ - 50^\circ$ or 40° = log. cot. $\frac{90^\circ - 10^\circ}{2}$ = log. cot. of half the colatitude of 10°. In like manner, tan. 55° = cot. 35° = cot. $\frac{90^\circ - 20^\circ}{2}$ = cot. of half the colatitude of 20°, and so of others. To facilitate, therefore, the application of the line, the divisions marked 50, 60, 70, &c. are also numbered 40, 30, 20, &c. by which means they exhibit at once the half colatitudes, to which the tangents 50, 60, 70, &c. are cotangents. Hence the following simple rule, for finding the projected distance of any parallel of latitude, from the equator.

Extend the compasses from the extremity of the line 45, to the number denoting half the colatitude of the parallel, and it will be the distance required. Thus, the distance of the parallel of 20° is found by extending the compasses from 45 to $\frac{90 - 20}{2} = 35$, and so of any other. Hence also, to find the projected distance between any two parallels, take the distance between the numbers denoting half the colatitudes of each; thus the distance between the parallels of 20° and 40° on the chart = the distance between 35 and 25 on the scale.

But though the distances of the parallels, or the lengths of the degrees of latitude, are thus readily found, it is obvious that these distances must correspond to some particular scale of longitudes. In order, therefore, to construct a chart by the line of tangents, it becomes necessary to determine the length of the degree of longitude which corresponds to that line, and which may be found thus.

Construction of a line of longitudes.

Take from the line Mer. any latitude whatever, as 37° 6′, and applying that distance to the line E : P, mark the corresponding length, which in this case will be 40; or divide the number opposite to 37° 6′ in the table of meridional parts, which is 2400, by 60, and mark the quotient, viz. 40. From 45 on the line Tan. extend the compasses to half the colatitude of 37° 6′, the assumed latitude, which is 26° 27′; apply this distance to any scale of equal parts, as of 1 inch, and divide the corresponding distance, which in this case will be about 3.4 *in.* by 40, the number found on E : P, or from the table corresponding to the assumed latitude; the quotient, in the present instance .085, will be the length of a degree of longitude, corresponding to the above latitudes, in terms of the unit of the scale of equal parts, viz. inches. Hence, if the distances of every tenth parallel be taken from a line of tangents of the dimension supposed above, every tenth meridian will be found by setting off on the equator, or on any parallel of latitude, divisions each equal to .85 *in.*

It follows, from the meridians in this projection being parallel to one another, that the rhumb-lines, which on the globe are spirals continually approaching the poles, are represented on the chart by straight lines; a property which renders this construction of vast importance in navigation. See NAVIGATION.

Construction of gores for covering globes.

The only other projection that we shall notice, as connected with the subject of the present Section, is the construction of *gores*, for covering globes, each of which may be considered as a developement of a small portion of the surface of the sphere, extending longitudinally, in the direction of the meridian. We formerly observed, in treating of the construction of globes, that in an indefinitely small portion of the sphere, ÆNQS (Plate CCLXV. Fig. 7.), ÆQ and *ac*, portions of the equator and a parallel of latitude, may be regarded as straight lines, perpendicular to MN. In practice, however, the gore is not taken so small as to warrant this assumption; and therefore these lines are really portions of circles. The following method of projecting gores, has been recommended by several eminent artists, as well as astronomers.

Plate CCLXV. Fig. 7.

Draw a straight line ÆQ, equal to the breadth of the intended gore at the equator, which is generally $\frac{1}{12}$ of the whole circumference, and bisect it by a perpendicular MN, equal to $\frac{1}{4}$ of the circumference. Divide MN into 9 equal parts, and through each, from points in MN produced, with radii equal to the cotangents of their respective latitudes, to rad. MN, describe arches for the parallels of every 10th degree. From each of the divisions in MN, and with radii equal to the fractions opposite their respective latitudes in the Table, p. 151, multiplied into the length of MÆ, describe arches intersecting the parallels, on both sides of MN; then the curves N *a* Æ, N *c* Q drawn through these divisions, will be the meridians distant from one another $\frac{1}{12}$ of the circumference, or 30°, that is the segment of the gore Æ *a* N *c* Q applied to the globe will cover $\frac{1}{12}$ of a hemisphere. The same operation repeated will give the other gores, after which the different portions of the earth's surface, or celestial sphere, are to be delineated as on any other maps. The globe, as was formerly observed, is generally covered in this way, from the equator to the parallel of 70° or 80°; but the space round the pole is projected on one circular piece, whose radius is equal to the sine of its distance from the pole. It is hardly necessary to observe, that neither by this, nor any other method, can gores be constructed, so as accurately to cover any given portion of a sphere. It is even found that the dimensions of the different pieces, undergo a considerable alteration in consequence of their being moistened, for the purpose of being fixed on the globe. The best method of correcting these irregularities, is by enlarging or diminishing, as may be necessary, the size of the globe itself.

SECT. IV. *Construction of Maps representing small Portions of the Earth's Surface, and the Method of filling up the Outlines of Maps in general.*

THOUGH the various methods of projection, explained in the course of this article, are sufficient for the con-

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struction of any kind of maps, yet when it is required to represent a small portion of the earth's surface, and to exhibit the different parts nearly in their true proportions, the following is perhaps the most convenient, as well as the most accurate of any.

Suppose it is required to construct a map, extending from 50° to 60° N. Latitude, and from 3° E. to 7° W. Longitude.

Plate CCLXVII. Fig. 6.

Draw an indefinite straight line AB (Plate CCLXVII. Fig. 6.) for the parallel of 50°, and from a point C near the middle of the map, erect a perpendicular for the middle meridian, or that of 2° W. longitude. From C set off to D 10 equal parts, taken from a scale of any convenient length, as inches, to denote degrees of latitude, and through D draw EF parallel to AB, for the parallel of 60°. Take from the Table, p. 151, the fraction corresponding to 50°, which is .64279 or .643 nearly, and it will be the length in parts of the same scale, in this case inches, to be set off from C towards A, and from C towards B for degrees of longitude. In like manner, take the fraction opposite to 60° in the Table, which is .5, and it will give the length to be set off from D to E and from D to F. Then lines drawn through the divisions of CD, parallel to AB, will be parallels of latitude, and lines joining the corresponding divisions in AB and EF will be meridians. A scale of miles adapted to the map, may be constructed as formerly explained under Flamstead's projection.

Natural divisions of the globe.

Of the objects to be delineated on a map, or of the method of representing them, it will not be necessary to say much, as such details must be familiar to all our readers. The great natural division of the globe, is into *land* and *water*. The subdivisions of the former are *continents*, or large tracts containing several kingdoms and states, as Europe, Asia, Africa, and America, and *islands*, or smaller tracts, wholly surrounded by water, as Britain. A tract of land, surrounded with water on all sides but one, whatever be its extent, is called a *peninsula*, as Spain and Africa; and the side by which it is united to other land, is called an *isthmus*, as the isthmus of Suez, which joins Africa to Asia. A point of land running into the sea is called a *cape*, *promontory*, or *head-land*. The subdivisions of the water are *oceans*, or those large collections which surround the continents, and which are usually reckoned five, viz. the Northern, Southern, Atlantic, Pacific, and Indian; and *seas*, or those branches of the ocean which intersect the continents, as the Baltic and Mediterranean. When a narrow branch of the sea, or ocean, projects far into the land, it is called a *gulf*, as the Arabian Gulf, and a *bay*, when its entrance is wider, as the Bay of Biscay. The canal that unites a gulf with a sea or an ocean, is called a *strait*, as the Straits of Babelmandel and Gibraltar.

Continents. Islands. Peninsula. Isthmus. Cape. Oceans. Seas. Gulf. Bay. Strait.

Method of representing these subdivisions.

All these divisions are traced out on the map, by a crooked or waving line representing the coast, from which small parallel lines are drawn towards the water, of about a tenth, or sometimes two tenths of an inch in length. These lines, while they render the separation more distinct, have also the effect of making the sea appear to project from the surface of the map. In charts, or maps chiefly intended for representing coasts, harbours, &c. the direction of the parallel lines is reversed, which gives to the land the appearance of projecting. The latter seems to be the most natural representation. In modern maps, the parallel lines are generally drawn quite across the sea, from coast to coast, by which the division of land and water is rendered still more distinct. In representing mountains, geographers formerly employed vertical sections, as A (Fig. 7.) but of late, the *bird's eye view* is more frequently used. This consists in small waving lines, as B, diverging from a point, the point representing the summit, and the lines the declivity of the mountain. Rivers are represented by waving lines, roads by crooked lines, either single or double, and towns by small circles, varying in magnitude, according to the size of the towns themselves, and the scale of the map.

Plate CCLXVII. Fig. 7.

As the reduction of maps from one scale to another, is frequently a problem of importance in practical geography, we shall point out a method of making such a reduction, which, if not extremely accurate, deserves to be noticed for its simplicity.

Method of reducing maps. Fig. 8.

Let ABCD (Fig. 8.) be a given map, and *a b c d* a similar figure of a reduced size, upon which it is required to lay down points corresponding to E, F, G, H, and to trace a line corresponding to the line LMN. Divide ABCD into any number of equal squares, or parallelograms, by straight lines parallel to AB and AD, and divide *a b c d* also into the same number, by lines parallel to *a b*, *a d*; then, by comparing the corresponding parallelograms, points *e*, *f*, *g*, *h* may easily be found occupying very nearly the same positions in *a b c d*, that the points E, F, G, H do in ABCD, and a line *l m n* may also be traced, differing little in its direction from LMN. This method may be advantageously employed for filling up the details of a map, after the principal points have been determined by some more accurate method. For the use of the pentagraph, in reducing maps, see the article Drawing Instruments, vol. viii. p. 129. See, for the construction of maps, *Precis de la Geographie Universelle*, par M. Malte Brun, tom. ii. Paris 1812; *Memoires sur la Projection des Cartes Geographiques*, par M. Henry, Paris 1810; Lorgna, *Principii di Geografia*, Verona 1789; Playfair, *Outlines of Natural Philosophy*, vol. ii. p. 66, &c.

Sect. V. *On the Determination of the Longitudes and Latitudes of Places on the Earth's Surface.*

In the preceding Sections, we have pointed out the various methods which may be employed in delineating the whole or a part of the earth's surface, either upon a sphere or upon a plane. Before a map, however, can be completed, it is necessary to have the exact position of various places in reference to the equator, and to some fixed meridian; and hence the determination of the longitudes and latitudes of places by astronomical, trigonometrical, or chronometrical observations, is one of the most important operations in geography.

We have already pointed out in our article Astronomy, the method of making these observations by the aid of the planets or the fixed stars; and in our articles Navigation, Surveying, and Timekeeper, we shall have occasion to consider the method of determining longitudes and latitudes by trigonometrical instruments, and by chronometers. We shall, therefore, conclude this article with a Table of geographical positions, exhibiting the latitude of the principal points on the earth's surface, and their longitudes, or difference of meridians, in relation to the observatory of Greenwich.

This Table, which is by far the most correct that has ever been published, has been taken principally from the *Connoissance des Tems* for 1816, and contains the results of the best observations which have been made by astronomers and navigators, and by those eminent individuals who have from time to time been employed in measuring degrees of the meridian. We have corrected many of the positions, and have added more than two hundred new places in England and Scotland, from the accurate observations of Colonel Mudge and Captain Coleby. No place is inserted, unless its position has been actually determined either by astronomical, trigonometrical, or chronometrical observation.

Mathematical Geography.

TABLE OF LONGITUDES AND LATITUDES,

AS DETERMINED BY

Astronomical, Trigonometrical, and Chronometrical Observations.

Names of Places.	Latitude. ° ′ ″	Longitude. ° ′ ″
Aalborg	57 2 32 N	9 56 41 E
Aarhus	56 9 35 N	10 14 5 E
Aberystwith Station	52 45 29 N	4 3 19 W
Abbeville	50 7 4 N	1 49 58 E
Aberdeen	57 9 1 N	2 8 0 W
Abo	60 27 10 N	22 20 15 E
Acapulco	16 50 19 N	99 48 18 W
Actopan	20 17 28 N	98 49 0 W
Adelsberg	45 38 10 N	14 23 25 E
Admiralty Island	2 11 45 S	146 12 2 E
Adria	45 2 57 N	12 3 55 E
Adventure bay	43 21 29 N	147 23 55 E
Aerschoot	50 59 15 N	4 49 46 E
Agde	43 18 40 N	3 28 10 E
Agen	44 12 22 N	0 36 35 E
Agero fort	59 1 0 N	10 55 15 E
Agria	47 53 54 N	20 21 45 E
Ahus	55 55 30 N	14 16 20 E
Aichstadt	48 53 30 N	11 10 30 E
Aigues-Mortes	43 33 58 N	4 11 22 E
Air point lighthouse	53 21 28 N	3 18 35 W
Aire	43 41 52 N	0 15 36 W
Aix	43 31 48 N	5 26 47 E
Aix, Isle of	46 1 38 N	1 10 41 W
Ajaccio	41 55 1 N	8 44 4 E
Akerman	46 12 0 N	30 44 0 E
Alais	44 7 22 N	4 4 25 E
Alausi	2 13 22 S	79 0 15 W
Albano	41 43 50 N	12 38 15 E
Albans, St Peter's steeple	50 45 19 N	0 19 31 W
Albemarle Isle, N. W. point	0 2 0 N	91 30 0 W
Albi	43 55 46 N	2 8 33 E
Alboran, Isle of	35 57 0 N	3 0 40 W
Alcala de Henarez	40 28 40 N	3 23 22 W
Alcmaer	52 38 2 N	4 44 45 E
Aleppo	36 11 25 N	37 10 15 E
Alet	42 59 39 N	2 15 21 E
Alexandretta	36 35 27 N	36 15 15 E
Alexandria	31 13 5 N	29 50 45 E
Algiers, the lighthouse	36 48 36 N	3 1 20 E
Algesiras	36 8 0 N	5 26 12 W
Alicante	38 20 41 N	0 28 35 W
Almaguer	5 54 29 N	76 55 2 W
Almeria	36 51 0 N	2 31 0 W
Alost	50 56 18 N	4 2 13 E
Altavela Isle	17 28 11 N	71 38 45 W
Altdorf	47 45 8 N	9 34 15 E
Altenrode	51 51 29 N	10 43 53 E
Altengaard	69 55 0 N	23 4 15 E
Amasreh	41 46 3 N	32 24 24 E
Amboyna, Isle of	3 41 41 S	128 7 20 E
Ambrim, Isle of	16 9 30 S	167 51 36 E
Amiens	49 53 41 N	2 18 11 E
Amlwch steeple	53 23 0 N	4 19 17 W
Amsterdam	52 22 17 N	4 53 15 E
Amsterdam, Isle, west point	37 47 46 S	77 25 11 E
Anchorite Islands	1 0 0 S	145 25 6 E
Ancona	43 37 54 N	13 29 7 E
Andover steeple	51 12 39 N	1 28 19 W
Andujar	38 1 32 N	3 59 33 W
Anegada, Isle, south-east pt.	18 43 48 N	64 22 50 W

Names of Places.	Latitude. ° ′ ″	Longitude. ° ′ ″
Angelos, los	19 0 15 N	98 2 30 W
Angers	47 28 9 N	0 33 0 W
Angouleme	45 38 57 N	0 9 16 E
Anguilla, Isle, west point	18 12 6 N	63 12 2 W
Anguille, cape	47 55 0 N	59 23 5 W
Anholt, lighthouse	56 44 20 N	11 38 51 E
Aniwa, cape	46 2 20 N	143 30 20 E
Anna-Maria harbour	8 56 32 S	139 39 0 W
Annabon, Isle of, north point	1 25 0 S	5 45 15 E
Annan spire	54 59 23 N	3 14 45 W
Ann's, St, Hill	51 41 39 N	5 8 53 W
Ann's, St, lighthouse	51 40 59 N	5 9 19 W
Anson's Island	5 0 30 S	154 35 0 E
Anstey, East, steeple	51 1 38 N	3 36 15 W
Anstruther, West, spire	56 13 33 N	2 41 37 W
Antibes	43 34 43 N	7 7 50 E
Anticosti, Isle of	49 26 0 N	63 37 55 W
Antigua, fort Hamilton	17 4 30 N	61 54 45 W
Antongil, bay of	15 27 23 S	53 23 30 E
Antwerp	51 13 16 N	4 24 10 E
Aor, Isle of	2 30 0 N	104 40 15 E
Apenrade	55 2 57 N	9 26 38 E
Apt	43 52 29 N	5 23 52 E
Apuré, mouth of the river	7 36 23 N	66 36 15 W
Aquileia	45 45 32 N	13 23 0 E
Aquin, bay of	18 13 48 N	73 20 52 W
Aranda on the Douro	41 40 12 N	3 39 42 W
Aranjuez	40 1 54 N	3 36 15 W
Archangel	64 31 40 N	40 43 30 E
Ardenbourg	51 16 27 N	3 26 56 E
Arendal	58 27 0 N	8 50 25 E
Arensbourg, Isle of Œsel	58 15 9 N	22 27 45 E
Argental, Cape	42 23 25 N	11 9 39 E
Arica	18 26 40 S	70 11 5 W
Arles	43 40 31 N	4 37 47 E
Arona, the statue of St Ch.	45 45 53 N	8 33 8 E
Arras	50 17 34 N	2 46 25 E
Asaph, St, cathedral	53 15 28 N	3 25 44 W
Ascension, Isle of	7 57 0 S	13 58 45 W
Ashwell spire	52 2 32 N	0 9 23 W
Asinara, Isle of, the summit	41 5 40 N	8 17 34 E
Aspoe, Isle of	61 13 20 N	4 45 55 E
Assenede	51 13 42 N	3 45 18 E
Assise	43 4 22 N	12 35 28 E
Astorga	42 27 9 N	6 10 1 W
Astracan	46 21 12 N	48 2 45 E
Ath	50 42 17 N	3 46 32 E
Athens	37 58 1 N	23 46 14 E
Atherington steeple	50 59 26 N	3 59 40 W
Atour, Isle, road of Ouimea	21 57 0 N	159 39 15 W
Atures	5 38 34 N	67 59 0 W
Aueh	43 38 39 N	0 35 11 E
Augsburg	48 21 46 N	10 54 42 E
Aurich	53 28 12 N	7 27 22 E
Aurora Isle	15 8 0 S	167 58 6 E
Autun	46 56 48 N	4 17 59 E
Auxerre	47 47 57 N	3 34 21 E
Aveiro	40 38 18 N	8 38 45 W
Aves, Isle	15 50 18 N	63 38 2 W
Avignon	43 57 8 N	4 48 30 E
Avranches	48 41 23 N	6 2 2 W

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Names of Places.	Latitude. ° ′ ″	Longitude. ° ′ ″
Aveilli	46 10 8 N	5 0 0 E
Avatcha, Bay of	52 51 45 N	158 46 45 E
Axedge	53 14 0 N	1 56 27 W
Axholme steeple	53 29 27 N	0 50 40 W
Ayavaca	4 37 51 S	79 41 5 E
Aylesbury steeple	51 49 3 N	0 48 41 W
B		
Baba, Cape	39 30 15 N	25 51 40 E
Baçaim	19 19 0 N	72 40 15 E
Bagdad	33 19 40 N	44 24 45 E
Bajoly, Cape	40 2 45 N	3 52 5 E
Balada, harbour of Bougioué	20 16 41 N	164 25 32 E
Balaguer	40 59 30 N	0 59 15 E
Baldock telegraph	51 58 36 N	0 10 35 W
Balsham steeple	52 8 13 N	0 20 3 E
Bamborough castle, flagstaff	55 36 42 N	1 42 8 W
Baradello	45 47 13 N	9 5 44 E
Barbadoes, Bridgetown	13 5 0 N	59 40 0 W
Barbary point	15 53 0 N	16 31 0 W
Barcelona, New	10 6 52 N	64 44 30 W
Barcelona, tower of Montjoy	41 22 44 N	2 9 57 E
Barfleur lighthouse	49 40 21 N	1 15 15 W
Barlingues Isles	39 25 6 N	9 29 57 W
Barnaould	53 20 0 N	83 29 0 E
Barnaby moor	54 33 31 N	1 6 58 W
Bartina	41 42 53 N	32 14 0 E
Bashee Isles, Grafton	21 4 0 N	121 0 15 E
Basle	47 33 34 N	7 35 27 E
Bass Rock, highest point	56 4 53 N	2 37 47 W
Bassano	45 45 34 N	11 44 50 E
Bastia	42 41 36 N	9 26 45 E
Batavia	6 12 0 S	106 54 1 E
Bath	51 22 30 N	2 21 15 W
Bald, Cape	51 39 45 N	55 27 35 W
Bayeux	49 16 34 N	0 41 56 W
Bayonne	43 29 15 N	1 27 26 W
Bazas	44 25 55 N	0 12 32 W
Beachyhead	50 44 24 N	0 15 12 E
Beaconsfield spire	51 36 3 N	0 38 0 W
Bebbington spire	53 20 55 N	2 59 32 W
Beauvais	49 26 7 N	2 5 0 E
Bees, St, Head lighthouse	54 30 55 N	3 37 24 E
Behring, Isle	55 36 0 N	167 46 15 E
Belleisle	47 17 17 N	3 4 45 W
Bembridge	50 40 15 N	1 0 0 W
Benavente	41 59 56 N	5 39 28 W
Bencoolen	3 49 16 S	102 10 45 E
Bender	46 50 32 N	29 46 15 E
Bergamo	45 41 51 N	9 40 26 E
Bergen-op-Zoom	51 29 44 N	4 17 23 E
Bergen	60 24 0 N	5 20 40 E
Berlin	52 31 45 N	13 22 15 E
Berne	46 56 55 N	7 26 15 E
Berry, Isles, the one most S.E.	25 30 45 N	78 1 38 W
Berryhead	50 24 1 N	3 28 14 W
Berwick spire	55 46 21 N	1 59 41 W
Besançon	47 13 45 N	6 2 45 E
Beziers	43 20 31 N	3 13 0 E
Bidston lighthouse	53 24 6 N	3 3 46 W
Biggleswade spire	52 5 12 N	0 15 55 W
Biorneborg	61 29 3 N	21 43 5 E
Birch, Bay of	48 53 30 N	122 26 15 W
Bizati, harbour	37 18 27 N	22 54 3 E
Blackhead	50 1 12 N	5 3 59 W
Blankenburg	51 47 53 N	10 57 15 E
Blenheim Palace	51 50 29 N	1 20 45 W
Bletchworth	51 14 35 N	0 14 39 W
Blois	47 35 20 N	1 20 16 E
Blomoe	60 31 55 N	4 54 45 E
Bojador, Cape	26 12 30 N	14 25 45 W
Bolabola, Isle	16 32 30 S	151 50 35 W
Bolcheretz	52 54 30 N	156 50 15 E
Bologna	44 30 12 N	11 21 30 E
Bolt Head	50 13 15 N	3 48 3 W
Bombay	18 56 40 N	72 38 15 E
Bommel	51 48 53 N	4 55 10 E
Boni, harbour of	0 2 30 S	131 1 59 E
Bonifacio	41 23 10 N	9 9 16 E
Boothby steeple	53 7 7 N	0 31 24 W
Borchloen	50 48 17 N	5 20 33 E
Boscawen and Keppel Isles	15 53 0 S	174 34 45 W
Boston	42 22 11 N	70 58 45 W
Botany Bay	34 0 0 S	151 23 15 E
Botol, Isle of, east point	21 46 38 N	122 4 54 E
Bouc, the tower of	43 23 31 N	4 58 49 E
Bouca. See Anson's Island.		
Boulogne	50 43 37 N	1 36 59 E
Bourbon Isle, St Denis	20 51 43 S	55 30 15 E
Bourdeaux	44 50 14 N	0 33 59 W
Bourg de l'Ain	46 12 26 N	5 13 45 E
Bourges	47 5 4 N	2 23 55 E
Boutin, point	51 52 0 N	141 48 15 E
Bouton, the town of	5 27 53 S	122 29 37 E
Bozzolo	45 6 4 N	10 29 36 E
Brandenburg	52 27 0 N	12 53 15 E
Braunau	48 14 0 N	12 56 45 E
Bray steeple	51 30 33 N	0 41 53 W
Breda	51 35 23 N	4 46 36 E
Bregançon, fort of	43 5 28 N	6 19 21 E
Bregentz	47 30 30 N	9 43 55 E
Bremen	53 4 38 N	8 48 0 E
Brescia	45 32 30 N	10 14 9 E
Brescou	43 15 21 N	3 27 8 E
Breslaw	51 6 30 N	17 2 18 E
Brest	48 23 14 N	4 28 45 W
Briel	51 54 15 N	4 9 51 E
Bridgewater	51 7 41 N	2 59 39 W
Brighton	50 49 32 N	0 7 40 W
Brill, rock of	6 5 0 S	118 51 15 E
Bristol	51 27 6 N	2 35 29 W
Brixen	46 40 0 N	11 37 15 E
Brocken, Mountain	51 48 29 N	10 36 35 E
Brouage	45 52 3 N	1 3 45 W
Bruck	47 24 34 N	15 15 41 E
Bruges	51 12 33 N	3 13 33 E
Brunn	49 11 28 N	16 35 21 E
Brunswick	52 15 43 N	10 29 30 E
Brussels	50 50 59 N	4 22 15 E
Buda	47 29 44 N	19 2 30 E
Buenos Ayres	34 35 26 S	58 31 0 W
Buga	3 55 20 N	76 21 50 W
Bucharest	44 26 45 N	26 8 15 E
Buckingham spire	51 59 53 N	0 59 5 W
Burgas	40 14 30 N	26 27 7 E
Burgeo, Isles of	47 35 30 N	57 36 0 W
Burgos	42 20 59 N	2 40 15 W
Button Isle	60 35 0 N	64 19 45 W
Bwlch Mawr	53 0 19 N	4 19 46 W
C		
Cabrera, middle of the Isle of	39 7 30 N	3 0 20 E
Cadiz, observatory	36 32 0 N	6 17 22 W
Cader Idres	52 42 2 N	4 28 3 W
Caen	49 11 12 N	0 21 38 W
Caffa	45 6 30 N	35 12 45 E
Cagliari	39 13 9 N	9 5 45 E
Cahors	44 25 59 N	1 27 17 E

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Names of Places.	Latitude. ° ′ ″	Longitude. ° ′ ″
Cairo	30 2 21 N	31 18 45 E
Cajaneburg	64 13 30 N	27 45 30 E
Cajeli, Bouro Isle	3 22 33 S	127 2 49 E
Calais	50 57 32 N	1 51 16 E
Calcutta	22 34 45 N	88 31 45 E
Callao, port of	12 3 9 S	77 14 15 W
Calmar	56 40 30 N	16 26 15 E
Calshot Castle	50 48 13 N	1 18 6 W
Calvi	42 34 7 N	8 45 16 E
Cambray	50 10 37 N	3 13 47 E
Cambridge, Trinity spire	52 12 45 N	0 7 42 E
Camerino	43 6 26 N	13 24 18 E
Caminha	41 52 42 N	8 43 57 W
Campeachy	19 50 45 N	90 30 30 W
Cananore	11 51 0 N	75 24 15 E
Candia, town of	35 18 45 N	25 18 15 E
Canea	35 28 45 N	24 12 45 E
Canigon, mount	42 31 7 N	2 27 23 E
Cansau, harbour of	45 20 7 N	60 54 45 W
Canton	23 8 9 N	113 2 45 E
Canterbury	51 18 26 N	0 55 8 E
Canzer, cape	36 17 50 N	35 40 15 E
Cape Français, town	19 46 20 N	72 17 55 W
Cape Français, Old	19 40 30 N	70 1 15 W
Cape of Good Hope	33 55 15 S	18 24 0 E
Cape Blanc	20 55 30 N	17 9 45 W
Ditto	47 16 0 S	65 59 15 W
Ditto	33 11 30 N	35 7 15 E
Cape North	54 31 30 S	73 16 14 W
Cape North in Europe	71 10 0 N	26 0 45 E
Cape North east of Asia	68 56 0 N	180 48 45 E
Cape Verd	14 43 45 N	17 30 30 W
Capo d'Istria, town	45 30 36 N	13 42 48 E
Capraja, isle of	43 0 18 N	9 48 13 E
Caprera, isle	41 12 46 N	9 28 23 E
Caraccas	10 30 50 N	67 4 45 W
Carcassonne	43 12 54 N	2 21 0 E
Cardigan steeple	52 4 59 N	4 38 18 W
Carlaverock castle	54 58 41 N	3 30 41 W
Carlota	37 39 41 N	4 56 35 W
Carlsburg	46 4 21 N	23 34 30 E
Carlscrona	56 6 57 N	15 33 0 E
Carlsham	56 10 40 N	14 51 0 E
Carmona	37 28 1 N	5 39 59 W
Carolina	38 17 5 N	3 36 13 W
Carpentras	44 3 28 N	5 2 43 E
Carpio	37 56 37 N	4 29 26 W
Carthagena	10 25 18 N	75 29 45 W
Carthagena	37 35 50 N	1 0 21 W
Carwar, cape	14 47 0 N	73 56 15 E
Casal-Maggiore	44 59 12 N	10 25 38 E
Casbin	36 11 0 N	49 33 15 E
Cashel	51 19 20 N	9 35 18 E
Casletnaudari	43 19 4 N	1 52 36 E
Castiglione, fort	42 45 58 N	10 52 15 E
Castres	43 37 3 N	2 15 1 E
Castries, bay of	51 29 0 N	140 56 19 E
Catherinesburgh	56 50 38 N	60 40 15 E
Cavada	43 20 43 N	3 42 19 W
Cavaillon	43 50 6 N	5 2 10 E
Cavan	53 51 41 N	7 25 15 W
Caxamarca	7 8 38 S	78 35 15 W
Cayenne	4 56 15 N	52 14 45 W
Cayman Great	19 19 0 N	80 46 15 W
Cayman Chico	19 42 0 N	79 38 30 W
Cayos, town of	18 11 10 N	73 50 19 W
Cayo d'Argan, N. E.	20 31 0 N	69 32 30 W
Cayo Acore	20 29 24 N	70 3 52 W

Names of Places.	Latitude. ° ′ ″	Longitude. ° ′ ″
Cayo Confites	22 11 44 N	77 44 30 W
Cayo Cruz del Padre	23 14 0 N	81 3 45 W
Cayo Guinchos	22 44 0 N	78 4 45 W
Cayo de Lobos	22 24 50 N	77 36 30 W
Cayo Romaine	21 53 0 N	77 42 15 W
Cayo de Don Christoval	22 10 0 N	82 0 45 W
Cayo de Sel	23 39 8 N	80 14 45 W
Cayo vert	22 5 6 N	77 40 15 W
Cayques	21 44 15 N	71 26 50 W
Cerigo, isle, south point	36 6 0 N	22 51 38 E
Cers, isle of	49 23 32 N	2 24 30 W
Cervia	44 15 31 N	12 19 43 E
Cette, the lighthouse	43 23 37 N	3 41 5 E
Ceuta, the mountain of Acho	35 54 4 N	5 16 15 W
Chalons-sur-Marne	48 57 16 N	4 22 1 E
Chalons-sur-Saone	46 46 53 N	4 51 8 E
Chandernagore	22 51 26 N	88 29 30 E
Charkov	49 59 43 N	36 26 32 E
Charleton steeple	50 16 16 N	3 44 31 W
Charlotte's, Queen, Cape	22 15 0 S	167 13 0 E
Chartres	48 26 54 N	1 19 20 E
Chassiron, the tower	46 2 51 N	1 24 12 W
Chateau, Isles of	22 7 45 N	74 25 30 W
Chatham Isle, cape Young	43 48 0 S	176 58 0 W
Chatham, port	35 3 0 S	116 35 0 E
Chelidony, Cape	36 13 25 N	30 20 25 W
Cheltenham steeple	51 4 7 N	2 4 6 W
Cherbourg	49 38 31 N	1 37 3 W
Chester Trinity spire	53 11 26 N	2 53 1 W
Chester-le-Street spire	54 51 28 N	1 33 49 W
Cheviot hill	55 28 52 N	2 8 12 W
Chiloe, isle, at Don Carlos	41 53 0 S	72 44 45 W
Chipiona, point	36 44 18 N	6 24 0 W
Chiquinquira	5 32 0 N	74 13 52 W
Choul, fort	18 32 0 N	72 48 45 E
Christchurch	50 42 57 N	1 45 11 W
Christian, Isle	36 15 0 N	25 3 45 E
Christiania	59 55 20 N	10 48 45 E
Christiansand	58 8 5 N	8 3 13 E
Christiansfeldt	55 21 36 N	9 28 55 E
Christianstadt	56 1 15 N	14 9 30 E
Christiansand	63 6 35 N	7 42 45 E
Christinæstad	62 16 9 N	21 18 5 E
Cilley	46 40 0 N	15 24 45 E
Cimbritzham	55 33 27 N	14 20 45 E
Ciotat	43 10 29 N	5 37 0 E
Civita-Vecchia	42 5 24 N	11 44 45 E
Clausthal	51 48 30 N	10 20 32 E
Clermont	49 22 48 N	2 25 5 E
Clermont Ferrand	45 46 44 N	3 5 17 E
Cleves	51 47 40 N	6 7 7 E
Cobham's pillar	52 2 3 N	1 0 24 W
Cobourg	50 15 18 N	10 58 0 E
Cochin	9 56 30 N	76 16 15 E
Cocos, or Keeling isle, middle	12 11 0 S	96 23 15 E
Codera, Cape of	10 35 54 N	65 59 15 W
Coimbra	40 12 30 N	8 24 44 E
Coleby spire	53 8 4 N	0 32 25 W
Collioure	42 31 31 N	3 5 17 E
Colnet, Cape of, N. Caledonia	20 30 0 S	164 56 15 E
Colnet, North West America	30 58 0 N	116 2 0 W
Cologne	50 55 21 N	6 55 15 E
Colombretta Isle	39 56 0 N	4 0 17 E
Columbia, mouth of the river	46 19 0 N	123 54 0 W
Commachio	44 40 27 N	12 10 2 E
Como	45 48 22 N	9 5 41 E
Comorin, Cape	7 56 0 N	77 32 15 E
Conception	36 49 10 N	73 54 45 W

Mathematical Geography.

Names of Places.	Latitude. ° ′ ″	Longitude. ° ′ ″
Conchée, the tower of	48 41 2 N	2 3 15 W
Conclusion, port	56 15 0 N	134 23 30 W
Condom	43 57 49 N	0 22 22 E
Condor, Isle	8 40 0 N	106 31 52 E
Constantinople, St Sophias	41 1 27 N	28 55 15 E
Constance	47 36 10 N	9 8 15 E
Cope, Cape	37 24 40 N	1 31 40 W
Copenhagen	55 41 4 N	12 35 6 E
Copiapo	27 10 0 S	71 6 15 W
Coquet Isle lighthouse	55 20 11 N	3 11 47 W
Coquimbo	29 54 40 S	71 19 15 W
Cordova	37 52 13 N	4 45 53 W
Cordova, port	45 45 0 S	67 27 15 W
Cordovan, tower	45 35 15 N	1 10 25 W
Corientes, Cape, in Cuba	21 44 30 N	84 28 37 W
Corientes, Cape, in Mexico	20 25 30 N	105 35 36 W
Corinth	37 58 22 N	23 28 29 E
Cork	51 53 54 N	8 29 0 W
Corneto	42 15 23 N	11 43 15 E
Coron	36 47 26 N	21 58 52 E
Corte	42 18 2 N	9 8 46 E
Corvo, Isle, south point	39 40 45 N	31 2 45 W
Coudras, Isles of	47 23 1 N	70 23 19 W
Coupang	10 9 55 S	123 28 28 E
Coutances	49 2 54 N	1 26 23 W
Courtray	50 49 43 N	3 16 6 E
Cowes	50 45 27 N	1 19 24 W
Cracatoa, Isle	6 6 0 S	105 36 15 E
Cracow	50 3 38 N	19 57 9 E
Crail spire	56 15 58 N	2 36 55 W
Crema	45 21 29 N	9 41 57 E
Cremona	45 7 43 N	10 2 12 E
Cremsmunster	48 3 29 N	14 8 8 E
Creux, Cape of	42 19 35 N	3 20 50 E
Criffel mountain	54 56 44 N	3 36 55 W
Crillon, Cape of	45 56 0 N	142 59 54 E
Croc, harbour of	51 3 17 N	55 49 45 W
Croisic	47 17 43 N	2 30 15 W
Crossfell	54 42 18 N	2 28 37 W
Cross-sound, entry	58 12 0 N	136 5 0 W
Croydon steeple	52 7 57 N	0 4 45 W
Cucao, mountain	42 45 0 S	74 6 15 W
Cuenca	2 55 3 S	79 13 22 W
Cullera, Cape	39 9 0 N	0 10 40 W
Cumana	10 27 37 N	64 9 45 W
Cumanacoa	10 16 11 N	63 58 35 W
Cummin, Isle of,	31 40 0 N	121 41 0 E
Cura	10 2 47 N	67 44 45 W
Cuxhaven lighthouse	53 52 21 N	8 43 1 E
D		
Daffenside beacon	54 49 27 N	2 30 47 W
Dagelet, Isle	37 22 18 N	130 57 22 E
Dager-ort	58 56 1 N	22 9 15 E
Dalrymple, Cape	48 21 0 N	142 50 0 E
Damietta	31 25 40 N	31 50 0 E
Damme	52 31 34 N	8 12 18 E
Danger, Isles of, middle	10 51 0 S	167 4 45 W
Dantzic	54 20 48 N	18 38 5 E
Danville Cape	31 27 30 N	131 27 15 E
Dardanelles, old castle	40 9 8 N	26 19 30 E
Darmstadt	49 56 24 N	8 34 49 E
Daventry spire	52 15 39 N	1 9 3 W
David's, St, cathedral	51 52 56 N	5 14 53 W
Dax	43 42 19 N	1 3 3 W
Deadman	50 13 20 N	4 47 4 W
Deception, Cape	8 32 30 S	157 2 29 E
Deliverance, Cape of	10 59 20 S	154 26 30 E
Delft	52 0 49 N	4 21 45 E
Delmenhorst	53 3 29 N	8 39 28 E
Dendera	26 8 26 N	32 30 57 E
Denis, Cape	8 24 0 S	151 3 52 E
Derby steeple	52 55 32 N	1 28 16 W
Dereham, East	52 40 0 N	0 55 0 E
Descada, or Desirade, Isle, N. E. point	16 20 0 N	61 1 50 W
Devizes, St John's steeple	51 21 15 N	1 59 6 W
Diarbeker	37 54 0 N	39 53 45 E
Dibeh, mouth of the Nile	31 22 6 N	32 7 30 E
Die	44 45 31 N	5 22 33 E
Diego Ramirezo, Isle	56 27 30 S	68 39 14 W
Diephelz	52 36 30 N	8 21 1 E
Diemens Isle, south cape	43 38 30 S	146 50 45 E
Diemen, harbour, north of	43 32 17 S	146 56 48 E
Dieppe	49 55 34 N	1 4 44 E
Digg, Cape of	62 41 0 N	78 49 45 W
Digne	44 5 18 N	6 14 19 E
Dijon	47 19 25 N	5 2 5 E
Dillingen	48 34 17 N	10 30 29 E
Discovery, Port	48 2 30 N	122 37 41 W
Disseada Cape	53 4 15 S	74 30 45 W
Diu Cape	20 42 0 N	70 47 15 W
Dixmude	51 2 12 N	2 52 3 E
Dobryzn	52 38 5 N	19 35 15 E
Doera Cape	33 0 0 N	22 16 45 E
Dol	48 33 8 N	1 45 3 W
Domburg	51 33 51 N	3 29 52 E
Dominica, Roseau	15 18 23 N	61 32 15 W
Donawert	48 43 15 N	10 47 3 E
Dorchester	50 42 57 N	2 25 25 W
Dordrecht	51 48 54 N	4 39 42 E
Doro, Cape	38 9 30 N	24 19 45 E
Dorpat	58 22 47 N	26 45 15 E
Dortmund	51 31 24 N	7 26 41 E
Dover Castle	51 7 47 N	1 19 7 E
Drake Island, observatory	50 21 21 N	4 8 18 W
Dresden	51 2 50 N	13 43 1 E
Dromedary, Mount	36 16 33 S	150 19 57 E
Drontheim	63 25 50 N	10 23 25 E
Druja	55 47 29 N	27 13 45 E
Dublin	53 21 11 N	6 18 45 W
Duisburgh	51 26 6 N	6 45 39 E
Dunchurch steeple	52 20 16 N	1 16 56 W
Dundee	56 25 0 N	3 2 15 W
Dungeness lighthouse	50 55 1 N	0 57 48 E
Dunkirk	51 2 9 N	2 22 37 E
Dunnose	50 37 7 N	1 11 36 W
Dunse spire	55 46 50 N	2 19 58 W
Durham cathedral	54 46 31 N	1 34 6 W
Dusseldorf	51 13 42 N	6 46 25 E
E		
Easter Island	27 8 30 S	109 51 15 W
Eastham spire	53 18 50 N	2 57 1 W
Ebersdorf	50 29 33 N	11 40 23 E
Edam	52 30 49 N	5 2 56 E
Eddystone lighthouse	50 10 55 N	4 15 3 W
Eddystone Island	8 18 0 S	156 30 53 E
Edgecumbe	57 2 0 N	135 46 15 W
Edinburgh observatory	55 57 57 N	3 10 21 W
Egersund	58 26 10 N	5 57 0 E
Eisenach	50 58 55 N	10 20 15 E
Eisgarn	48 54 1 N	14 59 56 E
Elbingen	54 8 20 N	19 22 0 E
Elbingerode	51 47 2 N	10 47 44 E
Eldon hills, highest point	55 35 6 N	2 42 27 W
Elisabeth, Cape	59 9 0 N	151 7 0 W
Elsfleet	53 11 21 N	8 26 20 E

Mathematical Geography.

Names of Places.	Latitude. ° ' "	Longitude. ° ' "
Ely Minster	52 24 49 N	0 16 35 E
Embden	53 22 3 N	7 11 1 E
Embrun	44 34 7 N	6 26 9 E
Emeralda	3 11 0 N	66 3 0 W
Emmerich	51 49 52 N	6 14 51 E
Enare	68 56 30 N	27 15 15 E
Endeavour river, mouth of	15 26 0 S	145 11 8 E
Engano, Cape,	18 34 42 N	68 25 37 W
Engelholm	56 14 20 N	12 52 15 E
Enkuysen	52 42 22 N	5 17 41 E
Enos	40 41 58 N	25 58 44 E
Epworth steeple	53 23 18 N	0 48 58 W
Erdingen	48 18 25 N	11 55 8 E
Eregri	41 17 51 N	31 27 20 E
Erfurth	50 58 45 N	11 2 26 E
Erlangen	49 35 36 N	11 4 0 E
Erromanga Isle,	18 46 30 S	168 57 36 E
Erronan, Isle of,	19 34 0 S	170 0 6 E
Escurial	40 35 50 N	4 7 50 W
Espoda Cape	18 19 48 N	68 34 13 W
Estaing Bay,	48 59 38 N	142 31 59 E
Etaple	50 31 40 N	1 35 45 E
Etoile, Isle of, Peak,	14 29 0 S	167 52 5 E
Evangelist, Isles of	52 34 0 S	75 5 15 W
Evaux	40 10 42 N	2 11 18 E
Eversden, Great, steeple	52 8 35 N	0 0 20 E
Evoux, Isles	55 32 12 S	66 47 14 W
Evreux	48 55 30 N	1 9 19 E
Exeter	50 44 0 N	3 34 15 W
Exeter cathedral	50 43 25 N	3 31 0 W
Ezija	37 31 51 N	5 4 34 W
F		
Fairhill	59 28 0 N	1 54 45 W
Fairweather Cape	58 50 40 N	138 5 50 W
Falkenberg	56 53 54 N	12 30 15 E
Falkland Isles, Port Egmont	51 25 0 S	59 59 15 W
Falmouth	50 8 0 N	5 2 15 W
Falsterbo	55 23 4 N	12 49 45 E
Fanagoria	45 12 16 N	36 35 0 E
Fano	43 51 0 N	12 59 53 E
Farewell Cape	59 38 0 N	42 41 45 W
Farnham steeple	51 32 6 N	0 36 41 W
Faro, from St Ant. de Alto	36 59 12 N	7 51 57 W
Fawley steeple	51 34 34 N	0 54 32 W
Fayal, Isle, from la Horte	38 30 55 N	28 41 48 W
Fecamp	49 45 24 N	0 23 3 E
Feldkirchen	47 14 20 N	9 35 15 E
Fells, the tower of the castle	41 16 7 N	1 57 48 E
Feltre	46 0 43 N	11 55 24 E
Fermo	43 10 18 N	13 41 41 E
Fernando-Noronha, Isle	3 56 20 S	32 37 45 W
Fernando-Po, Isle	3 28 0 N	8 40 15 E
Ferrara	44 49 56 N	11 36 25 E
Ferro Isle, west point of	27 45 0 N	18 9 45 W
Ferrol	43 29 0 N	8 15 0 W
Fez	34 0 3 N	5 1 19 W
Figueras	42 16 1 N	2 57 39 E
Finisterre, cape	42 54 0 N	9 16 0 W
Fivehead steeple	51 0 17 N	2 54 33 W
Fiume	45 20 10 N	14 26 22 E
Fladstrand	57 27 3 N	10 33 30 E
Flatholme's lighthouse	51 22 33 N	3 6 25 W
Freckeroe	58 5 0 N	8 1 0 E
Flensburg	54 47 18 N	9 27 40 E
Florence	43 46 41 N	11 15 45 E
Flores, Isle	39 33 59 N	31 8 15 W
Flushing	51 26 42 N	3 34 57 E
Foerder, lighthouse	59 2 3 N	10 37 23 E
Folkstone	51 4 47 N	1 10 52 E
Fontarabia	43 21 36 N	1 47 15 W
Fonthill Abbey	51 4 43 N	2 6 34 W
Foston spire	52 56 33 N	0 46 21 W
Formby point, N.W. landmark	53 33 34 N	3 5 2 W
Fortaventura Isle, W. point	28 4 0 N	14 31 15 W
Foulpoint	17 40 14 S	49 53 15 E
Frampton House	51 25 1 N	3 29 15 W
Francais, harbour of	58 36 0 N	137 25 50 W
France, Isle of, harbour	20 9 45 S	57 28 30 E
Frankfort on the Main	50 7 29 N	8 36 0 E
Frankfort on the Oder	52 22 8 N	14 33 15 E
Fravenburgh	54 21 34 N	19 40 30 E
Frehel, Cape	48 41 10 N	2 18 36 W
Freisengen	48 23 58 N	11 45 30 E
Freistadt	48 29 0 N	14 22 15 E
Frejus	43 25 52 N	6 44 9 E
Fria, Cape	23 2 0 S	41 31 15 W
Frontignan	43 26 42 N	3 45 18 E
Fuentes, Cape	46 8 29 N	9 24 59 E
Fulda	50 33 57 N	9 44 0 E
Furnes	51 4 23 N	2 39 51 E
G		
Gabey Isle	0 6 0 S	126 24 0 E
Gallego river	51 40 0 S	69 4 45 W
Gallipoli	40 25 33 N	26 37 30 E
Gamaley, Cape	40 37 40 N	139 43 30 E
Gamjam	19 22 30 N	85 18 15 E
Gap	44 33 46 N	6 4 28 E
Gaspay, bay of	48 47 30 N	64 27 15 W
Gate, cape of	36 44 0 N	2 12 50 W
Geer Cape	30 38 0 N	9 51 45 W
Gefle	60 39 45 N	17 8 30 E
Gelnhausen	50 13 25 N	9 13 53 E
Geneva	46 12 0 N	6 9 30 E
Genoa	44 25 0 N	8 58 0 E
George's, King, harbour	35 5 30 S	118 14 15 E
Georgetown	38 55 0 N	77 9 48 W
Georgia, Isle, N. Cape	54 4 45 S	38 14 45 W
Gera	50 53 22 N	12 4 1 E
Gerona, the Cathedral	41 59 21 N	2 49 34 E
Gertruydenberg	51 42 5 N	4 51 54 E
Ghent	51 3 21 N	3 43 50 E
Gibraltar	36 6 30 N	5 19 31 W
Gidros	41 52 48 N	32 54 30 E
Gijon	43 35 19 N	5 44 49 W
Gillingham steeple	51 2 20 N	2 16 8 W
Giraglia, tower of	43 1 42 N	9 23 53 E
Girgé	26 20 3 N	31 55 6 E
Glandeves	43 56 43 N	6 48 25 E
Glasgow	55 51 32 N	4 16 45 W
Gloucester cathedral	51 52 3 N	2 14 15 W
Gluchow	51 40 30 N	34 20 15 E
Gluckstadt	53 47 42 N	9 27 2 E
Goa	15 31 0 N	73 45 15 E
Goave	18 26 51 N	72 54 19 W
Goes	51 30 18 N	3 53 31 E
Golowatschef Cape	53 30 15 N	141 55 0 E
Gomera, Isle, harbour	28 5 40 N	17 7 45 W
Gonava, Isle, N. E. point	18 40 10 N	73 0 47 W
Gorgon Isle	43 25 46 N	9 53 10 E
Gore Isle	60 17 0 N	177 11 15 E
Goree Isle	14 40 10 N	17 24 45 W
Goring	50 48 34 N	0 25 29 W
Gortz	45 57 30 N	13 28 45 E
Gotha, Obs. of Seeberg	50 56 8 N	10 44 0 E
Gothaab	64 9 55 N	64 27 15 W
Gottenburg	57 42 4 N	11 57 45 E

Names of Places.	Latitude. ° ′ ″	Longitude. ° ′ ″
Gottingen	51 31 54 N	9 55 15 E
Gotto Isle, S. W. ext.	32 34 50 N	128 44 0 E
Goudá	51 59 51 N	4 42 44 E
Goula-Battou, rock	9 15 0 S	123 51 15 E
Gradisca	45 53 30 N	13 25 0 E
Grado	45 39 55 N	13 23 51 E
Granby steeple	52 55 8 N	0 52 47 W
Grand Combe de Bois	47 8 36 N	6 47 15 E
Grange, the point of	19 54 35 N	71 48 55 W
Graoharum lighthouse	60 5 50 N	25 2 10 E
Granville	48 50 16 N	1 35 57 W
Grasse	43 39 19 N	6 55 24 E
Gratz	47 4 9 N	15 27 15 E
Gravelines	50 59 10 N	2 7 50 E
Gravesend	52 0 20 N	4 9 45 E
Gravois point	18 1 3 N	74 1 16 W
Gray's harbour	47 0 0 N	123 53 0 W
Greenwich Observatory	51 28 40 N	0 0 0
Gregory Cape	43 26 0 N	124 32 30 W
Griefswalde	54 4 35 N	13 33 15 E
Grenaae	56 24 57 N	10 53 59 E
Grenada, Fort	12 2 54 N	61 48 0 W
Grenoble	45 11 42 N	5 43 49 E
Grodno	53 40 30 N	23 49 45 E
Gronskar	59 15 50 N	19 2 30 E
Gronais isle	47 38 4 N	3 26 8 W
Guacara	10 11 23 N	68 5 15 W
Guadaloup isle	28 53 0 N	118 15 48 W
Guadaloup	15 59 30 N	61 45 0 W
Guaduas	5 4 4 N	74 47 58 W
Guaira	10 36 19 N	67 6 45 W
Guaisabon, sugar loaf	22 47 46 N	83 26 32 W
Guanaxuato	21 0 15 N	100 54 45 W
Guastalla	44 54 58 N	10 39 46 E
Guayaquil, town of	2 11 21 N	79 56 15 W
Gueldres	51 30 43 N	6 19 9 E
Guibert, port	56 37 0 N	134 55 50 W
Guildford steeple	51 14 2 N	0 34 0 W
Guntherberg	49 9 37 N	13 27 30 E
Gunzburg	48 27 15 N	10 16 30 E
Gurief	47 7 0 N	51 59 30 E
Gwynier steeple	50 11 17 N	5 21 6 W
H		
Haarlem	52 22 56 N	4 38 19 E
Haddenham spire	52 22 20 N	0 9 26 E
Hadersleben	55 15 15 N	9 30 49 E
Hafringe lighthouse	58 35 40 N	17 18 30 E
Hague	52 4 50 N	4 18 47 E
Halberstadt	51 53 55 N	11 3 33 E
Haldon obelisk	50 37 3 N	3 30 27 W
Halifax	44 44 0 N	63 35 45 W
Hallands-Vadero	56 26 56 N	12 32 30 E
Halle	51 29 5 N	11 58 2 E
Halmstadt	56 39 45 N	12 52 0 E
Halsall spire	53 35 11 N	2 56 24 W
Hamburgh	53 32 51 N	9 58 35 E
Hameln	52 5 29 N	9 20 5 E
Hammarshus	55 18 0 N	14 48 30 E
Hammersfort	70 38 22 N	23 43 30 E
Hango-Udd, isle and cape	59 46 20 N	22 57 45 E
Hano	56 1 0 N	14 49 30 E
Hanover	52 22 25 N	9 42 55 E
Haradskar	58 8 30 N	16 59 0 E
Hardwick spire	52 12 55 N	0 0 6 W
Harefield	51 36 10 N	0 27 45 E
Harlingen	53 10 32 N	5 24 47 E
Hartland point	51 1 22 N	4 30 26 W
Hastings	50 52 10 N	0 41 25 E
Havannah	23 9 27 N	82 22 53 E
Havre	49 29 14 N	0 6 38 E
Hawk-hill, near Edinburgh	55 57 37 N	3 8 30 W
Hawkestone obelisk	52 51 34 N	2 36 59 W
Helbre lighthouse	53 23 34 N	3 10 13 W
Heligoland light-house	54 11 34 N	7 53 13 E
Helkinton	52 23 24 N	1 3 33 W
Helsinborg	56 2 55 N	12 43 15 E
Helsing-fors	60 10 0 N	25 0 15 E
Helston steeple	50 6 15 N	5 15 29 W
Helvellyn mountain	54 31 43 N	3 0 21 W
Helvoet-Sluys	51 49 29 N	14 7 53 E
Henley steeple	51 32 21 N	0 53 48 W
Henlopen Cape	38 46 0 N	75 12 15 W
Henry, cape	36 57 0 N	76 31 15 W
Heraclea	41 1 3 N	27 54 34 E
Herenthals	51 10 45 N	4 50 29 E
Hermit Isles	1 28 30 S	145 7 35 E
Hernosand Isle	62 38 0 N	17 53 15 E
Hervey Isle	19 17 0 S	158 47 45 W
Hesseloe	56 11 46 N	11 40 1 E
Highbury-house	51 33 13 N	0 5 30 W
High Pike	54 42 27 N	3 2 49 W
Hilary, St, steeple	50 9 23 N	5 23 2 W
Hinchinbrock, cape	60 12 30 N	146 39 20 W
Hioring	57 27 44 N	10 0 28 E
Hoaiagnan	33 34 40 N	118 49 45 E
Hoapinsu, isle	25 49 39 N	122 40 0 E
Hoborg, cape	56 56 0 N	18 11 0 E
Hogsties, isles, most eastern	21 38 50 N	73 56 4 W
Hogstraeten	51 24 5 N	4 45 48 E
Hola	65 44 0 N	19 43 45 W
Holy Isle castle, flagstaff	55 40 20 N	1 46 38 W
Honda	5 11 42 N	74 53 30 W
Hondschotte	50 58 56 N	2 35 14 E
Honfleur	49 25 13 N	0 14 14 E
Hood point	34 23 0 N	119 49 0 E
Hooglede	50 58 44 N	3 5 0 E
Hope harbour	33 55 17 S	121 54 50 E
Hope, Cape of	9 31 33 S	159 41 30 E
Horn, Cape	55 58 30 S	67 21 14 W
Huaheine Isle	16 42 45 S	151 10 45 W
Hudwiks-vall	61 43 45 N	17 7 59 E
Huehuitoca	19 48 39 N	99 11 40 W
Huiddings-oe,	59 3 54 N	5 25 15 E
Hulst	51 16 53 N	4 3 27 E
Hume castle	55 40 5 N	2 27 38 W
Huntingdon steeple	52 20 27 N	0 11 3 W
Hurst castle	50 42 23 N	1 32 41 W
Husum	54 28 59 N	9 4 42 E
Hyeres	43 7 2 N	6 7 55 E
I		
Iakutsk	62 1 50 N	129 42 30 E
Ibagua	4 27 45 N	75 20 0 W
Ibarra	0 21 0 N	78 18 34 W
Iena	50 56 28 N	11 37 15 E
Ieniseisk	58 27 17 N	91 58 45 E
Iglau	49 23 29 N	15 36 15 E
Ilchester steeple	51 0 23 N	1 40 14 W
Illon steeple	50 57 9 N	2 54 48 W
Imst	47 14 20 N	10 43 45 E
Inague, the greater W. point	21 3 41 N	72 47 28 W
Inague, the lesser, E. point	21 29 0 N	73 1 28 W
Ingolstadt	48 45 47 N	11 25 51 E
Ingleborough hill	54 10 4 N	2 23 18 W
Ingornachoix	50 37 17 N	57 15 15 W
Inichi	42 0 26 N	33 56 30 E
Inselberg, mountain	50 51 35 N	10 28 15 E
Inspruck	47 16 8 N	11 23 45 E
Ipsera Isle, south point	38 30 0 N	25 36 30 E

Mathematical Geography.

Names of Places.	Latitude. (deg. min. sec.)	Longitude. (deg. min. sec.)
Irkutch	52 16 41 N	104 11 30 E
Irois, the point of	18 22 23 N	74 35 40 W
Isabelique, the point	19 50 43 N	71 16 35 W
Islamabad	22 20 0 N	91 45 15 E
Ismail	45 21 0 N	28 50 15 E
Isola Bella	45 53 11 N	8 32 3 E
Ispahan	32 24 34 N	51 50 15 E
Isselburgh	51 50 29 N	6 26 22 E
Istacalco	19 22 44 N	99 4 30 W
Istapalapa	19 22 19 N	99 3 0 W
Ives, St, steeple	52 20 19 N	0 4 45 W
Ivica, Isle, castle	38 53 16 N	1 29 12 E
J		
Jackson, Port, Sydney Cove	33 51 3 S	152 12 15 E
Jagua	2 10 19 N	75 35 59 W
Jahde	53 20 45 N	8 12 43 E
Jaroslawl	57 37 30 N	40 10 15 E
Jassy	47 8 30 N	27 30 15 E
Jenikola	45 21 0 N	36 26 45 E
Jeremiah, point	18 39 57 N	74 13 22 W
Jersey Isle, from St Aubin	49 12 59 N	2 10 44 W
Jerusalem	31 47 47 N	35 20 15 E
Jever	53 34 28 N	7 52 45 E
Johannisberg	53 37 48 N	21 49 15 E
Johnston steeple	51 45 17 N	4 58 41 W
Jonas, peak of	56 25 30 N	143 15 45 E
Juan Fernandez, Isle	33 40 0 S	78 58 15 W
Judembourg	47 43 20 N	14 42 45 E
K		
Kaisersheim	48 45 52 N	10 47 58 E
Kallandburg	55 40 54 N	11 6 33 E
Kaluga	54 30 0 N	36 5 15 E
Kaminiek	48 40 50 N	27 1 30 E
Kamyschin	50 5 6 N	45 24 15 E
Kasan	55 47 51 N	49 21 9 E
Kaskon	62 22 10 N	21 10 35 E
Katwik-sur-Mer	52 12 15 N	4 23 35 E
Kauf Beuren	47 53 30 N	10 26 45 E
Kelshall steeple	52 0 29 N	0 3 51 W
Kerguelen isle, cape George	49 54 30 S	70 12 15 E
Kerguelen, harbour of Noel	48 41 15 S	69 2 15 E
Kew observatory	51 28 37 N	0 16 45 W
Kiam-Cheu	35 37 0 N	111 29 30 E
Kiel	54 19 43 N	10 8 18 E
Kilrenny spire	56 14 17 N	2 40 35 W
Kingston steeple	50 18 54 N	3 51 40 W
Kiow	50 27 0 N	30 27 45 E
Kiringskoi-Ostrog	57 47 0 N	108 3 0 E
Kirk Newton	55 54 30 N	3 25 0 W
Kirkby Lonsdale steeple	54 12 18 N	2 35 15 W
Kittis	66 48 20 N	34 3 15 E
Klagenfurth	46 37 10 N	14 20 0 E
Klin	56 20 18 N	36 48 6 E
Kola	68 52 30 N	33 0 45 E
Kongelf	57 51 45 N	11 59 0 E
Kongsback	57 27 0 N	12 7 0 E
Konigsberg	54 42 12 N	20 29 15 E
Konswinger	60 12 11 N	11 58 0 E
Korn Neuburg	48 21 22 N	16 19 0 E
Koslow	45 11 54 N	33 22 48 E
Kostroma	57 45 40 N	41 12 51 E
Kovima, the lower	68 18 0 N	163 18 15 E
Kovima, the upper	65 28 0 N	153 35 15 E
Krageroe	58 51 35 N	9 30 42 E
Krannichfeld	50 51 55 N	11 11 45 E
Krasnoyars	56 1 2 N	92 20 52 E
Krembs	48 21 30 N	15 36 0 E

Names of Places.	Latitude. (deg. min. sec.)	Longitude. (deg. min. sec.)
Krementzouk	49 3 28 N	33 29 0 E
Kritch spire	53 15 43 N	1 7 10 W
Kullen, the lighthouse	56 18 3 N	12 35 45 E
Kumi	24 33 13 N	123 19 43 E
Kursk	51 43 30 N	36 27 45 E
Kyloe steeple	55 39 36 N	1 54 39 W
L		
Labiau	54 51 20 N	21 6 45 E
Ladrone Isles, the greatest	22 2 0 N	113 56 15 E
Lagos	37 6 0 N	8 38 3 W
Lagos	40 58 42 N	25 3 36 E
Laholm	56 32 38 N	13 1 0 E
Lamanon peak	47 45 0 N	141 52 45 E
Lambhuus	64 6 17 N	21 55 15 W
Lampsacus	40 20 52 N	26 36 55 E
Lancaster	40 2 39 N	76 10 30 W
Lancaster steeple	54 3 8 N	2 47 41 W
Lancerotte Isle, east point	29 14 0 N	13 25 45 W
Landsberg	48 2 58 N	10 53 31 E
Landscroon	55 52 27 N	12 46 1 E
Land's End, at Stone	50 4 7 N	5 41 32 W
Landsorbe lighthouse	58 43 56 N	17 52 0 E
Langle, peak of	45 11 0 N	141 13 13 E
Langle, bay of	48 59 0 N	142 33 4 E
Langres	47 51 59 N	5 20 5 E
Langtree steeple	50 55 58 N	4 11 24 W
Lansdown monument	51 25 29 N	2 22 22 W
Laon	49 33 54 N	3 37 27 E
Larneca, the castle	34 54 30 N	33 40 45 E
Largo Law	56 14 15 N	2 54 52 W
Latikia	35 32 30 N	35 44 15 E
Laubach	46 1 48 N	14 46 40 E
Lausanne	46 31 5 N	6 45 30 E
Lavaur	43 40 52 N	1 49 18 E
Leasowes lighthouse	53 24 50 N	3 6 49 W
Lecluse	51 18 35 N	3 23 9 E
Lectoure	43 55 54 N	
Ledstone beacon	53 46 31 N	1 18 47 W
Leeds	53 48 0 N	0 37 26 E
Leer	53 13 49 N	1 34 0 W
Lefao	9 12 15 S	124 15 15 E
Legnago	45 11 18 N	10 59 13 E
Leghorn	43 33 5 N	10 16 45 E
Leicester	52 38 0 N	1 8 30 W
Leigh steeple	51 13 28 N	2 25 58 W
Leipsic	51 20 16 N	12 21 45 E
Leiva	5 30 0 N	73 54 52 W
Le Mans	48 0 30 N	0 11 35 E
Leon, Isle of	36 27 45 N	6 12 0 W
Leona, Isle of	14 6 0 S	169 16 22 W
Le Puy	45 25 2 N	3 53 36 E
Lescar	43 19 52 N	0 25 52 W
Levata Isle, south point of	36 59 0 N	26 16 45 E
Lewin Cape	34 25 50 S	115 35 15 E
Leyden	52 9 30 N	4 29 13 E
Libau	56 31 36 N	20 55 20 E
Lichtenau	51 37 24 N	8 54 7 E
Liege	50 39 22 N	5 31 42 E
Lilienthal	53 8 30 N	8 54 15 E
Lima	12 2 34 S	77 7 30 W
Limoges	45 49 53 N	1 15 23 E
Limpjada	40 36 43 N	23 43 47 E
Lincoln Minster	53 14 7 N	0 32 1 W
Lindes Noess, or Derneus	57 58 0 N	7 6 15 E
Lintz	48 13 54 N	14 16 45 E
Lisbon observatory	38 42 18 N	9 7 33 W
Liskeard	50 26 55 N	4 41 30 W

Mathematical Geography.

Names of Places.	Latitude. ° ′ ″	Longitude. ° ′ ″
Litchfield spire	52 41 12 N	1 49 21 W
Little Port	52 27 59 N	0 18 40 E
Little Brickhill steeple	51 58 59 N	0 40 21 W
Liverpool, St Paul's	53 24 40 N	2 58 55 W
Lizard Cape lighthouse	49 57 44 N	5 11 5 W
Lizieux	49 8 50 N	0 13 47 E
Llanelly steeple	51 41 2 N	4 8 41 W
Loampit-hill	51 28 7 N	0 1 0 W
Lodeve	43 43 47 N	3 19 3 E
Lodi	45 18 31 N	9 30 52 E
Loheia	15 42 8 N	42 18 45 E
Lombez	43 28 30 N	0 54 24 E
Lomond top, east	56 14 44 N	3 12 33 W
Lomond top, west	56 14 57 N	3 17 4 W
London, St Paul's	51 30 49 N	0 5 30 W
Looz, Isle of	9 27 0 N	13 20 45 W
Lopatka, Cape	51 0 15 N	156 42 45 E
Loretto	43 27 0 N	13 35 5 E
L'Orient	47 45 11 N	3 21 2 W
Louisbourg	45 53 40 N	59 55 45 W
Louisiada, Cape of	11 20 42 N	128 20 55 E
Louvain	50 53 26 N	4 41 46 E
Lubeck	53 51 18 N	8 40 52 E
Lubni	50 0 37 N	33 3 45 E
Lucipara	3 10 45 S	106 17 45 E
Lucon	46 27 15 N	1 9 45 W
Lugano	45 59 56 N	8 57 35 E
Lugo	43 0 4 N	7 34 10 W
Lulworth flagstaff	50 39 19 N	2 18 28 W
Lunde	58 27 10 N	6 36 6 E
Lunden, tower	55 42 26 N	13 12 42 E
Luxembourg	49 37 38 N	6 9 41 E
Lyme	50 43 10 N	2 75 29 W
Lyons	45 45 58 N	4 49 24 E
M		
Macao	22 12 44 N	113 35 15 E
Macclesfield, bank	15 51 0 N	114 18 15 E
Macerata	43 18 36 N	13 26 15 E
Macon	46 18 27 N	4 50 8 E
Madeira, west point,	32 37 40 N	16 55 45 W
Madras, Fort St George	13 4 54 N	80 29 0 E
Madrid, great square	40 24 57 N	3 42 15 W
Maestricht	50 51 7 N	5 41 1 E
Magdeburg	52 8 4 N	11 38 59 E
Mahe, on Seichelles Isle	4 38 0 S	55 85 15 E
Mahon, Cape of Mola	39 51 10 N	4 25 28 E
Mahouna Isle	14 20 45 S	170 16 35 W
Maisy Cape	20 16 40 N	74 7 53 W
Malacca	2 12 0 N	102 5 15 E
Malaga	36 43 30 N	4 25 2 W
Malvern Hill	52 6 18 N	2 19 47 W
Maldonado	34 56 19 S	54 51 5 W
Malespina Cape	43 42 15 N	141 19 0 E
Malines	51 1 52 N	4 28 59 E
Mallicda, Port Sandwich	16 25 20 N	167 32 6 E
Malmoe	55 36 37 N	13 1 19 E
Malouine Isles, see Falkland Isles.		
Malta, from the town	35 53 41 N	14 30 45 E
Manchester, St Mary's spire	53 29 0 N	2 14 22 W
Mandal	58 0 42 N	7 28 45 E
Mandry, harbour of	37 44 10 N	23 48 45 E
Mangea Isle	21 56 45 S	158 2 45 W
Manheim observatory	49 29 18 N	8 28 0 E
Manilla	14 36 0 N	120 58 15 E
Mantua	45 9 16 N	10 48 12 E
Marburg	46 34 42 N	15 43 0 E
Margueritta Isle, Cape Macan	11 3 30 N	64 27 15 W
Maria Cape	18 37 20 N	74 33 32 W
Marienburgh	54 1 31 N	19 1 56 E
Markoe	57 59 10 N	6 59 15 E
Marikan Isle	46 50 0 N	152 30 15 E
Marmora Isle	40 37 4 N	27 30 50 E
Marseilles observatory	43 17 49 N	5 22 15 E
Marstrand lighthouse	57 53 51 N	11 36 0 E
Martinique, Port de France	14 35 49 N	61 5 45 W
Martin-Vas, Isles of	20 30 0 S	27 59 44 W
Masafuero	33 45 30 S	80 37 15 W
Maskelyne Isle	16 32 0 S	167 48 21 E
Matance, Peak of	23 1 39 N	81 45 2 W
Matapan Cape	36 23 20 N	22 29 30 E
Mataro	41 32 23 N	2 26 48 E
Matifou Cape	36 51 10 N	3 12 35 E
Matsumay	41 32 0 N	140 4 0 E
May, Isle of, south point	15 6 0 N	23 9 45 W
May, Isle of, lighthouse	56 11 22 N	2 32 47 W
Maypures	5 13 32 N	68 17 15 W
Meaux	48 57 40 N	2 52 45 E
Meiningen	50 35 26 N	10 24 13 E
Melille	35 18 15 N	2 56 10 W
Memel	55 42 15 N	21 8 3 E
Mende	44 30 42 N	3 29 34 E
Mendocin Cape	40 29 0 N	124 29 15 W
Merguy	12 12 0 N	98 18 15 E
Metz	49 7 10 N	6 10 28 E
Mewstone	50 18 30 N	4 5 33 W
Mewstone	43 48 0 S	146 27 15 E
Mexico	19 25 45 N	99 5 15 W
Mexicalcingo	19 21 22 N	99 4 30 W
Michael's, St, Mount	50 7 2 N	5 27 33 W
Middleburg	51 30 6 N	3 37 30 E
Milan observatory	45 28 2 N	9 11 45 E
Milford steeple	51 42 43 N	5 20 13 W
Milo Isle, the harbour	36 42 30 N	24 13 32 E
Mirepoix observatory	43 5 7 N	1 52 26 E
Mispalu Isle	0 19 15 S	132 7 18 E
Mittau	56 39 6 N	23 43 27 E
Mocha	13 16 0 N	43 10 15 E
Mogana Isle, N. E. point	22 18 0 N	72 46 0 W
Mohilew	53 54 0 N	30 24 45 E
Mole, St Nicholas	19 49 20 N	73 29 33 W
Monance, St, spire	56 12 24 N	2 45 37 W
Mongat Fort	41 27 50 N	2 16 45 E
Mongon Cape, from tower	42 6 34 N	3 10 29 E
Monopin mountain	2 3 0 S	105 22 45 E
Montaigu	50 58 56 N	4 59 1 E
Montalto	42 59 44 N	13 35 29 E
Montacute signal-staff	50 57 2 N	2 42 44 W
Montauban observatory	44 0 55 N	1 20 45 E
Montdego Cape	40 12 6 N	8 53 9 W
Monte Christo	42 20 26 N	10 18 10 E
Monte Figo	37 9 40 N	7 40 9 W
Monterey	36 35 45 N	121 51 6 W
Monte Video	34 54 48 S	56 14 30 W
Mont Lauro	42 45 47 N	8 57 22 W
Montpellier observatory	43 36 16 N	3 52 40 E
Monte Rosa	45 55 56 N	7 52 32 E
Montsein, the most northern peak	41 28 48 N	2 17 30 E
Montserrat, the highest peak	41 38 59 N	1 46 7 E
Montserrat Isle, N.E. point	16 47 35 N	62 13 25 W
Monza	45 34 41 N	9 17 11 E
Morales	8 15 30 N	74 1 0 W
Morant Point	17 57 45 N	76 15 8 W
Morotay Isle	21 10 0 N	161 57 15 E
Mortory Isle	41 4 42 N	9 36 26 E
Morup Tange	56 55 57 N	12 21 45 E

Mathematical Geography.

Names of Places.	Latitude. ° ′ ″	Longitude. ° ′ ″
Moscow	55 45 45 N	37 33 0 E
Mosdok	43 43 40 N	43 50 15 E
Mote steeple	51 53 33 N	4 47 55 W
Mouchoircar,	21 0 0 N	70 57 30 W
Moulins, point of	36 37 15 N	4 28 30 W
Moxillones	23 5 0 S	70 25 15 W
Mowee isle, E. point	20 50 30 N	156 2 30 W
Mulgrave harbour	59 34 17 N	139 42 6 W
Mulhausen	51 12 59 N	10 28 45 E
Mulheim	47 48 40 N	7 37 38 E
Mumbles lighthouse	51 34 0 N	3 57 20 W
Munich	48 8 20 N	11 34 30 E
Munster	51 58 10 N	7 36 21 E
Musquito Cove	64 55 13 N	52 56 30 W
Muyden	52 19 48 N	5 4 15 E
Muzo	5 24 0 N	74 22 52 W
N		
Naerden	52 17 49 N	5 9 50 E
Namur	50 28 30 N	4 51 7 E
Nancy	48 41 55 N	6 10 31 E
Nangasaki	32 45 50 N	129 52 7 E
Nankin	32 4 40 N	118 47 15 E
Nantes	47 13 6 N	1 22 44 W
Naples	40 50 15 N	14 15 45 E
Narbonne	43 11 22 N	3 0 22 E
Narva	59 22 53 N	28 14 30 E
Narvase Isle	18 22 19 N	75 7 45 W
Naseby steeple	52 23 52 N	0 59 3 W
Necker, Isle of	23 34 0 N	164 31 45 W
Needles, lighthouse	50 39 53 N	1 33 55 W
Neschin	51 2 45 N	31 49 45 E
Neustadt	47 48 27 N	15 13 32 E
Nevers	46 59 17 N	3 9 31 E
New Year's Harbour	54 48 54 S	64 0 14 W
Newark	53 55 19 N	8 31 24 E
Newark steeple	53 4 30 N	0 49 18 W
Newmarket	52 15 28 N	0 27 12 E
Newnham Cape	58 41 30 N	162 19 15 W
New York	40 40 0 N	73 58 37 E
New Zealand, North Cape	34 26 0 S	173 1 30 E
Idem. South Cape	47 19 0 S	167 8 15 E
Nice	43 41 16 N	7 16 35 E
Nidingen	57 18 21 N	11 55 0 E
Nieuport	51 7 54 N	2 45 15 E
Nieves Isle, S. point	17 5 12 N	62 33 21 W
Nimeguen	51 51 20 N	5 50 51 E
Nismes	43 50 8 N	4 21 15 E
Ningpo, on the Liampo	29 57 45 N	120 18 15 E
Nizhnei, Novogorod	56 19 43 N	44 28 30 E
Nizhnei, Oudinsk	54 55 22 N	99 1 45 E
Nocera	43 6 40 N	12 46 17 E
Noel, isle of	1 57 45 N	157 34 45 W
Noel, harbour of	55 21 54 S	69 47 14 W
Noirmoutier	47 0 5 N	2 14 7 W
Norburg	55 3 53 N	9 45 52 E
Nordingen	48 51 0 N	10 28 30 E
Nordkoping	58 35 0 N	16 11 0 E
Norfolk isle	29 1 45 N	168 10 15 E
Norham castle	51 43 29 N	2 8 30 W
Norriton	40 9 56 N	75 33 30 W
Norr Telge	59 45 45 N	18 39 0 E
North Berwick Law, staff	56 3 8 N	2 42 11 W
Noto Cape	37 39 12 N	137 35 0 E
Nottingham steeple	52 57 8 N	1 8 14 W
Novara	45 26 38 N	8 37 46 E
Novogorod	58 31 32 N	31 16 24 E
Nootka Sound	49 35 15 N	126 36 46 W
Noyon	49 34 42 N	3 0 50 E
Nuremberg	49 24 55 N	11 4 15 E
Nurtingen	48 37 36 N	9 19 30 E
O		
Ocanna	39 56 33 N	3 30 51 W
Odemira, the bar	38 39 0 N	8 50 27 W
Odessa	46 29 30 N	30 45 22 E
Oerebro	59 17 12 N	15 13 20 E
Ohelema Isle	22 27 0 S	150 46 45 W
Ohitahou Island	9 55 30 S	139 8 25 W
Okhotsk	59 20 10 N	143 13 45 E
Okosir Isle	42 9 0 N	139 30 0 E
Oldenburg	53 8 40 N	8 14 35 E
Oleron	43 11 1 N	0 36 15 W
Olinda	8 13 0 S	35 5 15 W
Olonne	46 29 52 N	1 47 50 W
Onehecow Isle	21 49 30 N	160 13 15 W
Oonalaska Isle	53 54 45 N	166 26 45 W
Oporto	41 8 56 N	8 36 9 W
Oran, castle of St Croix	35 44 27 N	0 39 24 W
Orange	44 8 10 N	4 48 23 E
Orchilla Isle	11 52 0 N	66 5 46 W
Oregrund	60 20 0 N	18 26 30 E
Orel	52 54 40 N	35 57 15 E
Orenburgh	51 46 5 N	55 4 45 E
Orford, Cape	42 52 0 N	124 25 0 W
Orizava peak	19 2 17 N	97 15 0 W
Orleans	47 54 12 N	1 54 41 E
Orleans, New	29 57 45 N	89 58 30 W
Ormskirk spire	53 34 12 N	2 52 36 W
Oropesa, Cape	40 5 33 N	0 8 25 E
Orrengrund	60 15 0 N	26 35 5 E
Orsk	51 12 30 N	58 31 0 E
Ortegal, Cape	43 46 40 N	7 54 0 W
Orwell pole	52 5 41 N	0 0 1 E
Osimo	43 29 36 N	13 27 23 E
Osnaburgh	52 16 35 N	8 1 11 E
Ostaschoff	57 9 40 N	33 12 21 E
Ostend	51 13 57 N	2 55 8 E
Osterode	51 44 15 N	10 16 54 E
Oster Risoer	58 42 33 N	9 19 55 E
Ost-Hammar	60 14 30 N	18 23 30 E
Otchakof	46 37 29 N	31 26 15 E
Otaheite Isle	9 55 30 S	5 3 6 W
Ouessant Isle	48 28 8 N	166 26 45 W
Owyhee Isle, north point	20 17 0 N	155 58 45 W
Oxford observatory	51 45 40 N	1 15 30 W
P		
Paderborn	51 43 37 N	8 43 51 E
Padua observatory	45 24 2 N	11 52 45 E
Paimbeuf	47 17 15 N	2 1 31 W
Paix, port de	19 55 0 N	72 53 30 W
Palamos	41 51 10 N	3 5 0 E
Palermo observatory	38 6 44 N	13 22 0 E
Palk's Tower	50 39 53 N	3 34 46 W
Palma	39 34 4 N	2 39 15 E
Palma Isle, at Tassacorte	28 38 0 N	17 57 45 W
Palos Cape	37 37 15 N	0 41 0 W
Pamiers	43 6 44 N	1 36 36 E
Pampeluna	42 49 57 N	1 41 15 W
Panama	8 58 50 N	79 27 15 W
Para	1 28 0 S	48 39 45 W
Paris, imperial observatory	48 50 14 N	2 20 15 E
Do. Obs. Coll. of Fran.	48 50 58 N	2 20 15 E
Do. Ob. Palace of Arts	48 51 29 N	2 20 45 E
Do. Obs. of the Mil. School	48 51 6 N	2 18 15 E
Do. Obs. of Mesier	48 51 4 N	2 20 17 E
Do. Obs. of Delambre	48 51 38 N	2 21 32 E
Parkham steeple	50 58 14 N	4 18 51 W

Mathematical Geography.

Names of Places.	Latitude. ° ′ ″	Longitude. ° ′ ″
Parma	44 48 1 N	10 26 45 E
Pasto	1 13 6 N	77 21 25W
Patience Cape	48 52 0 E	144 46 45 E
Patrixfiord	65 35 45 N	24 8 38W
Pavia	45 10 47 N	9 9 48 E
Peel castle	54 3 49 N	3 9 41W
Pekin, Imperial Observ.	39 54 13 N	116 27 45 E
Pelew Isles at Ourolong	7 18 0 N	134 40 15 E
Pello	66 48 16 N	23 58 30 E
Pembroke Cape	62 57 0 N	81 59 45W
Pendennis Castle	50 8 49 N	5 1 44W
Penicho, Cape Corvoeiro	39 21 48 N	9 23 56W
Peniscola	40 22 40 N	0 29 30W
Penlec	50 19 24 N	4 10 40W
Penrith beacon	54 50 37 N	2 43 59W
Pera, Cape of	39 42 12 N	3 31 40 E
Perekop	46 8 57 N	33 42 9 E
Perigueux	45 11 8 N	0 43 34 E
Perinaldo	43 53 20 N	7 44 0 E
Perm	58 1 13 N	56 26 30 E
Perotta	19 32 54 N	97 13 24W
Perouse	43 6 46 N	12 22 13 E
Perpignan	42 42 3 N	2 54 9 E
Pesaro	43 55 1 N	12 53 36 E
Petatlan, Morro de	17 32 0 N	101 20 39W
Peterborough cathedral	52 35 40 N	0 14 45W
Petersburgh	59 56 23 N	30 18 45 E
Petropaulowskoi	53 0 15 N	158 49 0 E
Petrosawods	61 47 4 N	34 23 45 E
Pettau	46 26 21 N	15 59 26 E
Petworth	50 54 12 N	0 34 9W
Pevensey	50 49 11 N	0 20 29 E
Philadelphia	39 56 55 N	75 11 30W
Philipville	50 11 19 N	4 32 34 E
Philippine	51 16 55 N	3 45 27 E
Philipsburgh	49 14 1 N	8 26 49 E
Piacenza	45 2 44 N	9 42 32 E
Pico, isle of, the peak	38 27 0 N	28 28 15W
Pickersgill, harbour	45 47 27 S	166 18 24 E
Pilares, Cape	52 46 0 S	74 51 14W
Pilier, Isle of	47 2 32 N	2 21 5W
Pillau	54 33 39 N	19 52 30 E
Piombino	42 55 27 N	10 31 2 E
Pisa	43 43 11 N	10 24 0 E
Pitcairn Isle	25 22 0 S	133 20 45W
Pittenweem spire	56 12 48 N	2 43 2W
Planier, isle of	43 11 54 N	5 14 1 E
Plata, La	2 23 0 S	75 51 35W
Plymouth	50 22 24 N	4 7 31W
Plynlymmon	52 28 3 N	3 46 4W
Poictiers	46 35 0 N	0 20 43 E
Pollingen	47 48 17 N	11 9 0 E
Polotz	55 28 56 N	28 48 0 E
Pondicherry	11 55 41 N	79 51 45 E
Ponoi	67 4 33 N	41 9 15W
Poole	50 42 50 N	1 58 55 E
Popayan	2 26 18 N	76 39 54W
Popo Isle	1 15 45 S	129 41 30 E
Porkala-udd, Cape	59 56 10 N	24 26 35 E
Porquerolles, citadel	42 59 48 N	6 12 15 E
Port Royal	18 0 0 N	76 45 15W
Port au Prince	18 33 42 N	72 27 11W
Portland, upper lighthouse	50 31 22 N	2 26 50W
Portland, isle of	63 22 0 N	18 53 45W
Portland isles, the most eastern	2 36 0 S	149 39 0 E
Porto	41 46 44 N	12 14 25 E
Porto Bello	9 33 9 N	79 35 15W
Porto Cabello	10 28 22 N	68 16 45W
Porto Ferrajo	42 49 6 N	10 19 35 E
Porto Galate	43 20 10 N	3 5 20W
Porto Rico Island, the town	18 29 10 N	66 13 15W
Porto Rico, Cape St John, E.P.	18 26 0 N	65 43 15W
Porto Rico, Cofre a Morts	17 50 0 N	66 38 15W
Porto Rico, N. W. point	18 31 18 N	66 12 18W
Porto Santo, Isle of	33 5 0 N	16 17 15W
Porto Vecchio	41 35 29 N	9 16 37 E
Portsmouth Academy	50 48 2 N	1 6 1W
Portsmouth, America	43 4 15 N	70 43 0W
Prague	50 5 19 N	14 25 15 E
Praslin port	4 49 27 S	153 6 45 E
Prater's Banks, N. E. ex.	20 57 30 N	116 57 45 E
Prater's Banks, S. W. ex.	20 42 0 N	116 40 15 E
Presbourg	48 8 7 N	17 10 45 E
Prescot spire	53 25 45 N	2 47 44W
Princes, Isle of, harbour	1 37 0 N	7 40 15 E
Idem	6 36 15 S	105 15 15 E
Prince Edward's Isle	46 46 0 S	37 55 0 E
Prior Cape	43 34 15 N	8 22 0W
Providence	41 50 40 N	71 19 45W
Providence Isle, Nassau	25 4 33 N	77 22 6W
Q		
Quebec	46 47 30 N	71 9 45W
Quedlingburg	51 47 58 N	11 7 39 E
Queensberry hill	55 17 2 N	3 34 47W
Quelpaert Isle	33 7 49 N	126 18 57 E
Queretaro	20 36 39 N	100 10 15W
Quimper	47 58 29 N	4 5 45W
Quito	0 13 17 S	78 45 15W
R		
Ramhead	50 18 52 N	4 12 29W
Ramsey Island, highest part	51 51 43 N	5 19 36W
Randers	56 27 48 N	10 3 32 E
Raoul Isles, N. W. point	29 15 45 S	181 55 55 E
Ratisbon	49 0 53 N	12 4 30 E
Ratmanoff Cape	51 0 30 N	143 43 0 E
Rauma	61 8 0 N	21 27 5 E
Ravenna	44 25 5 N	12 10 51 E
Razat, Cape	33 4 0 N	21 47 51 E
Raze, Cape	46 40 0 N	52 3 15W
Real Corona	8 0 26 N	64 45 0W
Recanati	43 25 44 N	13 31 23 E
Research, port of	43 32 23 S	147 6 15 E
Remedios, port de	57 24 15 N	135 53 50 E
Rennes	48 6 50 N	1 40 47W
Rendsburg	54 18 40 N	9 39 53 E
Retford, east spire	53 23 58 N	0 54 3W
Reyes, point of	38 0 8 N	122 57 0W
Revel	59 26 33 N	24 35 9 E
Rhe, Isle of, lighthouse	46 14 49 N	1 33 25W
Rheims	49 14 41 N	4 2 47 E
Rhodez	44 21 8 N	2 34 29 E
Richmond	51 28 8 N	0 18 30W
Riesenkuppe	50 43 18 N	15 40 0 E
Rieux	43 15 23 N	1 12 15 E
Riez	43 48 57 N	6 5 21 E
Riga	56 57 1 N	24 7 45 E
Rimini	44 3 43 N	12 32 51 E
Riobamba, Nuevo	1 41 46 N	78 48 46W
Rio Janeiro, the castle	22 54 2 S	43 17 44W
Ripatransone	43 0 24 N	13 44 45 E
Ripon church	54 8 11 N	1 30 47W
Roca, Cape	38 46 6 N	9 29 21W
Rochefort	45 56 10 N	0 57 34W
Rochelle	46 9 21 N	1 9 40W
Rodota	40 58 34 N	27 25 31 E
Rodrigo Isle	19 40 40 N	63 11 45 E

Mathematical Geography.

Names of Places.	Latitude. ° ′ ″	Longitude. ° ′ ″
Romanzoff	45 25 50 N	141 34 30 E
Romberg	53 26 30 N	141 44 45 E
Rome, St Peter's	41 53 54 N	12 28 15 E
Ronaldsay Cape	59 20 0 N	2 45 15 W
Rondoe	62 21 35 N	5 35 40 E
Rosetta	31 25 0 N	30 28 20 E
Rossal point, landmark	53 55 18 N	3 2 20 W
Rot	47 59 24 N	12 8 45 E
Rothenburgh	48 29 36 N	8 56 54 E
Rotterdam	51 55 22 N	4 29 11 E
Rouen	49 26 27 N	1 5 59 E
Rour, Isle of	1 33 40 S	143 12 45 E
Roverida	45 55 36 N	11 0 35 E
Royan	45 37 28 N	1 1 17 W
Royston steeple	52 2 53 N	0 1 9 W
Rube, or Rypen	55 19 57 N	8 47 20 E
Rufflaw	55 13 16 N	1 45 13 W
Ruremonde	51 11 48 N	5 59 14 E
S		
Saba, middle of the Isle	17 39 30 N	63 20 49 W
Sabionetta	44 59 47 N	10 30 5 E
Sable, Cape of	43 23 45 N	65 29 45 W
Sachalin Isle, N. point	54 24 30 N	142 46 30 E
Sacratif, Cape	36 41 0 N	3 27 0 W
Saddle Back	54 38 30 N	3 2 17 W
Saeby	57 20 2 N	10 33 9 E
Saeloe lighthouse	58 21 0 N	11 15 30 E
Sagan	51 42 12 N	15 22 30 E
Sagewien Isle	0 56 45 S	130 33 15 E
Saints, bay of	32 10 50 S	133 54 13 E
Salisbury spire	51 3 56 N	1 47 24 W
St Andrew, Cape	35 36 30 N	34 32 45 E
St Anthony, Cape	21 54 0 N	84 57 15 W
Idem	36 52 30 S	56 47 14 W
Idem	38 49 50 N	0 9 30 E
Idem, port	45 2 30 S	65 48 44 W
St Anthony's Head	50 8 34 N	4 59 31 W
St Augustine, bay	23 35 29 S	43 9 15 E
St Bartholemy Isle	17 53 30 N	63 0 15 W
St Bertrand	43 1 27 N	0 34 19 E
St Bla, harbour	21 32 48 N	105 15 33 W
St Brieuc	48 31 2 N	2 43 55 W
St Carlos	1 53 42 N	67 33 15 W
St Christopher's Isle,	17 19 30 N	62 49 15 W
St Claude	46 23 18 N	5 52 5 E
St Diego	32 39 30 N	117 16 58 W
St Diez	48 17 27 N	6 56 54 E
St Elie, mountain	60 17 35 N	140 51 6 W
St Esprit	14 56 8 S	166 59 6 E
St Eustathia Isle, road	17 29 0 N	63 4 45 W
St Fiorenzo	42 41 2 N	9 17 43 E
St Flour	45 1 53 N	3 5 39 E
St François port	37 48 30 N	122 8 0 W
St Genest, tower of	43 22 10 N	4 39 15 E
St George, isle, S. E. point	38 30 45 N	27 51 0 W
Idem, cape	4 51 17 S	152 48 55 E
St Ines, cape	54 8 0 S	66 57 26 W
St Istrate, isle, S. E. point	39 30 15 N	24 45 30 E
St John, isle, east cape	18 20 30 N	64 47 9 W
Idem, fort	47 38 45 N	52 39 45 W
Idem, cape	54 56 0 S	63 57 0 W
St Joseph	23 3 13 N	109 40 53 W
St Julien, harbour	49 8 0 S	67 43 14 W
St Kivern	50 3 6 N	5 4 8 W
St Levan, point	50 3 54 N	5 41 4 W
St Lizier	43 0 3 N	1 8 20 E
St Louis Fort, old	18 14 27 E	73 39 9 E
St Lucas, cape	22 52 28 N	109 50 23 W
St Lunaire, bay of	51 28 57 N	55 29 45 W
St Malo	48 39 3 N	2 1 11 W
St Mark, the cape of	19 2 18 N	12 54 52 W
St Marcou, isle	49 29 52 N	1 8 41 W
St Martin de Rhe	46 12 18 N	1 21 52 W
St Martin, isle, N. W. point	18 4 26 N	63 14 27 W
St Matthieu, lighthouse	48 19 34 N	4 45 39 W
St Michel, the mountain	48 38 14 N	1 30 24 W
Idem, isle, west point	37 54 15 N	25 57 2 W
Idem, west point	37 54 15 N	26 5 15 W
St Omer	50 44 52 N	2 15 12 E
St Papoul	43 19 43 N	2 38 25 E
St Paul	23 33 10 S	46 39 10 W
St Paul, trois Chateaux	44 21 3 N	4 45 54 E
St Paul de Leon	48 41 24 N	3 58 22 W
St Polten	48 12 22 N	15 36 7 E
St Pons	43 31 34 N	2 43 52 E
St Quintin	49 50 51 N	3 17 40 E
St Sebastian	43 19 30 N	1 58 30 W
St Thomas, isle, harbour of	18 20 30 N	65 3 6 W
St Thom de Nue	8 8 11 N	63 55 15 W
St Thomas ra Guaya Isle, the Road	0 20 0 N	6 48 15 E
St Tropez	43 16 27 N	6 38 44 E
St Valery sur Somme	50 11 21 N	1 37 51 E
St Vincent, cape	37 2 54 N	8 58 39 W
St Yago isle, la Praya	14 53 40 N	23 31 15 W
St Agnes, lighthouse	49 53 37 N	6 19 33 W
Sta. Barbara	34 24 0 N	119 7 0 W
St Catherine isle, Fort Atom	27 21 58 S	48 3 45 W
Idem, tower	50 35 33 N	1 12 51 W
Idem, isle	35 52 0 N	27 39 45 E
St Cathalina	10 53 50 S	162 26 45 E
St Clair, isle	30 45 15 N	129 54 15 E
St Croix, isle, Cape Byron	10 41 0 S	166 4 45 E
St Croix, harbour	17 44 8 N	64 47 29 W
St Domingo	18 28 40 N	69 59 37 W
St Elizabeth	48 30 17 N	32 27 45 E
Sta. Fe	30 12 0 N	104 53 45 W
Sta. Fe de Bogota	4 35 48 N	74 14 53 W
St Helena, isle	15 55 0 S	5 49 45 W
Sta. Maria, isle, S. E. point	36 56 47 N	25 18 30 W
Idem, isle	49 57 30 N	6 15 15 W
Idem, cape	36 55 24 N	7 47 14 W
Sta. Martha	11 19 34 N	74 8 30 W
Sta. Manza, tower	41 24 59 N	9 15 11 E
Sta. Reparata, tower	41 14 7 N	9 8 37 E
Saintes	15 51 25 N	61 40 25 W
Saintes	45 44 42 N	0 38 2 W
Salagua	19 6 0 N	104 28 0 W
Salamanca	20 40 0 N	100 55 45 W
Salayer, north point	5 45 0 S	120 25 15 E
Sale, or Rabath	34 5 0 N	6 42 45 W
Salehhieh	30 48 28 N	31 59 46 E
Salizano, cape	35 10 45 N	32 8 10 E
Salonica	40 38 7 N	22 56 0 E
Salou, cape	41 4 30 N	1 11 50 E
Salzburg	47 48 10 N	13 1 24 E
Salvages, Isles of	30 8 30 N	15 54 45 W
Samana, isle, west point	23 9 10 N	73 54 28 W
Idem, cape	19 16 26 N	69 13 35 W
Samara	48 29 35 N	35 20 15 E
Sandsoe, isle	68 56 15 N	16 57 15 E
Sandwich, isle of	58 33 0 S	26 45 45 W
Idem, Southern Thule	59 34 0 S	27 44 45 W
Sandy Cape	24 45 0 S	153 9 15 E
Sandy Hook, lighthouse	40 25 0 S	74 13 0 W
Sangaar, Cape	41 16 30 N	140 14 0 E

Mathematical Geography.

Names of Places.	Latitude. ° ′ ″	Longitude. ° ′ ″
Santa	8 59 3 S	78 52 45 W
Santona	43 26 50 N	3 20 27 W
Sapata isle, east point	10 4 30 N	109 13 15 E
Saratov	51 31 28 N	46 0 15 E
Saristcheff, peak	48 2 0 N	152 52 36 E
Sarlat	44 53 20 N	1 13 4 E
Sarot,	40 36 37 N	26 42 17 E
Savannah, lighthouse	32 0 45 N	80 56 45 W
Savu, isle, north point	10 24 20 S	121 46 35 E
Schiedam	51 55 9 N	4 24 0 E
Schleswig	54 31 27 N	9 33 57 E
Schlukenau	51 0 30 N	14 26 30 E
Schnittken	53 48 10 N	21 27 42 E
Schreckhorn, mount	46 31 42 N	8 8 26 E
Schwats	47 22 50 N	11 39 30 E
Schweidnitz	50 50 37 N	16 27 15 E
Schwezingen	49 23 4 N	8 34 19 E
Scilly Bank	54 33 43 N	3 32 54 W
Scott Isles, west extremity	50 52 0 N	129 28 50 W
Seez	48 36 23 N	0 10 59 E
Seieroe	55 52 55 N	11 10 25 E
Selinginskoi Ostrog	51 6 6 N	106 38 45 E
Selivrie	41 4 35 N	28 11 3 E
Selsey	50 45 19 N	0 45 41 W
Senez	43 54 40 N	6 24 20 E
Senlis	49 12 28 N	2 35 13 E
Sens	48 11 55 N	3 16 59 E
Setuval	38 28 54 N	8 53 32 W
Sevastopool	44 41 30 N	33 15 35 E
Shaftsbury, Trinity steeple	51 0 24 N	2 11 25 W
Sheerness	51 27 3 N	0 46 6 E
Sherf hill beacon staff	54 52 59 N	1 34 23 W
Shields, North, steeple	55 0 48 N	1 26 27 W
Shipunskoi Noss	52 55 0 N	159 43 0 E
Sherburne, castle	51 39 25 N	0 57 15 W
Shoreham	50 50 0 N	0 16 19 W
Shrewsbury, St Chad's steeple	52 42 28 N	2 44 53 W
Siam	14 20 40 N	100 50 15 E
Sienna	43 22 0 N	11 10 15 E
Siezran	53 9 53 N	48 25 0 E
Sines, castle	37 57 30 N	8 44 45 W
Singanfu	34 16 45 N	108 57 0 E
Sinigaglia	43 43 16 N	13 11 45 E
Sinope	42 2 16 N	34 41 15 E
Siout	27 13 14 N	31 13 32 E
Sirevaag	58 29 40 N	5 44 15 E
Sisteron	44 11 51 N	5 56 2 E
Skagen Cape, lighthouse	57 43 44 N	10 37 50 E
Skanor	55 24 52 N	12 50 30 E
Skiddaw mountain	54 39 12 N	3 8 9 W
Skudenas	59 8 45 N	5 19 15 E
Slough	51 30 20 N	0 36 0 W
Smalkald	50 44 36 N	10 26 15 E
Small's lighthouse	51 43 18 N	5 58 34 W
Smeinagors	51 9 27 N	82 9 45 E
Smyrna	38 28 7 N	27 6 48 E
Snares, isle of	48 3 0 S	166 20 0 E
Snea Fell	54 17 28 N	4 26 46 W
Snies, castle of	37 57 30 N	13 33 15 E
Snowdon	53 4 9 N	4 3 38 W
Soder Arm, lighthouse	59 46 0 N	19 26 30 E
Soder Hamn	61 17 47 N	17 0 30 E
Soissons	49 22 52 N	3 19 37 E
Sombrero	18 38 4 N	63 31 46 W
Somersham steeple	52 23 46 N	0 0 0
Sonderburgh	54 54 59 N	9 47 13 E
Sonderhausen	51 22 33 N	10 45 21 E
Southofen	47 31 7 N	10 16 23 E
Soulon, isle Tulian	5 57 0 N	121 15 45 E
Sourabaya	7 14 23 S	112 41 28 E
South Foreland, lighthouse	51 8 26 N	1 22 6 E
South Sea, castle	50 46 43 N	1 5 2 W
South Molton steeple	51 1 18 N	3 49 17 W
Southerness point, landmark	54 52 30 N	3 34 53 W
Soutra hill pile	55 51 1 N	2 45 6 W
Sparogskaia-Sjebza	41 31 35 N	34 22 45 E
Spartel, Cape	35 48 40 N	5 50 10 W
Speard, Cape	47 31 22 N	52 37 35 W
Specia	44 4 10 N	9 52 0 E
Spichel, Cape	38 24 54 N	9 12 32 W
Spire	49 18 51 N	8 26 16 E
Spoleta	42 44 50 N	12 35 46 E
Stade	53 36 32 N	9 28 34 E
Standish spire	53 35 17 N	2 39 4 W
Stanmore station	51 37 17 N	0 20 38 W
Stanque de Vares	43 47 25 N	7 39 0 W
Staples, West, lighthouse	55 37 11 N	1 38 51 W
Staples, East, lighthouse	55 38 9 N	1 37 5 W
Start Point	50 13 26 N	3 38 21 W
Stathern point	52 52 33 N	0 49 50 W
Stavanger	58 58 20 N	5 56 45 E
Stickhausen	53 13 10 N	7 36 30 E
Stockholm	59 20 31 N	18 3 30 E
Stolberg	51 35 0 N	10 56 53 E
Stralsund	54 19 0 N	13 32 15 E
Strasburg	48 34 56 N	7 44 51 E
Stretham steeple	52 21 41 N	0 13 48 E
Stromness Isle	58 56 0 N	3 31 5 W
Stromstadt	58 55 30 N	11 12 0 E
Stuttgard	48 46 15 N	9 11 0 E
Suez	29 59 6 N	32 35 20 E
Suffren, bay of	47 51 0 N	139 32 56 E
Sulphur Island	24 48 0 N	141 20 15 E
Sunderland lighthouse	54 55 12 N	1 21 16 W
Sunds-vall	62 22 30 N	17 16 30 E
Surville Cape	10 50 30 S	162 21 57 E
Sutton spire	53 7 36 N	1 42 38 W
Swaffham spire	52 15 35 N	0 18 39 E
Swansea castle	51 37 13 N	3 55 32 W
Syene	24 5 23 N	32 54 34 E
T		
Tacuba	19 31 0 N	99 8 45 W
Taganrock	47 12 40 N	38 39 0 E
Tagomago Isle	39 0 30 N	1 40 40 E
Tali Isle, point Venus	17 29 17 S	149 30 15 W
Talcaguana	36 42 21 S	73 39 12 W
Talsarn	52 13 8 N	4 7 8 W
Tambow	52 43 44 N	41 45 15 E
Tamerton, North, steeple	50 45 5 N	4 22 44 W
Tanna Isle, port Resolution	19 32 25 S	164 39 41 W
Tara	56 54 31 N	74 0 18 E
Tarapia	41 8 24 N	29 0 45 E
Tarbes	43 13 52 N	0 4 14 E
Tariffe Isle	36 0 30 N	5 35 15 W
Tarquinio, peak	19 52 57 N	76 50 7 W
Tarragona	41 8 50 N	1 15 30 E
Tarvestad	59 22 40 N	5 15 5 E
Tasco	18 35 0 N	99 29 45 W
Tassi Isle	40 46 40 N	24 39 9 E
Taunton, St Mary's	51 0 59 N	3 5 22 W
Tavastehus	61 3 0 N	24 26 30 E
Tavolara, tower of	40 54 46 N	9 43 28 E
Tcherkask	47 13 34 N	39 23 15 E
Tchukoskoi-Noss	64 14 30 N	178 11 15 E
Tedeles, Cape	36 57 0 N	4 14 3 E
Teklenburgh	52 13 28 N	7 47 25 E

Mathematical Geography.

Names of Places.	Latitude. ° ′ ″	Longitude. ° ′ ″
Tenedos Isle, north-east pt.	39 51 15 N	25 53 0 E
Teneriffe Isle, the peak	28 17 0 N	16 39 45 W
Idem, from the mole St Croix	28 28 30 N	16 16 45 W
Tercera Isle	38 38 10 N	27 12 40 W
Ternay, bay of	45 10 32 N	137 1 15 E
Terracina	41 18 14 N	13 13 22 E
Tescuco	19 30 40 N	98 51 0 W
Tewkesbury steeple	51 59 27 N	2 9 7 W
Thebes, ruins of	25 43 0 N	32 39 21 E
Thiels	51 0 4 N	3 19 42 E
Three Kings Isle, the most E.	34 12 30 S	172 10 0 E
Tiburon, Cape	18 19 25 N	74 34 0 W
Tilton on the Hill	52 38 46 N	0 51 45 W
Timana	1 58 32 N	75 51 40 W
Tinian Isle	14 58 0 N	145 51 15 E
Tobago Isle	11 6 0 N	60 49 45 W
Tobolsk	58 11 42 N	68 6 15 E
Toluca	19 16 19 N	99 21 30 W
Tomependa	5 31 2 S	78 36 22 W
Tomsk	56 29 38 N	85 9 51 E
Tondern	54 56 30 N	8 53 42 E
Tongataboo Isle	21 7 35 S	175 12 59 W
Tongres	50 47 7 N	5 27 43 E
Tonningen	54 19 25 S	8 58 45 E
Toothill telegraph	50 57 56 N	1 27 6 W
Torulo	65 50 50 N	24 12 15 E
Torschock	57 2 9 N	35 3 15 E
Tortona	44 53 26 N	8 56 32 E
Tortosa, the cathedral	40 48 46 N	0 33 0 E
Tortua, isle, S. E. point	120 3 33 N	72 42 55 W
Tortuga isle	10 59 0 N	65 34 13 W
Totma	60 8 0 N	60 41 15 E
Totness steeple	50 25 57 N	3 40 29 W
Toul	48 40 32 N	5 53 16 E
Toula	54 11 40 N	7 31 6 E
Toulon	43 7 9 N	5 55 41 E
Toulouse	43 35 46 N	1 26 36 E
Tournay	50 36 20 N	3 23 17 E
Tours	47 23 46 N	0 40 38 E
Trafalgar, Cape	36 10 15 N	6 0 0 W
Travemunde	53 57 46 N	10 51 40 E
Trebizonde	41 2 41 N	39 28 0 E
Trecastle beacon	51 52 58 N	3 41 35 W
Tregonning signal-staff	50 6 59 N	5 20 1 W
Treguier	48 46 54 N	3 13 35 W
Trelleborg	55 22 14 N	13 10 30 E
Trent	46 6 26 N	11 3 45 E
Tres Forcas	35 27 55 N	2 56 10 W
Treves	49 46 37 N	6 38 20 E
Trevose Head	50 32 57 N	2 0 54 W
Triest	45 38 8 N	13 47 8 E
Trincomalee	8 32 0 N	81 12 15 E
Trinidad	21 48 20 N	80 0 52 W
Trinity, isle	10 38 42 N	61 38 0 W
Idem, isle	20 31 0 S	28 36 44 W
Tripoli	34 26 25 N	35 44 20 E
Idem	32 53 40 N	13 21 22 E
Troyes	48 18 5 N	4 4 49 E
Trumpington steeple	52 10 45 N	0 6 58 W
Truxillo	8 6 9 S	79 3 22 W
Tschirikoff, cape	32 14 15 N	131 41 30 E
Tschitschagoff, cape	30 56 45 N	130 36 30 E
Idem	8 57 0 S	139 42 11 W
Tso-Choui	35 30 0 N	129 16 7 E
Tsus Sima isle, north point	34 40 30 N	129 27 7 E
Tubingen	48 31 10 N	9 3 35 E
Tulles	45 16 3 N	2 54 13 E
Tunis, or Fondouc	36 47 59 N	10 11 15 E
Turbaco	10 18 5 N	75 21 38 W
Turin,	45 4 6 N	7 40 15 E
Turks isles, Sandkey	21 11 10 N	71 14 52 W
Turer	56 51 44 N	35 57 23 E
Twymbarlum mountain	51 37 41 N	3 4 55 W
Tynemouth lighthouse	55 1 21 N	1 24 31 W
Typa	22 9 20 N	113 44 0 E
Tyrnau	48 23 5 N	17 35 15 E
U		
Udino	46 3 14 N	13 15 2 E
Uddevalla	58 21 15 N	11 56 30 E
Ufa	54 42 45 N	55 53 45 E
Uffculme steeple	50 54 15 N	3 19 16 W
Ugborough spire	50 23 13 N	3 50 53 W
Ulietea, isle	16 45 35 N	151 36 45 W
Ulm	48 23 20 N	9 59 6 E
Umba	66 44 30 N	34 13 0 E
Umhea	66 4 0 N	20 22 30 E
Unst, isle	60 40 0 N	0 46 45 W
Untiefen, cape of	52 32 30 N	143 14 30 W
Upsal	59 51 50 N	17 39 0 E
Urals	51 11 0 N	51 35 30 E
Uraniburg	55 54 38 N	12 42 59 E
Urbino	43 43 36 N	12 37 5 E
Ust-Kamenorsk	49 56 45 N	82 40 15 E
Utklippar	55 58 0 N	15 41 30 E
Uto, isle,	59 47 18 N	21 17 19 E
Utrecht	52 5 31 N	5 7 16 E
Uzes	44 0 45 N	4 25 17 E
V		
Vabres	43 56 27 N	2 50 31 E
Vaison	44 14 28 N	5 4 9 E
Valdivia	39 51 0 S	73 26 15 W
Valence	44 55 59 N	4 53 25 E
Valentia	39 28 45 N	0 23 3 W
Valladolid	19 42 0 N	100 52 0 W
Valparaiso	33 0 30 S	71 38 15 W
Vannes	47 39 26 N	2 45 4 W
Varberg	57 6 18 N	12 16 0 E
Varna	43 6 56 N	27 59 7 E
Vavao isle	18 33 54 S	173 59 45 W
Vence	43 43 13 N	7 6 44 E
Vendola, isle	2 14 0 S	148 10 6 E
Venice, St Mark	45 25 32 N	12 20 59 E
Venloo	51 22 17 N	6 10 31 E
Vera Cruz	19 11 52 N	96 8 45 W
Verden	52 55 37 N	9 12 45 E
Verdun	49 9 31 N	5 22 17 E
Verona observatory	45 26 7 N	11 1 15 E
Versailles	48 48 21 N	2 7 22 E
Vianna	41 42 36 N	8 42 39 W
Vibora	16 50 0 N	78 23 34 W
Viborg	56 27 11 N	9 26 20 E
Vicenza	45 31 40 N	11 33 24 E
Vienna	48 12 40 N	16 22 45 E
Vienne	45 32 57 N	4 53 39 E
Vigevano	45 18 54 N	8 52 1 E
Vigo	42 13 20 N	8 33 30 W
Villa de Conde	41 21 20 N	8 36 28 W
Villa del Pao	8 38 1 N	64 48 0 W
Villach	46 35 0 N	13 52 15 E
Villalpando	41 51 10 N	5 24 16 W
Ville Franche	43 40 20 N	7 19 30 E
Virgin Gorda, east cape	18 31 7 N	64 25 24 W
Virgins Cape	52 21 0 S	68 17 25 W
Viviers, observatory	44 29 14 N	4 41 0 E
Voghera	44 59 21 N	9 1 25 E
Vologda	59 13 30 N	40 11 15 E

Mathematical Geography.

Names of Places.	Latitude. ° ′ ″	Longitude. ° ′ ″
Vona	41 7 0 N	37 46 45 E
Vulcan, isle of	5 32 20 S	148 4 15 E
Idem	10 25 12 S	165 48 21 E
Idem, bay of Port End	42 33 11 N	140 52 47 E
Idem, isle	30 43 0 N	130 16 40 E
W		
Waigioa isle, Boni	0 2 30 S	131 1 59 E
Wakefield	53 41 2 N	1 29 24 W
Waldeck	51 12 43 N	9 1 32 E
Waldes, harbour	42 30 0 S	63 40 15 W
Wallis isle	13 18 0 S	177 21 45 W
Walsingham cape	62 39 0 N	77 47 45 W
Waltham spire	52 49 5 N	0 48 21 W
Wangeroeg lighthouse	53 48 26 N	7 52 35 E
Wanstead	51 34 10 N	0 3 45 E
Warasdin	46 18 18 N	16 26 6 E
Warberg, fort	57 6 18 N	12 16 0 E
Wardhuus	70 22 36 N	31 7 0 E
Wardour castle	51 2 32 N	2 5 45 W
Warmensdorf	51 17 13 N	12 56 7 E
Warkworth castle	55 20 54 N	1 36 14 W
Warren bank	52 5 49 N	4 36 18 W
Warrington steeple	53 23 30 N	2 33 11 W
Warsaw	52 14 28 N	21 2 45 E
Washington	38 55 0 N	76 58 45 W
Watelin isle, S.E. point	25 56 31 N	74 37 2 W
Watford spire	51 39 16 N	0 23 36 W
Weaver Hill	53 0 55 N	1 51 10 W
Wednesbury spire	52 33 23 N	2 0 44 W
Weimar	50 59 12 N	11 21 0 E
Welford steeple	52 25 5 N	1 3 13 W
Wellington steeple	50 58 54 N	3 12 49 W
Wernigerode	51 50 34 N	10 47 28 E
Wesel	51 39 17 N	6 37 8 E
West Cappel	51 31 49 N	3 26 55 E
West Morchard steeple	50 51 15 N	3 43 52 W
Westende	6 48 0 S	105 5 15 E
Westerwick	57 44 50 N	16 40 15 E
Whattley spire	51 13 39 N	2 22 23 W
Whatton spire	52 57 1 N	0 53 15 W
Whernside mountain, great	54 9 44 N	1 59 24 W
Whernside, Ingleton fells	54 13 45 N	2 23 35 W
Whitchurch steeple	51 52 51 N	0 49 49 W
Whitehaven windmill	54 32 50 N	3 34 56 W
Wibourg	60 42 40 N	28 46 5 E
Wildeshausen	52 54 26 N	8 27 54 E
Wilna	54 41 2 N	25 17 27 E
Wilton beacon	53 59 54 N	0 45 29 W
Winchester cathedral	51 3 40 N	1 18 26 W
Winckley steeple	50 51 22 N	3 55 48 W
Wingaac, pyramid of	57 38 12 N	11 38 0 E
Wing steeple	51 53 49 N	0 43 3 W
Wisby	57 39 15 N	18 26 30 E
Wisp Hill	55 17 13 N	2 57 22 W
Wittenberg	51 52 39 N	12 45 44 E
Woerden	52 5 13 N	4 44 6 E
Wolfembuttel	52 8 44 N	10 21 44 E
Woburn Abbey	51 54 47 N	0 35 42 W
Wolverhampton Spire	52 34 54 N	2 7 10 W
Woodbury signal staff	50 37 22 N	3 20 17 W
Worcester	52 9 30 N	2 0 0 W
Workington Chapel	54 38 34 N	3 33 30 W
Worms Head	51 33 56 N	4 18 56 W
Wornas	40 37 49 N	8 21 12 E
Woronetz	51 40 30 N	39 21 30 E
Wouhahou isle	21 40 30 S	158 1 15 W
Wrekin, the	52 40 11 N	2 31 30 W
Wurtzburg	49 46 6 N	9 55 30 E
Wurzen	51 22 2 N	12 42 44 E
Wushnei Wolotschok	57 35 12 N	34 41 0 E
X		
Xam-hay	31 16 0 N	121 32 0 E
Xanten	51 40 13 N	6 25 53 E
Y		
Yartcombe	50 52 22 N	3 4 34 W
Yelling spire	52 15 16 N	0 9 19 W
Yeovil steeple	50 56 34 N	2 37 1 W
Yetminster Steeple	50 53 40 N	2 34 6 W
Yeu, isle of	46 42 26 N	2 19 35 W
Ylo	17 36 15 S	71 10 45 W
Ynaliog mountain	52 48 41 N	4 43 30 W
Ynys Gadarn	53 22 9 N	4 14 15 W
York Minster	53 57 48 N	1 4 34 W
York's, Duke of, isle	8 41 6 S	173 25 45 W
Ypres	50 51 10 N	2 53 4 E
Ystad	55 25 31 N	13 48 30 E
Z		
Zachea, isle of	18 23 48 N	67 34 1 W
Zalappa	19 30 8 N	96 54 39 W
Zarizin	48 42 20 N	44 27 45 E
Zeal Monachorum	50 49 4 N	3 48 23 W
Znaim	48 31 15 N	16 1 57 E
Zumpango	19 46 52 N	99 3 45 W
Zurich	47 22 33 N	8 31 30 E
Zuriksee	51 39 4 N	3 54 59 E
Zutphen	52 8 26 N	6 11 52 E

Geology, Geometrical Analysis.

GEOLOGY, or GEOGNOSY, is that branch of mineralogy which relates to the arrangement and mode of formation of the different mineral substances of which the earth is composed. We originally proposed to discuss this subject under the present article, but it has been thought proper to include it under the general head of MINERALOGY.

GEOMETRICAL ANALYSIS, is the particular form of proceeding, employed by the ancient geometers in the investigation of geometrical truth. It originated in the school of Plato, and was alike applicable to the demonstration of theorems, and the investigation of problems. We learn from the writings of Pappus Alexandrinus, that in his time there existed thirty-three books relating to this subject; many of these have been lost, and their restoration has afforded an exercise to the ingenuity of mathematicians of modern times.

We have sufficiently indicated the nature of the geometrical analysis, and the mode of its application in our article ANALYSIS. When at that part of our work, it was our intention to have treated at some length on the subject in this place; but as we dvanced, we have, with a view to give sufficient room to other oranches of knowledge, found it necessary to limit somewhat our views. The history of its origin and progress will be found in the introduction to the article GEOMETRY, and it will be noticed again under the words INCLINATION, LOCUS, PORISM, TANGENCY, and SECTION. Works which treat on the subject are enumerated in the introduction to GEOMETRY. (ξ)

GEOMETRY.

History.

Geometry is that branch of mathematics which treats of the properties of extension and figure. The name is derived from γεωμετρία, the *science of land measuring.*

There is a certain degree of geometrical knowledge which naturally arises out of the wants of man, in every state of society. It is impossible to build houses and temples, or to apportion territory, without employing some of the principles of geometry. Hence we cannot expect to find a period of society, or a country in which it was altogether unknown.

[Or]igin of [Ge]ometry.

Ancient writers have generally supposed that it was first cultivated in Egypt; and, according to some, it derived its origin from the necessity of determining every year the just share of land that belonged to each proprietor, after the waters of the Nile, which annually overflowed the country, had returned into their ordinary channel. It may however be remarked, that the obliteration of the landmarks, by the inundation, is quite a conjecture, and not a very probable one.

Some writers, among whom is Herodotus, fix the origin of geometry at the time when Sesostris intersected Egypt by numerous canals, and divided the country among the inhabitants. Sir Isaac Newton has adopted this opinion in his chronology, and has supposed that this division was made by Thoth the minister of Sesostris, who, according to him, was the same as Osiris; and this conjecture is supported by some ancient authorities. Aristotle has however attributed the invention to the Egyptian priests, who, living secluded from the world, had leisure for study. Thus, various opinions have been entertained respecting the origin of geometry, but all have agreed in fixing it in Egypt.

[Ge]ometry [bro]ught to [Gr]eece by [Th]ales, [A.] C. 640.

The celebrated philosopher, Thales of Miletus, transplanted the sciences, and particularly mathematics, from Egypt into Greece. He was born about 640 years before Christ, and being unable to gratify his ardent desire for knowledge at home, he travelled into Egypt, at an advanced period of life, where he conversed with the priests, the only depositories of learning in that country. Diogenes Laertius relates, that he measured the height of the pyramids, or rather the obelisks, by means of their shadow; and Plutarch says, that the king Amasis was astonished at this instance of sagacity in the Greek philosopher; which is a proof that the Egyptians had made but little progress in the science. It is also stated by Proclus, that Thales employed the principles of geometry to determine the distance of vessels remote from the shore. On his return to Greece, his celebrity for learning drew the attention of his countrymen: he soon had disciples, and hence the foundation of the Ionian school, so called from Ionia his native country.

[Ion]ian [sch]ool [fou]nded.

There were some slight traces of what may be called natural geometry in Greece, before the time of Thales: Thus, Euphorbus of Phrygia is said to have discovered some of the properties of a triangle; the square and the level have been ascribed to Theodorus of Samos; and the compasses to the nephew of Dædalus. But these can only be considered as a kind of instinctive geometry; the origin of the true geometry among the Greeks must be fixed to the period of the return of Thales. It was he that laid the foundation of the science, and inspired his countrymen with a taste for its study; and various discoveries are attributed to him, concerning the circle, and the comparison of triangles. In particular, he first found that all angles in a semicircle are right angles; a discovery which is said to have excited in his mind that lively emotion, which is perhaps only felt by poets and geometers: he foresaw the important consequences to which this proposition led, and he expressed his gratitude to the muses by a sacrifice. This, however, is but a small part of what geometry owes him; and it is much to be regretted that the loss of the ancient history of the science should have left us in uncertainty as to the full extent of the obligation.

Early geometers. Ameristus and Anaximander. Born 610 A. C.

It is probable that the greater number of the disciples of Thales were acquainted with geometry; but the names of Ameristus and Anaximander only have reached our times. The first is said to have been a skilful geometer; the other composed a kind of elementary treatise or introduction to geometry, the earliest on record. Thales was succeeded in his school by Anaximander, who is said to have invented the sphere, the gnomon, geographical charts, and sun-dials; he was succeeded by Anaximenes; and this philosopher again was succeeded by his scholar Anaxagoras, who, being cast into prison on account of his opinions relating to astronomy, employed himself in attempting to square the circle. This is the earliest effort on record, to resolve the most celebrated problem in geometry.

Anaximenes. Born 554 A. C. Anaxagoras. Born 500 A. C.

Pythagoras. Born 580 A. C.

Pythagoras was one of the earliest and most successful cultivators of geometry. He was born about 580 years before the Christian æra; he studied under Thales, and by his advice travelled into Egypt. Here he is said to have consulted the columns of Sothis, on which that celebrated person had engraven the principles of geometry, and which were deposited in subterranean vases. A learned curiosity induced him to travel also into India; and it is far from being improbable, that he was more indebted for his knowledge to the Brahmins, on the banks of the Ganges, than to the priests of Egypt. On his return, finding his native country a prey to tyranny, he settled in Italy, and there founded one of the most celebrated schools of antiquity. He is said to have discovered that in any right angled triangle, the square on the side opposite the right angle, is equal to the two squares on the sides containing it; and, on this account, to have sacrificed one hundred oxen, to express his gratitude to the muses. This, however, was incompatible with his moral principles, which led him to abhor the shedding of blood on any account whatever; and besides, the moderate fortune of a philosopher would not admit of such an expensive proof of his piety. The application which the Pythagoreans made of geometry gave birth to several new theories, such as the incommensurability of certain lines, for example, the side of a square, and its diagonal, also the doctrine of the regular solids, which, although of little use in itself, must have led to the discovery of many propositions in geometry. Diogenes Laertius has attributed to Pythagoras the merit of having discovered, that of all figures having the same boundary, the circle among plane figures, and the sphere among solid figures, are the most capacious: if this was so, he is the first on record that has treated of isoperimetrical problems.

Pythagorean school founded about 550 A. C.

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The Pythagorean school sent forth many mathematicians; of these Archytas claims attention, because of his solution of the problem of finding two mean proportionals; also on account of his being one of the first that employed the geometrical analysis, which he had learnt from Plato, and by means of which he made many discoveries. He is said to have applied geometry to mechanics, for which he was blamed by Plato; but probably it was rather for applying, on the contrary, mechanics to geometry, as he employed motion in geometrical resolutions and constructions.

Democritus.

Democritus of Abdera studied geometry, and was a profound mathematician. From the titles of his works, it has been conjectured that he was one of the principal promoters of the elementary doctrine respecting the contact of circles and spheres, and concerning irrational numbers and solids. He treated besides of some of the principles of optics and perspective.

Hippocrates, 380 A. C.

Hippocrates was originally a merchant, but having no turn for commerce, his affairs went into disorder; to repair them, he came to Athens, and was one day led by curiosity to visit the schools of philosophy. There he heard of geometry for the first time; and as probably there is a natural adaptation of certain minds to particular studies, he was instantly captivated with the subject, and became one of the best geometers of his time. He discovered the quadrature of a space bounded by half the circumference of one circle, and one fourth the circumference of another, their convexities being turned the same way. This figure, called a *lune*, he shewed to be equal to a right angled triangle having its sides about the right angle equal, and the remaining side equal to the common chord of the two arcs; and thus he was the first that proved a curvilineal to be equal to a rectilineal space. But although a kind of quadrature, it cannot be compared as a discovery with the quadrature of the parabola found afterwards by Archimedes: the former is merely a geometrical trick, which leads to nothing further; but the latter was an important step in the progress of the science. Hippocrates attempted the quadrature of the circle, but if his mode of reasoning has been correctly handed down to us, he committed a blunder: this is the oldest paralogism in geometry upon record. On the other hand it must be mentioned to his credit, that he first proved the duplication of the cube to depend on the finding of two mean proportionals between two given lines: (See Introduction to Conic Sections.) He was also the first that composed Elements of Geometry, which, however, have been lost, and are only to be regretted, because we might have learnt from them the state of the science at that period. It has been said that, notwithstanding his want of success in commerce, he retained something of the mercantile spirit: he accepted money for teaching geometry, and for this he was expelled the school of the Pythagoreans. This offence we think might have been forgiven, in consideration of his misfortunes.

Bryson and Antiphon.

Two geometers, Bryson and Antiphon, appear to have lived about the time of Hippocrates, and a little before Aristotle. These are only known by some animadversions of this last philosopher on their attempts to square the circle. It appears that before this time, geometers knew that the area of a circle was equal to a triangle whose base was equal to the circumference, and perpendicular equal to the radius.

Having briefly traced the progress of geometry during the two first ages after its introduction into Greece, we come now to the origin of the Platonic school, which may be considered as an æra in the history of the science. Its celebrated founder had been the disciple of a philosopher (Socrates) who set little value on geometry; but Plato entertained a very different opinion of its utility. After the example of Thales and Pythagoras, he travelled into Egypt, to study under the priests. He also went into Italy, to consult the famous Pythagoreans, Philolaus, Timæus of Locris, and Archytas, and to Cyrene to hear the mathematician Theodorus. On his return to Greece, he made mathematics, and especially geometry, the basis of his instructions. He put an inscription over his school, forbidding any one to enter, that did not understand geometry; and when questioned concerning the probable employment of the Deity, he answered, that *he geometrized continually*, meaning no doubt that he governed the universe by geometrical laws.

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Platonic school founded about 400 A. C.

Invention of geometrical analysis.

It does not appear that Plato composed any work himself on mathematics, but he is reputed to have invented the Geometrical Analysis: (See Analysis.) The theory of the Conic Sections originated in this school; some have even supposed that Plato himself invented it, but there does not seem to be any sufficient ground for this opinion. See Conic Sections.

Of geometrical loci.

A third discovery due to the Platonic school was that of the *geometrical loci*; when the conditions which determine the position of a point are such as to admit of its being any where in a line of a particular kind, but do not admit of its being out of that line, then the line is called the *locus* of the point: Thus, if one end of a straight line of a given length be at a given point, the *locus* of the other end will be the circumference of a given circle: Again, if the base of a triangle of a given area be given in position and magnitude, the *locus* of its vertex will be a given straight line, which will be parallel to the base; also, if the base of a triangle be given in position and magnitude, and its vertical angle be given in magnitude, the *locus* of its vertex will be the circumference of a given circle: all this is evident from the elements of geometry. *Geometrical loci*, considered merely as speculative truths, are interesting; but their chief value arises from their utility in the resolution of problems, of which, in general, they suggest the most elegant solutions. See Locus.

Duplication of the cube.

The celebrated problem concerning the duplication of the cube, acquired its celebrity about the time of Plato. Its origin, however, was earlier; for it appears, that Hippocrates had reduced it to the determination of two mean proportionals between two given lines; but it had not then excited much attention among geometers. We have already given its history in the introduction to Conic Sections. Plato himself gave a solution, and it was also resolved by Archytas, Eudoxus, Eratosthenes, and Menæchmus. The solutions of eleven of the ancient geometers, are preserved in Eutocius' commentary on Archimedes, *de Sph. et Cyl.*

Trisection of an angle.

It is probable that the *trisection of an angle*, a problem of the same difficulty as the duplication of the cube, was likewise considered in the Platonic school. There is no absolute testimony of its being so ancient; but, according to the natural progress of the human mind, it must have occurred as soon as geometry assumed the form of a science; for the transition from the bisection of an arc to its division into three, or any number of equal parts, or into parts which have a given ratio to one another, is easy. The quadratrix, a curve almost as old as the time of Plato, appears to have been invented with a view to the solution of the problem in its most general form. One difficulty in the problems

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of doubling a cube, and trisecting an angle, must have arisen from the impossibility of resolving them by straight lines and circles alone; and of this the ancient geometrical analysis gave no certain indication. The modern analysis teaches how to resolve every such problem, and also shews by what lines it may be effected.

These discoveries must be attributed to the Platonic school in general; for it is impossible to say with whom each originated. Some of advanced years frequented the school, as friends of its celebrated head, or out of respect for his doctrines; and others, chiefly young persons, as disciples and pupils. Of the first class were Laodamus, Archytas, and Theætetus. Laodamus was one of the first to whom Plato communicated his method of analysis, before he made it public; and he is said by Proclus to have profited greatly by this instrument of discovery. Archytas was a Pythagorean of extensive knowledge in geometry and mechanics. He had a great friendship for Plato, and frequently visited him at Athens; but in one of his voyages he perished by shipwreck. Theætetus was a rich citizen of Athens, and a friend and fellow-student of Plato under Socrates, and Theodorus of Cyrene, the geometer. He appears to have cultivated and extended the theory of the regular solids.

Laodamus, Archytas, Theætetus.

The progress that geometry had then made, from the time of Hippocrates of Chios, required that the elements of the science should be new modelled. This was done by Leon, a scholar of Neoclis, or Neoclide, a philosopher who had studied under Plato. To Leon has been ascribed also the invention of that part of the solution of a problem called its *determination*, which treats of the limits, or the cases in which it is possible. Eudoxus of Cnidus was one of the most celebrated of the friends and contemporaries of Plato. He generalized many theorems, and thereby greatly advanced geometry. It is believed that he cultivated the theory of the conic sections; and its invention has been attributed to him. He resolved the problem of the duplication of the cube; and it is to be regretted that Eutocius, who despised his solution, has not thought fit to record it with the others, in his Commentary on Archimedes. Diogenes Laertius has attributed to him the invention of curve lines in general; from which we may infer, that other curves than the conic sections were known in the school of Plato. Archimedes says, in the beginning of his treatise on the sphere and cylinder, that Eudoxus found the measure of the pyramid and cone, and that he had treated of solids; and others again have supposed, that he was the author of the theory of proportion as given in the fifth book of Euclid's Elements.

Leon.

Eudoxus. Died 368 A. C.

Passing over various geometers who are said to have distinguished themselves, but of whom hardly any thing more than the names are now known, we shall only mention Menæchmus, and his brother Dinostratus. The former extended the theory of conic sections, insomuch that Eratosthenes seems to have given him the honour of their discovery, calling them *the curves of Menæchmus*. His two solutions of the problem of two mean proportionals, are a proof of his geometrical skill. Several discoveries have been given to Dinostratus; but he is chiefly known by a property which he discovered of the *quadratrix*, a curve supposed to have been invented by Hippias of Elis.

Menæchmus, Dinostratus.

After the death of Plato, his school was divided into two, which, upon some points, held opposite sentiments, but agreed in regarding a knowledge of the mathematics as absolutely necessary to such as would study philosophy. Thus the geometrical theories which had been cultivated with so much ardour in his lifetime, still continued to make progress. Xenocrates, the successor of Plato after Speusippus, wrote on geometry and arithmetic. The principal geometers were all bred in the Platonic school, and among these probably we ought to reckon Aristæus, who is now little known, because his works are lost: we learn, however, from Pappus, that he was one of the ancients who had made the most progress in their *sublime geometry*. He composed a treatise on solid *loci*, in five books, and another on conic sections, also in five books, which last contained the greatest part of what was afterwards given by Apollonius in the first four books of his work. Pappus placed this work after the conics of Apollonius, in the order of study which he prescribed to his son: This shews that it was a profound theory, and supposed the doctrine of conics to be previously known. He is reputed to have been the friend and preceptor of Euclid.

Xenocrates.

Aristæus.

The progress of geometry among the Peripatetics was not so brilliant as it had been in the school of Plato, but the science was by no means neglected. The successor of Aristotle composed several works relating to mathematics, and particularly a complete history of these sciences down to his own time: there were four books on the history of geometry, six on that of astronomy, and one on that of arithmetic. What a treasure this would have been, had we now possessed it!

The next remarkable epoch in the history of geometry, after the time of Plato, was the establishment of the school of Alexandria, by Ptolemy Lagus, about 300 years before the Christian æra. This event was highly propitious to learning in general, and particularly to every branch of mathematics then known; for the whole was then cultivated with as much attention as had been bestowed on geometry alone in the Platonic school. It was here that the celebrated geometer Euclid flourished under the first of the Ptolemies: his native place is not certainly known, but he appears to have studied at Athens, under the disciples of Plato, before he settled at Alexandria. Pappus, in the introduction to the seventh book of his Collections, gives him an excellent character, describing him as gentle, modest, and benign towards all, and more especially such as cultivated and improved the mathematics. There is an anecdote recorded of Euclid, which seems to shew he was not much of a courtier: Ptolemy Philadelphus having asked him whether there was any easier way of studying geometry than that commonly taught; his reply was, "there is no royal road to geometry." This celebrated man composed treatises on various branches of the ancient mathematics, but he is best known by his Elements, a work on geometry and arithmetic, in thirteen books, under which he has collected all the elementary truths of geometry, which had been found before his time. The selection and arrangement have been made with such judgment, that, after a period of 2000 years, and notwithstanding the great additions made to mathematical science, it is still generally allowed to be the best elementary work on geometry extant. Numberless treatises have been written since the revival of learning, some with a view to improve, and others to supplant the work of the Greek geometer; but in this country, at least, they have been generally neglected and forgotten, and Euclid maintains his place in our schools.

School of Alexandria founded 300 A. C.

Euclid flourished 280 A. C.

Of Euclid's Elements, the first four books treat of the properties of plane figures; the fifth contains the theory of proportion; and the sixth its application to

Euclid's Elements.

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Euclid's Elements of Geometry.

plane figures; the seventh, eighth, ninth, and tenth relate to arithmetic, and the doctrine of incommensurables; the eleventh and twelfth contain the elements of the geometry of solids; and the thirteenth treats of the five regular solids, or *Platonic bodies*, so called because they were studied in that celebrated school: two books more, viz. the fourteenth and fifteenth, on regular solids, have been attributed to Euclid, but these rather appear to have been written by Hypsicles of Alexandria.

It is only the first six, and the eleventh and twelfth books, that are now commonly taught in the schools; for the books on arithmetic have been superseded by the modern theories of algebra, and the regular solids have long ceased to be particularly interesting: they may be compared to mines which have been abandoned because the produce was not equal to the expence of working them. Euclid's Elements have had a number of commentators; the earliest was Theon of Alexandria, who lived about the middle of the fourth century. Proclus also has given a commentary on the first book, which is only valuable on account of the information it contains respecting the history and metaphysics of geometry. After the revival of learning, the Elements of Euclid were first known in Europe, through the medium of an Arabic translation; from this it was deciphered and translated into Latin, by Athelard in England, and Campanus in Italy, about the same time, in the 12th or 13th centuries. Athelard's translation exists only in manuscript, in some libraries; that of Campanus served as the basis of the greater part of the Latin translations, made about the end of the 15th and the beginning of the 16th centuries. The *editio princeps* is that which Ratdolt of Augsburg, a celebrated printer, gave in 1482, at Venice, in folio; the Greek text did not appear until 1533, when it was printed at Basle, by J. Hervage, under the care of J. Grynæus. The earliest English edition is that of Bilingsley, in 1570: But the history of the various editions of this work, either in whole or in part, that have been published in all countries, in which science has been cultivated, is far too extensive to find a place here. The curious reader may find a copious list in the second volume of the *Bibliotheca Mathematica*, by Murhard. At present, the edition of Euclid most esteemed in this country, is that of the late Dr Simson of Glasgow, which contains the first six and the eleventh and twelfth books, and the book of Euclid's Data. We have lately seen the first volume of an edition in the original Greek, accompanied with a Latin and French translation by Peyrard, a French professor of mathematics, and author of a French translation of Archimedes; it gives the original text as exhibited in a great number of manuscripts, and on this account it must be extremely valuable.

Euclid's commentators.

Euclid's Data.

Besides the Elements, the only other entire geometrical work of Euclid that has come down to the present times, is his Data. This is the first in order of the books written by the ancient geometers to facilitate the method of resolution or analysis. In general, a thing is said to be given, which is actually exhibited, or can be found; and the propositions in the book of Euclid's Data, shew what things can be found from those which by hypothesis are already known.

We learn from Pappus of Alexandria, that there existed four books by Euclid on Conic Sections, and two concerning *Loci ad Superficiem*; these were curves of double curvature. But his most profound work, and that of which the loss is most regretted, was his three books on Porisms, which Pappus says were a most artful collection of many things that relate to the analysis of the more difficult and general problems. We shall explain this subject under the word PORISM. Proclus cites another work of Euclid's, which he entitles, *De Divisionibus*. This probably treated of the division of figures. These are all the known geometrical writings of Euclid:—his other works do not belong to this place. See EUCLID.

Archimedes. Born 287 A. C.

In the order of time, Archimedes is the next of the ancient geometers that has drawn the attention of the moderns. He was born at Syracuse, about the year 287 A. C. He cultivated all the parts of mathematics, and in particular geometry. The most difficult part of the science is that which relates to the areas of curve lines, and to curve surfaces. Archimedes applied his fine genius to this subject, and he laid the foundation of all the subsequent discoveries relating to it. His writings on geometry are numerous. We have, in the first place, two books on the sphere and cylinder; these contain the beautiful discovery, that the sphere is two-thirds of the circumscribing cylinder, whether we compare their surfaces, or their solidities, observing that the two ends of the cylinder are considered as forming a part of its surface. He likewise shews, that the curve surface of any segment of the cylinder between two planes perpendicular to its axis, is equal to the curve surface of the corresponding segment of the sphere. Archimedes was so much pleased with these discoveries, that he requested after his death that his tomb might be inscribed with a sphere and cylinder.

His book on the *Measure of the Circle*, is a kind of supplement to those on the sphere and cylinder. In this, he demonstrates that any circle is equal to a triangle having its base equal to the circumference, and its height equal to the radius; and he proves, that if the diameter of a circle be reckoned unity, the circumference will be between $3\frac{10}{70}$ and $3\frac{10}{71}$. The principles laid down by Archimedes were sufficient to carry the approximation to any degree of nearness; but he appears to have aimed at nothing more than a simple rule, sufficiently accurate for the common concerns of life.

His treatise on *Conoids* and *Spheroids* relates to the solids generated by the conic sections revolving about their axes: those produced by the rotation of the parabola and hyperbola, he called *Conoids*; and such as are generated by the revolution of the ellipse about either axis are his *Spheroids*. Here he compares the area of an ellipse with that of a circle; he also proves that the sections of conoids and spheroids are conic sections, and he treats of their tangent planes. He proves, for the first time, that a parabolic conoid is equal to three times the half of a cone of the same base and altitude, and he also shews what is the ratio of any segment of a hyperbolic conoid, or of a spheroid to a cone of the same base and altitude. His reasoning is a model of accuracy; and it exhibits the true spirit of the ancient synthetic method; it is however exceedingly prolix and difficult, insomuch that few will have patience to follow the steps of the venerable mathematician, more especially as the same conclusions may be found with equal certainty by the modern analysis, at an infinitely less expence of thought.

Conon.

His treatise on *Spirals* treats of a curve which was the invention of his friend Conon, who it seems had found its properties, but died before he had time to investigate their demonstrations: these Archimedes has supplied. The whole subject is, however, so much his own, that what is properly the spiral of Conon, is usually called the spiral of Archimedes. He has also treated *Of the Equilibrium of Planes, or of their centres of gravity*, in two books; and next *Of the Quadrature of the Parabola*. This is the first complete quadrature of a curve that was ever found. He here shews, that the area of any segment of a parabola cut off by a chord, is two-thirds of the circumscribing parallelogram, and this he proves by two different methods. His *Arenarius* was written to evince the possibility of expressing, by numbers, the grains of sand that might fill the whole space of the universe. Here he introduces a property of a geometrical progression, that has since been made the foundation of the theory of logarithms; but it would be going too far to suppose that Archimedes had made any approach to that valuable invention. This tract is valuable, not on account of the subject on which he treats, but because of the information it contains respecting the ancient astronomy, and the application which it gives of the Greek arithmetic. In addition to the works we have enumerated, there is a treatise *on bodies which are carried on a fluid*, in two books, and a book of *Lemmas*, which is a collection of theorems and problems, curious in themselves, and useful to the geometrical analysis. These are all the writings of Archimedes now extant, but many have been lost.

The writings of Archimedes are the most precious relict of the ancient geometry: they shew to what an extent such a genius as his could carry its method of demonstration; but they likewise prove, that there were certain limits beyond which it became inapplicable, on account of the unwieldiness of the machinery. In general, the progress of discovery is slow; but Archimedes took up the subject where men of ordinary capacities were at a stand, and, by the vigour of his mind, anticipated the labour of ages: he was undoubtedly the Newton of antiquity.

Eutocius has written a commentary on a part of the works of Archimedes, viz. on the books *De Sphæra et cylindro, de dimensione circuli et de æquiponderantibus*. In the year 1543, Nicolas Tartalea translated from Greek into Latin, and published at Venice, the treatises 1. *De Centris Gravium, &c.* 2. *Quadratura Parabolæ*. 3. *De Insidentibus aquæ, liber primus*; and, in 1555, the two books *De Insidentibus aquæ* appeared at Venice. In 1543, an edition of the works of Archimedes was published at Basle, with the Latin translation of John of Cremona, and revised by Regimontanus. In this, the two books *De Insidentibus in Fluido*, and the *Lemmata* were wanting, but it contained the commentary of Eutocius in Greek and Latin. Other editions of his works, or parts of them, have been given by Commandinus, Renault, Greaves and Foster, Borelli, Barrow, Maurolicus, Wallis, some with commentaries; but these are in a manner superseded by the Oxford edition of Torelli in Greek and Latin, printed in 1792, and the French translation of Peyrard in 4to and 8vo, the latter printed in 1808. For farther information respecting this geometer, see ARCHIMEDES.

Eratosthenes. Born 2?7 A. C.

Eratosthenes flourished in the Alexandrian school, about the time of Archimedes: his extensive acquirements in all branches of knowledge induced the third Ptolemy to make him his librarian. As a geometer, he might rank with Aristæus, Euclid, and Apollonius. His construction of the duplication of the cube, has come down to us in Eutocius' Commentary on Archimedes; and we find it recorded in Pappus, that he wrote two books on a branch of the geometrical analysis, which were entitled *De Locis ad medietates*; these appear to have been conic sections. There is an arithmetical invention attributed to him, by which the prime numbers may be determined. Its nature has been described in our article ARITHMETIC, page 372. It may be presumed that Eratosthenes composed many works; one is said to have been on the conic sections, and others on astronomy, but these are now completely lost.

Apollonius, 240 A. C.

About the time that Archimedes finished his career, another geometer of the highest order appeared. This was Apollonius of Perga, a town in Pamphylia. He was born towards the middle of the third century, before the Christian era, and he flourished principally under Ptolemy Philopater, or towards the end of that century. He studied in the Alexandrian school under the successors of Euclid; and so highly esteemed were his discoveries, that he acquired the name of the *Great Geometer*. It is mortifying to reflect, that sometimes consummate abilities are alloyed with great moral defects; Apollonius had a mind of the highest order, yet he was vain, jealous of merit in others, and always disposed to detraction. He was, however, one of the most inventive and profound writers that has treated of the mathematics, and it was in a great measure from his works that the true spirit of the ancient geometry was to be learnt. In the introduction to our article CONIC SECTIONS, we have had occasion to speak of his treatise on that subject; which contributed principally to his celebrity. The most material of his other works were the following treatises: 1. On the Section of a Ratio; 2. On the Section of a Space; 3. On Determinate Section; 4. On Tangencies; 5. On Inclinations; 6. On Plane Loci: The nature and contents of each of these has been particularly described in our article on ANALYSIS. We have understood that Peyrard, the learned French editor of the works of Euclid and Archimedes, had it in contemplation to give French translations of the writings of Apollonius, as well as the other ancient geometers, as far as they have been preserved; but we fear that the state of France is not likely to be soon favourable to the execution of his views.

The names of several mathematicians of antiquity contemporary with Archimedes and Apollonius, have come down to us. Apollonius has addressed the three first books of his conics to Eudemus of Pergamus, and speaks of him as a good judge in these matters, but he being dead before the fourth book was finished, Apollonius addressed it to Attalus. He says, in his first address to Eudemus, that Naucrates had instigated him to study the conics; and in that which precedes the second book, he requests Eudemus to communicate it to Philonides of Ephesus.

It appears that there was a geometer named Trasideus, who corresponded with Conon of Samos on the conic sections, and another Nicoteles the Cyrenean, who animadverted on some mistakes committed by Conon. Here, then, are five or six geometers besides Apollonius, who all cultivated the theory of conics. The regret which Archimedes expressed for the loss of Conon, gives us reason to think highly of him; but this is almost the only ground upon which we can form an idea of his skill as a geometer.

Dositheus was also a friend of Archimedes, who addressed to him several of his works. It is probable that Nicomedes, the inventor of the conchoid, lived about the period at which we are now arrived. This curve, and the application he made of it to the finding of two mean proportionals, are the only vestiges that now remain of his labours.

Nicomedes.

History.

As we descend towards the commencement of the Christian æra, we find a numerous list of mathematicians, most of whom are chiefly known as cultivators of astronomy, and some as writers on geometry. In this number were Geminus of Rhodes, who composed a work called *Enarrationes Geometricæ,* which consisted of six books; Philo, who gave a solution of the problem of two mean proportionals; Possidonius, who was a geometer, an astronomer, a mechanician, and a geographer. Dionysiodorus, who resolved a difficult problem of Archimedes, namely to divide a hemisphere in a given ratio by a plane parallel to its base; and Theodosius, the author of an excellent treatise on Spherics, in three books, which has been preserved, and which constitutes a part of the precious remains of the ancient geometry.

Possidonius.

Theodosius, 50 A. C.

Menelaus.

The astronomer and geometer Menelaus of Alexandria, lived in the second century of the Christian era: he composed a treatise on Trigonometry, in six books; and another on Spherics, in three books, which is still extant. He appears also to have treated of the geometry of curve lines.

Ptolemy. Born 70 A. D. Died 147.

The astronomer Ptolemy must be reckoned among the geometers of the second century. His work on Optics, which however is now lost, * is supposed to have contained some beautiful applications of geometry.

There were several geometers who flourished in the period of the three or four first centuries of the Christian era; but the exact time of each is not certainly known; as Serenus of Antissensis, who wrote on cylinders and cones; Hypsicles of Alexandria, who wrote two books on regular solids; Perseus Citticus, the inventor of certain lines called *spiriques,* which were curves made by the section of a plane and a solid, formed by the revolution of an arc of a circle about a given axis. Philo of Thyaneus, who appears to have treated of certain curves, which were also considered by Menelaus, but whose nature is not now known. Pappus also mentions Demetrius of Alexandria, as the author of a work which treated of curves, and hence it has been conjectured that the ancients had gone farther into this subject than has been generally supposed.

Serenus

Hypsicles.

We are now come to the period when learning began to decline, so that instead of brilliant discoveries, and original treatises, we have only commentaries and annotations on the works of former times, a presage of the approach of ignorance and barbarism. Of this nature were the works of Pappus, and Theon of Alexandria, two mathematicians who lived towards the end of the fourth century. The former of these, however, ranks in a higher class, on account of the genius displayed in his writings. Geometry is particularly obliged to him for his *Mathematical Collections,* which originally consisted of eight books; but of these, the first and half of the second are now lost. He seems to have intended to collect, into one body, several scattered discoveries, and to illustrate and complete, in many places, the writings of the most celebrated mathematicians, in particular Apollonius, Archimedes, Euclid, and Theodosius; for this purpose he has given a multitude of lemmas, and curious theorems, which they had supposed known; and he has also described the different attempts which had been made to resolve the more difficult problems, as the duplication of the cube, and the trisection of an angle. The preface to his seventh book is inestimably precious, for it has preserved from oblivion many analytical works on geometry, of which we should otherwise have been entirely ignorant. The abridgment which he has given of these is all that remains of the greater number; yet it has served to give a continuity to the history of geometry, and to inspire modern mathematicians with a high opinion of the theories of the ancients. In fact, such of their geometrical writings as have descended to our times are merely elementary; their more recondite works have either been entirely lost, or are only known by the account which Pappus has given of them. The books that remain of Pappus have suffered much from the injuries of time; there are many inaccuracies, and some passages so mutilated as to be hardly intelligible. The original Greek, except some extracts, has never been published. The only translation that has been given, which is by Commandinus, was published at Pesara in 1588, and again, with little variation, in 1660, at Bologna. Commandinus appears to have had access to only one manuscript, which wanted the first two books, and throughout was very faulty. There are, however, several manuscripts of Pappus in the libraries; the university of Oxford possesses two; one has half of the second book, and this part was published, with a Latin translation, in 1688, by Dr Wallis. It treats of arithmetic, so that probably the first two books treated of this subject. The university has already conferred a great favour on geometrical science, by the elegant editions it has given of Euclid, Apollonius, and Archimedes; and it is to be wished that the obligation were increased by an edition of Pappus. Our limits will not admit of a detailed statement of the contents of this valuable work; some account of it may be seen in Dr Hutton's Mathematical Dictionary, and also in Dr Traill's Life of Simson.

Pappus, A. D. 380.

Theon, the associate of Pappus in the Alexandrian school, wrote Scholia, or Notes on Euclid, which Commandinus has given in one of his Latin editions of that author. He is supposed, however, to have greatly vitiated the text; and Dr Simson, the learned editor of Euclid, has bestowed great labour in freeing it from what he supposed to be Theon's interpolations.

Theon.

Theon had a beautiful and accomplished daughter, named Hypatia, who cultivated geometry; and so learned was she in the science, that she was judged worthy to succeed her father in the Alexandrian school. She wrote commentaries on Apollonius and Diophantus, which are now lost. It is infinitely to be lamented that so exalted a being should have had so tragical a fate. This woman, the ornament of her sex and of human nature, fell a sacrifice to the blind fury of a fanatical mob, about the beginning of the fifth century.

Hypatia. Died

The philosopher Proclus, the chief of the Platonics at Athens, transferred thither, in some degree, the seat of the mathematical sciences, towards the middle of the fifth century; although he did not extend geometry, yet he held it in esteem. His very prolix commentary on the first book of Euclid, has made us acquainted with many traits in the history of the ancient geometry, and excited a regret that he did not extend it to the remaining books. Proclus was succeeded in his school by Marinus of Neapolis, who formed with Isidore of Miletus and Eutocius of Ascalon, a kind of succession, which brings the history of geometry down to the reign of Justinian. Marinus wrote a preface to Euclid's book of Data, which Dr Simson has rejected in his edition

Proclus.

Marinus.

Eutocius.

* A Latin translation of the Optics of Ptolemy has lately been discovered in the Royal Library at Paris. M. Le Chevalier Delambre, who mentioned to the Editor this curious fact, has given an analysis of the work in the *Connoissances des Tems* for 1816. See our article OPTICS. ED.

istory.

as of no use. Isidore is said, by Eutocius, to have invented an instrument for describing a parabola, by continued motion.

cles.

It would appear that Diocles lived about this period; he was the inventor of the *cissoid*, a curve contrived for the purpose of finding two mean proportionals. Eutocius also attributes to this geometer a solution of the Archimedean problem concerning the division of a sphere, which we have already noticed; it is highly creditable to him, and shews that he was skilful in the ancient analysis. We may place Sporus, and his master Philo, about this period; the former gave a solution of the problem of two mean proportionals, and the latter extended Archimedes' approximation of the ratio of the diameter to the circumference of a circle, as far as 10,000th parts.

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The labours of Proclus, and the geometers that followed him, were the last rays which the ancient mathematics scattered upon Greece. The long night of ignorance which elapsed from this time, until the destruction of the Greek empire, produced merely elementary writers, such as in better times would scarce have deserved the name of mathematicians. The school of Alexandria, however, yet existed, and the brilliant times of Euclid and Apollonius might have been renewed, had it not been for the troubles which agitated the East. The taking of Alexandria by the Saracens, gave a mortal blow to the sciences, not only in that celebrated capital, but also throughout the Greek empire. This happened in the year 640 A.D. The Alexandrian library, a treasure of inestimable value, was delivered to destruction, and the finest monument of human genius, the accumulated store of knowledge produced by the exertion of the most enlightened minds in many ages, was expended in heating the public baths of the city. See ALEXANDRIA.

ian
etry.

It is consoling to reflect, that although the followers of Mohammed, at this period, destroyed the sciences, yet they afterwards were entitled to the gratitude of posterity, for the care with which they cherished them. Within less than a century, we find the Arabs cultivating astronomy and geometry. Many of the Greek mathematicians, chiefly such as treat of astronomy, as Euclid, Theodosius, Hypsicles, Menelaus, were translated into Arabic in the reign of Almamon, or soon after; they even then began to study the more sublime geometry, for the four first books of the conics of Apollonius were translated by order of that enlightened prince. At a later period, the remaining books were translated, also Archimedes' treatise on the sphere and cylinder, and probably his other works; and it deserves to be remarked, that the Arabs cite several works of the Greek geometers, concerning which we know nothing; as a treatise on parallel lines, another on triangles, and a third on the division of the circle. We are indebted to the Arabs for the form under which trigonometry is now known. Ptolemy had greatly simplified the theory of Menelaus, yet he employed a laborious rule, called the *rule of six quantities*.

ben
a.

Geber ben Aphla, who lived in the 11th century, substituted, instead of the ancient method, three or four theorems, which are the foundation of modern trigonometry. The Arabs also simplified trigonometrical calculation, by substituting the sines of arcs, instead of the chords of the double arcs; and this was even one of their earliest inventions, for it is found in the writings of Albatenius, who flourished about the year 880 of our era. The names of many Arabian geometers are known, we shall, however, only mention Bagdadin, or Mahomet Al-Bagdadi, (of Bagdad,) the author of an elegant work on mensuration, which has been translated and published in 1570; and Alhazen, the celebrated author of a work on optics, which shews him to have been an excellent geometer. In general, the Arabian geometers had little invention, they were almost all compilers or commentators on the ancients.

History.

Bagdadin.

Alhazen, 1100.

Persian geometry.

Nassir-Eddin, 1270.

Persia has also had its geometers. The most celebrated was Nassir-Eddin Al-Tussi; he wrote a learned commentary on Euclid, which was printed in 1590 at the press of the Medici. He also revised the conics of Apollonius, and wrote a commentary on the subject; this was useful to Dr Halley, in restoring the fifth, sixth, and seventh books of that precious work. The geometer next in esteem was Maimon-Reschid: he wrote a commentary on Euclid, and is said to have indulged in a singular whim: he had conceived such an affection for one of the propositions of the first book of the Elements, that he wore the diagram as an ornament embroidered on his sleeve. Geometry has, in modern times, been respected among the Persians, but they have not made any improvements in the science. The traveller Chardin has given some traits of the pedantry of their literati. "They have given," says he, "a name to every proposition of the Elements. They call the 47th proposition of the first book of Euclid *the figure of the bride*, probably because it is to become the mother of a numerous progeny of other theorems. The 48th proposition, again, they call the *bride's sister*; and they, with reason, denominate geometry *the difficult science*.

Turkish geometry.

The Turks have not altogether neglected geometry. In the libraries of Constantinople, the greater number of the Greek mathematicians may be found translated into Arabic, and some into the Turkish language; but it does not appear that they pay attention to any thing beyond what is contained in Euclid's Elements, and inindeed they have never made one discovery in the sciences.

Hebrew geometry.

There are hardly any traces of geometry among the ancient Hebrews. Every one knows that when Solomon's temple was built, Hiram king of Tyre furnished architects and navigators, a proof that geometry must then have been very little known in Palestine. It was not until the second dispersion among the nations that they began to cultivate the sciences. In the ninth century, the Jews, after the example of the Arabians, began to translate the Greek geometers into their language; but they have discovered nothing whatever in geometry.

Geometry of India.

The researches of the learned have brought to light astronomical tables in India, which must have been constructed by the principles of geometry; but the period at which they have been formed has by no means been completely ascertained. Some are of opinion, that they have been framed from observations made at a very remote period, not less than three thousand years before the Christian æra; and if this opinion be well founded, the science of geometry must have been cultivated in India to a considerable extent, long before the period assigned to its origin in the West: so that many of the elementary propositions may have been brought from India to Greece. The Hindoos have a treatise called the *Suryá Sidhánta*, which professes to be a revelation from heaven, communicated to Meya, a man of great sanctity, about four million of years ago; but setting aside this fabulous origin, it has been supposed to be of great antiquity, and to have been written at least two thousand years before

History.

the Christian era. Interwoven with many absurdities, this book contains a rational system of trigonometry, which differs entirely from that first known in Greece or Arabia: In fact, it is founded on a geometrical theorem, which was not known to the mathematicians of Europe before the time of Vieta, about two hundred years ago. And it employs the sines of arcs, a thing unknown to the Greeks, who used the chords of the double arcs. The invention of sines has been attributed to the Arabs, but it is possible that they may have received this improvement in trigonometry, as well as the numeral characters, from India.

According to the natural progress of knowledge, the sciences of astronomy and geometry must have been long cultivated, and carried to some degree of perfection, before a system of trigonometry would be formed; we may therefore infer, that geometry had an earlier origin in India than the *Suryâ Sidhânta*. It is, however, proper we should state, that the high antiquity both of the Indian astronomy and the *Suryâ Sidhânta* has been controverted; but we cannot find room to enter on this point here. The antiquity of the Indian geometry has been asserted by Bailly in his *Astronomie Indienne*, and Professor Playfair in his *Remarks on the Astronomy of the Brahmins*, Edin. Trans. vol. ii. and *Observations on the Trigonometry of the Brahmins*, Edin. Trans. vol. iv. with great eloquence and strength of reasoning: (See our article ASTRONOMY, p. 585.) On this side of the question, the *Edinburgh Review*, vol. x. p. 455, may also be consulted. And on the opposite side, La Place, *Systeme du Monde*, 2d edit. p. 239; Bentley *On the Hindoo Systems of Astronomy*, in the *Asiatic Researches*, vol. viii.; *Edinburgh Review*, vol. xviii. p. 210; Leslie's *Geometry*, 2d edit. p. 456. Mr Leslie is of opinion, that the Hindoos derived their knowledge of mathematics from the West. In opposition to this, consult Strachey, in the Preface to *Bija Ganita;* and a review of the work in *Edinburgh Review*, vol. xxi. p. 364.

Chinese geometry.

The Chinese are well known to have observed the heavens from the most remote ages, yet they appear to have made little progress in geometry. When the Europeans came among them, it consisted of little more than the rules of mensuration: it is true, they have long known the famous property of a right angled triangle, and in this they have even gone before the Greeks; but this property, which, on account of its various applications, well deserved the sacrifice said to have been offered by Pythagoras to the Muses, has remained sterile in their hands. They did not become acquainted with spherical trigonometry before the 13th century; and then they probably learned it from the Arabs or Persians.

Roman geometry.

The Romans fell far short of the Greeks in their attention to the sciences. The mathematics, in particular, were greatly neglected at Rome; so that geometry, hardly known, went little beyond the measuring of land and the fixing of boundaries. The celebrated Varro, although no mathematician, had some knowledge of geometry, and wrote a treatise on the science, which has been cited by Frontinus and Priscianus under the title of *Mensuralia*. Cicero was not unacquainted with mathematics; although he did not write on the subject, his works contain expressions of esteem for the science. The pains he took to discover the tomb of Archimedes, in Sicily, was a proof that he could estimate the high merit of that illustrious man.

Vitruvius has displayed considerable knowledge in mathematics, particularly in the ninth book of his architecture. We owe to him many notices relating to the mechanics and gnomonics of his time.

Boetius, 500 A.

The fifth, sixth, and seventh centuries, present hardly any mathematicians. The senator and Roman consul Boetius, so well known by his misfortunes and his *Consolations of Philosophy*, was, in regard to the time, one of the most versed in mathematics. It was by his care that the Greek authors, as Nicomachus, Ptolemy, Euclid, &c. begin to be a little known in the Latin tongue. His geometry is a kind of free translation of Euclid.

Beda, 70

Alcuin, 750.

The beginning of the eighth century was brightened by the learning of Beda; he understood all the branches of mathematics, then so little known, but he attended chiefly to astronomy. It is a curious fact, that at this period mathematics were more cultivated in Britain than in any other part of Europe. This country produced Alcuin, who studied under Beda; he was well skilled in mathematics, and master to Charlemagne. The exertions of Alcuin and his exalted pupil to revive the sciences were unavailing: the light of science was almost extinguished, and the human mind enveloped in the darkness of ignorance; insomuch, that there is no trace of a single mathematician to be found during a period of 150 years preceding the middle of the tenth century. However, about that period a few scattered rays shot across the gloom. The monk Abbo, a man eminently endowed with a taste for knowledge, and in particular for mathematics, then hardly known, had made the monastery of Fleuri a school celebrated for its learning. Among his scholars was Gerbert, afterwards elevated to the pontificate by the name of Silvester II. His desire for learning could not be gratified by what was known among the Christians; he therefore travelled into Spain, and studied among the Arabs, in their celebrated schools of Cordova and Grenada. He soon went beyond his masters in mathematics, and on his return to France he wrote a book on geometry, which has been published by the learned authors of *Thesaurus Anecdotorum Novissimus*, and from which it appears that he was acquainted with the geometry of Euclid and Archimedes. It is a work on practical geometry, in which he gives rules for measuring heights and distances, by means of an instrument which he calls *Horoscopus*.

Abbo.

Gerbert 960 A.

Adelbo

Herm

Gerbert had imitators in his own age, and in that which followed it. Among the first was Adelbold, who wrote a small treatise on the solidity of the sphere. It appears he knew what had been done in this matter by Archimedes, but his own reasoning is vague and ungeometrical. About the year 1050, Hermann Contractus wrote several treatises on mathematics, and in particular one on the quadrature of the circle.

Adhel. 1130.

Robert Readi 1143.

Bacon Born Died

The twelfth century, notwithstanding the ignorance of the period, presents some mathematicians. The English monk Adhelard travelled into Spain and Egypt; and on his return he translated Euclid from Arabic into Latin. He appears to have been the first that made this author known in the West; but his work exists only in the libraries. Adhelard had various imitators among his countrymen, as Daniel Morlay, Robert of Reading, William Shell, Clement Langtown: They lived towards the end of this century, as did also Robert, bishop of Lincoln, called *Grotshead*, the author of a short treatise on the sphere, and his brother Adam Marsh. Roger Bacon, himself a mathematician, and their cotemporary in his youth, speaks highly of their skill in geometry. Passing over various writers on astronomy, we shall only farther mention Plato of Tivoli, who, about the year 1120, translated the Spherics of Theodosius from the Arabic into barbarous Latin.

Sacro-Bosco. Died 1256.

Campanus.

The thirteenth century was brilliant when compared with the ages that had gone before; it was the twilight of that bright day which has enlightened Europe for upwards of 200 years. Among the mathematicians of this time may be reckoned John of Halifax, called also *Sacro-Bosco*, who wrote a treatise on the sphere, and Campanus of Navarre, the celebrated translator of Euclid, and the author of a treatise on the quadrature of the circle; in which he has supposed that the approximate ratio found by Archimedes was quite exact; and proceeding on this, he has resolved some problems relating to the circle: His paralogism is excusable in consideration of the time in which he lived. The celebrated Albertus Magnus wrote on geometry in this century.

Albertus Magnus. Died 1280.

It is instructive to reflect upon the principles in human nature, by which, after ignorance has debased the mind, knowledge is again renovated. In the dark ages, when the true causes which bring about natural events were unknown or but little understood, the principle in the mind, by which men are led to suppose co-existing events as somehow connected, made them conjecture that the motions of the heavenly bodies, the most striking phenomena of nature, were closely connected with the common events of life. In this way, probably, astrology became a disease of the mind in the absence of genuine knowledge; but in pursuit of this delusion, it was necessary to cultivate astronomy, and this science again required the immediate aid of geometry. Thus we see, that from the very nature of the human understanding, it has a tendency to emerge from ignorance, and that probably we are indebted for the restoration of the ancient astronomy and geometry to the vain speculations of judicial astrology.

Wallingfort.

During the 14th century, England was fertile in mathematicians. They wrote treatises on arithmetic and geometry, but chiefly on astronomy. Their works, however, have chiefly remained in the public libraries. The most remarkable was Richard Wallingfort, who raised himself from an obscure condition by his merit. The science of geometry claims also the poet Chaucer as one of its cultivators. Even at this time, Britain gave indications of the approach of that brilliant æra of discovery, which will for ever render her illustrious among the nations.

Purbach. Born 1423. Died 1461.

Muller. Born 1436. Died 1475.

The period now approached in which geometry was to recover more than its original splendour. Its principal promoters were then Purbach and John Muller, called also Regiomontanus. They greatly improved trigonometry, and formed the resolution of travelling together into Italy, to study the Greek tongue; but Purbach dying, Regiomontanus went alone, and accomplished his purpose. Thus prepared, he translated the Almagest of Ptolemy from the original. He also gave Latin versions of the spherics of Menelaus, those of Theodosius, and his other astronomical treatises: besides, he corrected, by the Greek text, the ancient version of Archimedes made by Gerrard of Cremona. He translated the Conics of Apollonius, the Cylindrics of Serenus, and others of the ancient mathematicians. He commented on certain books of Archimedes, which Eutocius had passed over: he defended Euclid's definition of proportionals against Campanus; and he refuted a pretended quadrature of the circle by Cardinal Cusa.

Purbach rejected the ancient sexagesimal division of the radius, and instead of it he supposed it to be divided into 600,000. Regiomontanus, again, improved on Purbach; and, dividing the radius into 1,000,000 parts, he calculated new tables for every degree and minute of the quadrant, adding, for the first time, the tangents. It was Purbach that invented the geometrical square, and he appears to have been the first that applied the plumb line to mark the divisions on instruments.

De Burgo. 1480.

Lucus Pacciolus, or De Burgo, must be reckoned one of the distinguished cultivators of geometry of this period. He revised Campanus's translation of Euclid, but his labours did not appear until 1509. His work, *Summa de Arithmetica Geometria*, &c. 1494, contains a tolerable treatise on geometry. The progress which had now been made in the Greek tongue, and the invention of printing, contributed greatly to the dissemination of geometrical knowledge. The Greek mathematicians began now to be known in Europe; and Euclid was printed for the first time at Venice in 1482, in a folio volume, by Erhard Ratdolt, one of the first printers of the age: its title was, *Præclarissimus liber Elementorum Euclidis perspicacissimi in artem geometriæ incipit quam felicissime.* And at the end we read, *Opus Elementorum Euclidis Megarensis in geometricam artem; in id quoque Campani perspicassimi commentationes. Erhardus Ratdolt, Augustensis impressor Solertissimus, Venetiis impressit, anno salutis* MCCCCLXXXII. *Oct. cal. Junii. Lector vale.* On the back of the title-page, there is a dedication to the reigning Doge.

Commandinus. Born 1509. Died 1575.

Campanus's translation of Euclid was made from an Arabic manuscript; but in 1505, Zamberti gave a translation from the original Greek. In the year 1518, the spherics of Theodosius appeared for the first time; and in 1537, there came out a translation of the first four books (the only ones then known) of Apollonius by Memmius. But although Zamberti and Memmius might be good Greek scholars, they had little geometrical knowledge; and hence their translations were in some measure imperfect. Commandinus possessed both qualifications, and on that account succeeded better. He translated into Latin, and published in 1558, a part of the works of Archimedes, with a commentary. The two books on floating bodies, of which the Greek text has never been found, were published by him in 1565. He gave, in the following year, the first four books of Apollonius's conics, with the commentary of Eutocius, and the lemmas of Pappus. His Latin translation of Euclid appeared in 1572. Geometry is also indebted to him for a treatise on *Geodesia*, or the divisions of figures, by an Arabian geometer: the original was furnished by John Dee, an English mathematician. But his last and most important work was his translation of the mathematical collections of Pappus, the only one that has yet appeared. It is probable that, had it not been for his zeal in the cause of mathematics, this treasure of geometrical knowledge would still have been buried in the dust of libraries. Commandinus died in 1575, and his Pappus was printed after his death in 1588.

Maurolycus. Born 1495. Died 1575.

Maurolycus of Messina distinguished himself both by his editions of the ancients and his original works. In 1558, he published a new translation of the spherics of Theodosius from the Greek; to this he joined the spherics of Menelaus from the Arabic, and two new books as a supplement. He prepared an edition, or rather imitation of Archimedes, which was printed after his death; and he treated of the conic sections, deducing them elegantly from the cone itself. He made the

History.

useful remark in dialling, that the shadow of the top of a style describes a conic section on a plane.

Tartalea. Born 1479. Died 1557.

Tartalea, one of the earliest cultivators of algebra, contributed likewise to the revival of geometry. He made a translation of Euclid's Elements into Italian, which appeared in 1547. He also gave a Latin translation of part of Archimedes in 1543; he demonstrated the rule for finding the area of a triangle from its three sides; but the rule itself is probably of great antiquity, as it occurs in the Geodesia of Hero the younger.

The very prolix commentary of Proclus on Euclid, was given in a Latin translation by two mathematicians, Napolitain and Barozzi. And there were many other translators that would deserve notice in a history of geometry, if our limits would permit; but we cannot find room to notice particularly all the cultivators of the science in the 16th century. We shall therefore only mention a few; as Clavius, whose translation and commentary on Euclid are still esteemed; Benedictus, or Benedetto, mathematician to the Duke of Savoy, whose writings shew that he was well acquainted with the ancient geometrical analysis; Wolfius, who wished to demonstrate even the axioms of geometry; and Ramus, the author of various esteemed works on the science.

Clavius. Born 1537. Died 1612.

Ramus. Born 1515. Died 1572.

Vieta. Born 1540. Died 1603.

The celebrated Vieta, who flourished in France towards the end of the 15th century, deserves particular notice. He was profoundly skilled in the ancient geometry, and he restored the book of Tangencies of Apollonius, in his *Apollonius Gallus*, an exquisite model of geometrical elegance. He was the first that carried the approximate value of the ratio of the diameter of a circle to its circumference as far as eleven figures; and to him we owe the doctrine of angular sections, one of the most elegant theories in geometry.

Metius. Died 1636.

Romanus. Died 1625.

The Low Countries produced several geometers of distinguished merit; as Metius, who found a very convenient approximation to the ratio of the diameter of a circle to its circumference, viz. that of 113 to 355; and Adrianus Romanus, a geometer much esteemed in his time. He carried the approximation to the circumference of the circles as far as 17 decimal figures; and hence he was the plague of all the pretenders to its quadrature; for he was in every case able to shew, that the lines which they supposed equal to the circumference, were either greater than a polygon described about the circle, or else less than a polygon inscribed in it. In this way he refuted Joseph Scaliger, who imposed upon himself the task of squaring the circle as an amusement, just to shew his superiority to the plodding mathematicians, who had long sought it in vain. He wrote a treatise on Trigonometry, and was very successful in simplifying the number of cases.

Nonius. Born 1497. Died 1577.

Spain and Portugal can number only two geometers of note; the one was Nonius, or Nunez, who determined elegantly the time of the shortest twilight, a problem which seems for a long time to have puzzled James Bernoulli. The other was John of Royas, a Castilian, the inventor of a projection of the sphere.

Record. Died 1558.

Dee. Died 1608.

Wright. Died 1615.

At this period, England abounded in mathematicians. Robert Record, John Dee, Leonard and Thomas Digges, and H. Billingsley, all concurred in cultivating geometry. We are particularly indebted to Edward Wright for the invention of his chart, which is improperly called Mercator's. His book on the correction of certain errors in navigation, indicates a geometry beyond that of his time.

Werner. Born 1468. Died 1528.

Germany then produced but few geometers; it might, however, boast of John Werner of Nuremberg. He wrote on the conic sections; he attempted to restore Apollonius's treatise on the section of a ratio; he also translated Euclid from Greek into German, and cultivated trigonometry. His writings, however, have not been printed. Other German mathematicians did not cultivate so sublime a geometry. Rheticus extended the trigonometrical tables, and improved them by inserting the secants; and Pitiscus still farther extended them in his *Thesaurus Mathematicus sive Canon Sinuum*, &c. which contains the sines of every tenth second of the quadrant to 16 figures, and for every second of the first and last degree to 26 figures, together with the first, second, and in some cases the third differences. This is one of the most remarkable monuments of human patience, and is so much the more meritorious, that it was not accompanied with much renown.

Rheticus. Born 1514. Died 1576.

Pitiscus. Died 1613.

We now enter upon the 17th century, the most fertile of any in mathematical discoveries: in fact, the progress since made in the science is little more than their expansion; and whatever perfection it may attain in future ages, a great share of the glory will belong to the period at which we are now arrived.

L. Valerius 1604.

One of the earliest geometers of the 17th century was Lucas Valerius, an Italian, and Professor of Mathematics at Rome. He determined the centre of gravity in complete conoids and spheroids, as well as in their segments cut off by planes parallel to the base. Archimedes had resolved this problem only in the case of the parabolic conoid; and Commandinus had extended the subject a little farther, to the easiest cases; but Valerius went beyond them both.

Ghetaldus. Died 1609.

Marinus Ghetaldus, a native of Ragusa, was well acquainted with the ancient geometry. Guided by the indications of Pappus, he attempted to restore the lost book of Apollonius on *Inclinations*, in a work called *Apollonius Redivivus*. He also wrote a supplement to the *Apollonius Gallus* of Vieta. He died on a mission to Turkey in 1609.

Anderson.

Alexander Anderson was one of the earliest of the Scottish geometers. He appears to have been a friend or scholar of Vieta, some of whose posthumous works he published. He was well acquainted with the geometrical analysis; and of this he has given proof in his *Supplementum Apollonii Redivivi*, where he endeavours to supply what Ghetaldus has left incomplete in his work. See ANDERSON.

Ceulen. 1619.

The Low Countries produced in this period several mathematicians, whose labours were conducive to the progress of geometry. Ludolph Van Ceulen claims attention, on account of the immensely long calculation by which he determined that the diameter of a circle being supposed 1, the circumference will be between the number

$$3.14159,26535,89793,23846,26433,83279,50288,$$

and the same number increased by unity in the last figure. It must be acknowledged that there was more patience than genius displayed in this effort; for he proceeded simply after the manner of Archimedes, inscribing polygons in a circle, and describing others of an equal number of sides about it, until he found an inscribed and circumscribing polygon to agree in 36 figures. After the example of Archimedes, he desired that this, his greatest discovery, should be inscribed on his tomb. Geometry, however, derived more real service from his other labours.

Snellius Born 15.. Died 16..

Willebrod Snellius was another of the Dutch mathematicians: At the age of seventeen, he undertook to restore Apollonius's book of *Determinate Sections*, and

History.

he published his divination with the title *Apollonius Batavus.* He also treated of the approximate value of the circumference of a circle in his *Cyclometria.* He here shewed how Van Ceulen might have greatly shortened his labour by two limits nearer to the circumference than the circumscribing and inscribed polygons; and he verified the calculation, by computing the perimeter of a polygon of 1073741824 sides, which, according to the other method, would have given only 20 figures of the number.

Girard. Died 1633.

Albert Girard, another Fleming, was highly estimable as a geometer. He was the first that found the surface of a spherical triangle, or of a polygon bounded by great circles on the sphere. He deserves still more honour, however, for his divination of the *Porisms* of Euclid, if, as he asserted, he really had succeeded in restoring the work of the ancient geometer. Unfortunately his labours on this subject have never been published.

Kepler. Born 1571. Died 1630.

Want of room obliges us to pass over several whose reputation as geometers is excelled by that which they acquired in other branches of mathematics: we must not, however, omit the celebrated Kepler; he was the first that had the boldness to introduce the name and the idea of infinity into the language of geometry. The circle he considered as composed of an infinite number of triangles, having their vertices at the centre, and of which the bases form the circumference; and the cone, as made up of an infinite number of pyramids, whose bases formed its base, and which had with it a common vertex.

By the aid of these, and similar views, Kepler, in his *Nova Stereometria,* a work on gauging, demonstrated, in a direct manner, and with great brevity, those truths which the ancients had established by tedious and very peculiar modes of reasoning. Kepler opened in this book a vast field for speculation; for, passing beyond the views of Archimedes, he formed a multitude of new bodies, and he investigated their solidities. Archimedes limited his enquiries to those generated by the rotation of conic sections about an axis, but Kepler treated of solids generated by the rotation of these curves about any line whatever in their plane. He thus considered ninety solids besides those handled by the Sicilian geometer. Upon the whole, this book contained views which appear to have had great influence on the improvements that soon afterwards took place in geometry.

Guldin. Born 1577. Died 1643.

The problems proposed by Kepler probably led to the invention of the methods of Guldin and Cavallerius. The principal discovery of Guldin consisted in an application which he made of a property of the centre of gravity, to the measure of solids produced by revolution. "Every figure," says he, "formed by the rotation of a line, or a surface about an immoveable axis, is the product of the generating quantity by the line described by its centre of gravity. This principle, certainly one of the most beautiful discoveries in geometry, was however known in the days of Pappus; for it is distinctly stated at the end of the preface to his seventh book; yet Guldin takes no notice of the circumstance.

Cavallerius. Born 1598. Died 1647.

To Cavallerius we are indebted for the doctrine of indivisibles, which he published in 1635. In this, he considered a line as made up of an infinite number of points, a surface, of an infinite number of lines, and a solid, of an infinite number of surfaces: these elements of magnitudes he called *Indivisibles.* The introduction of so bold a postulate into geometry, was opposed by some of his contemporaries; but in answer, the Italian geometer explained that this hypothesis was by no means an essential part of his theory, which, in fact, was the same as the ancient method of exhaustions, but free from its tedious and indirect modes of reasoning.

In the first place, he considered such figures as had their increasing or decreasing elements at equal heights above the base, always in a given ratio; and he shewed that the figures themselves were to each other in the same given ratio. Next, he compared figures composed of an increasing or decreasing series of elements, with others in which the elements were all equal: for example, a cone, which he considered as composed of an infinite number of circles, increasing from the base to the vertex, with a cylinder, which is composed of an infinite number of circles, all of the same size; and to determine the ratio of the contents of the two solids, he found the ratio of the sum of the decreasing circles in the cone, to the sum of the circles which were equal to one another in the cylinder. In the cone, these circles decrease from the base to the vertex as the squares of the terms of an arithmetical progression. In other solids, they form other progressions: for example, in the parabolic conoid, it is simply that of an arithmetical progression. The general object of the method is to assign the ratio of this sum of an increasing or decreasing series of terms with that of the equal terms which form an uniform and known figure of the same base and altitude. The method of indivisibles is now superseded by the more extensive doctrine of fluxions; yet it was of immense importance at the time it was invented, and in fact was one step towards that grand discovery.

Fermat. Died 1665. Roberval. Born 1602. Died 1675.

The French geometers pursued the same career of discovery, and almost at the same time as Cavallerius; they even resolved more difficult problems. In 1636, Fermat had found the area of a spiral, of a different nature from that which Archimedes had handled; and soon afterwards, he proposed to Roberval to determine the areas of parabolic curves of the higher orders, (See FERMAT.) Roberval quickly resolved the problem; and he also determined their tangents. Fermat, again, on his part, found their centres of gravity. Roberval claimed the merit of having invented for himself a theory altogether similar to that of Cavallerius, before the latter had made his known; but as his selfish views led him to conceal it, that he might triumph over his contemporaries, he has but little claim on the gratitude of posterity as a discoverer, although he deserves credit for his skill as a geometer. Roberval did not venture to deviate so much from the common language of geometry as Cavallerius; he conceived his surfaces and solids to be made up of an indefinite number of very narrow rectangles and thin prisms, which decreased according to a certain law.

Descartes. Born 1596. Died 1650.

The celebrated Descartes contributed in no small degree to the developement of these new and brilliant discoveries in geometry. When Mersennus had sent him an account of Fermat's method of finding the centre of gravity of conoids, Descartes quickly sent him the determination of the centres of gravity of all parabolas, also their general quadrature, their tangents, and the ratios of their conoids.

It was in this period that the logarithmic spiral and cycloid were brought into discussion; the former was suggested by Descartes, the latter was first noticed by Galileo. See EPICYCLOID.

Pascal. Born 1623. Died 1662.

Passing over many geometers of ordinary merit, we must notice Pascal, who, at the age of twelve, had such a turn for geometry, that he undertook to construct a system for himself, guided by the recollection of the conversations which he had heard among the mathematicians that visited his father, who was himself a mathematician. He had gone as far as to discover that the three angles of any triangle were equal to two right angles, when he was observed by his father. At the age of 16, he is said to have composed a treatise on conic sections, in which all that Apollonius had demonstrated was elegantly deduced from a single proposition: this was shewn to Descartes, but the philosoper could not believe it to be the work of so young a geometer. The hopes he had so early excited, and the elegance of his disquisitions on the cycloid, gave geometers reason to regret that a larger portion of his short life was not dedicated to the science. He died in 1662, aged 39.

Gregory St Vincent. Born 1584. Died 1667.

Gregory St Vincent, a Flemish mathematician, held a respectable place among the geometers of his day. The main object of his researches was the quadrature of the circle, which he sought with the most persevering industry through all the difficulties of the geometry of his time. He even believed he had succeeded; but in this he was wrong: his researches, however, procured him a rich harvest of other geometrical truths.

Tacquet. Died 1660.

Andrew Tacquet, another Flemish mathematician, was a respectable geometer. He endeavoured to extend the boundaries of the science by a treatise on the mensuration of the surface and solidity of bodies formed by cutting a cylinder in different ways by a plane, and of different solids formed by the revolution of segments of circles and conic sections. In treating of these, he has affected the rigorous style of the ancient demonstration, a thing not entitled to commendation, considering that it was by adopting a more brief style, and new views, that the science was then receiving great improvement.

Huygens. Born 1629. Died 1695.

The celebrated Huygens was one of the brightest ornaments of that period. At an early age, he published his *Theoremata de Circuli et hyp. quad.* He completed what Snellius had done concerning approximations to the circle, in his work *De Circuli Magnitudine inventa*; these were the labours of his youth: afterwards he found the surface of conoids and spheroids, a problem which, on account of its difficulty, had not been attempted before his time. He determined the measure of the cissoid; he shewed how to reduce the problem of the rectification of curve lines to that of quadratures; and he invented the theory of involutes and evolutes. His treatise *De Horologio Oscillatorio*, is the finest specimen that has ever been given of the application of the most profound geometry to mechanics. In short, his name is associated in the history of geometry with some of the most brilliant discoveries that have been made in the science.

J. Gregory. Born 1638. Died 1675.

Our countryman, James Gregory, also stands in the very highest class as a geometer. He treated of the quadrature of the circle, and gave better methods of approximating to it than were known before his time. He attempted to shew that the complete solution of the problem was a thing impossible; but the correctness of his reasoning was questioned by Huygens. In 1668, Gregory published his *Geometriæ pars Universalis*, which gave the first idea of the logarithmic curve, and contained many curious theorems useful for the transformation and quadrature of curvilineal figures, for the rectification of curves, and for the measure of their solids of revolution, &c. He wrote various other works, some of which belong rather to the modern analysis than to the ancient geometry. The excellence of his writings, and their rareness, has induced Mr Baron Maseres to reprint them at his sole expence, as a testimony of his estimation of the author's merit, and to make the elegance of his views, and the extent of his claims as a discoverer, better known. Our mathematical readers will readily recollect, that this is not the only obligation of the kind that this worthy man has conferred upon science. See GREGORY.

Barrow. Born 1630. Died 1677.

Dr Barrow next claims our attention by his admirable geometrical writings; his geometrical lectures are composed partly in the style of the ancient, and partly in that of the modern geometry. He had the high honour of being the geometrical tutor of Newton, to whom he resigned his mathematical professorship, with a view to dedicate his time to theological studies; but seduced from his purpose by his favourite science, he did homage to it, by giving an edition of the writings of Archimedes, Apollonius, and Theodosius. Such was this excellent man's estimation of geometry, that he considered the contemplation of it as not unworthy of the Deity. The beginning of his Apollonius was inscribed with the words, Θεος γεωμετρει, *Tu autem Domine quantus es geometra*, "God himself geometrizes; O Lord, how great a geometer thou art!"

Torricelli. Born 1608. Died 1647.

In Italy, Torricelli, the disciple of Galileo, cultivated geometry: with such a master, it is easy to conceive any degree of excellence in the scholar. Among other geometrical enquiries, he treated of the solid formed by the rotation of a hyperbola about its asymptote; and he shewed that it had a finite magnitude, a thing which may appear paradoxical, when it is considered that the generating surface is infinitely great.

Borelli. Born 1608. Died 1679.

Borelli also claims attention on account of his editions of Euclid, Apollonius, and Archimedes, works remarkable for their brevity and perspicuity; and also because of his efforts in translating from the Arabic three books of the Conics of Apollonius, which were then supposed to have been lost. See CONIC SECTIONS.

Viviani. Born 1622. Died 1703.

Viviani, another disciple of Galileo, must here also be noticed. His geometrical writings were of the most elegant and valuable kind. We have spoken, in our treatise on CONIC SECTIONS, of his restoration of the Conics of Apollonius; and in our treatise on FLUXIONS, (art. 165.) of his beautiful problem concerning the quadrature of a portion of the surface of a sphere.

We have already noticed some of Descartes's geometrical labours, but his main effort, for which his name will be handed down to posterity with honour, was his application of algebra to geometry; an invention by which the properties of geometrical figures were represented by equations. His *Geometry*, which contains his views on this subject, was published first in 1637. The union of geometry and algebra promoted very much the discovery of the new calculus, the germ of which lay concealed in the method of exhaustions of the ancients, was partly evolved by Cavallerius, and still farther in the arithmetic of infinites of Dr Wallis, and, lastly, fully expanded by Newton and Leibnitz. The history of geometry becomes now interwoven with that of the modern analysis, and is chiefly interesting by the extent to which the science has been carried by that powerful instrument of invention.

Newton. Born 1642. Died 1727.

Although the ancient geometry was thus in a manner supplanted by the modern theories, the science by no means lost its interest. Sir Isaac Newton held it in such esteem, that he delivered his sublime discovery. ries in its language, and established their truth by its peculiar mode of demonstration. The conic sections, one of its earliest and most profound theories, acquired a value by its application to astronomy, far beyond what it ever had when considered merely as an object of intellectual speculation; and the learning and genius of Halley and Gregory were employed in restoring and bringing into view the precious remains of Euclid and Apollonius

1656. 1742. gory. 1661. 1710.

For upwards of a century, the physico-mathematical sciences have very much engaged the attention of mathematicians; but in these, the ancient geometry affords a very limited degree of aid in comparison to the modern: hence no doubt it has happened, that the venerable theories of the ancients have been less noticed. There have, however, been some who have sedulously cultivated them, and endeavoured to restore them to their former importance; and this spirit has been particularly manifested in Britain. It is a curious circumstance, that when the subtile reasonings of the ingenious Bishop of Cloyne had raised doubts as to the justness of the high claims of the doctrine of fluxions, the boast of the modern analysis; the ingenious Maclaurin thought the safest course he could follow, was to call geometry to its aid, and to explain its principles in the clear style, although circuitous manner, of the ancients.

rin. 1698. 1746.

Passing over several foreigners who have cultivated geometry in the 18th century, as well as natives of Britain, for whose particular labours we cannot find room, we must notice the celebrated Scottish geometer Dr Robert Simson. To him we are indebted for a treatise on conic sections, composed on the model of the ancients; also for restorations of the *Plane Loci* of Apollonius, and the books of determinate sections; but more especially for his restitution of the *Porisms* of Euclid: a task which we are not certain was ever accomplished by any geometer before his time; although Albert Girard, as we have already observed, claimed a like honour. His edition of the first six, and the eleventh and twelfth books of Euclid's Elements, has now in a manner superseded all others in this country, and is almost universally taught in our schools.

1687. 1768.

Dr Matthew Stewart, the friend of Simson, was another geometer, whose writings and example have greatly contributed to establish a correct taste for this study in Scotland. His first essay was, a *Collection of General Theorems;* the most elegant of any that are known in the whole compass of mathematics. They were given without demonstrations, except a few of the more simple, which he has proved with a degree of elegance that renders them the finest models of geometrical reasoning. His tracts, physical and mathematical, his essay on the sun's distance, and his solution of Kepler's problem, are attempts to apply pure geometry to the sublimest inquiries in astronomy. His partial success has shewn what may be accomplished by the force of genius; and the points in which he has failed serve also to shew, that even in such a masterly hand, the geometrical method is still limited in its application, and can by no means be compared in power with the modern geometry. This excellent geometer published also a work entitled *Propositiones Geometricæ, More Veterum demonstratæ, ad Geometriam Antiquam illustrandam et promovendam idoneæ,* which we reckon one of the most valuable that could be put into the hands of a student that is previously acquainted with the elements, and is desirous of learning the true spirit of the ancient geometry. To such of our readers as wish to appreciate the high

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merit of these two geometers, we recommend the Rev. Dr Traill's excellent life of Dr Simson (1812), and an elegant biographical account of Dr Stewart, composed by Mr Playfair, and read before the Royal Society of Edinburgh, (*Edin. Phil. Trans.* vol. i.) See also the articles SIMSON and STEWART in our Work. History.

Regretting that our limits oblige us to omit many British geometers, whose names deserve preservation, we shall yet mention two; the Rev. Mr Lawson, author of a Dissertation on the Geometrical Analysis of the Ancients, and English editions of the Tangencies and Determinate Section of Apollonius; and Dr Horsley, Bishop of St Asaph. This learned prelate has given a restoration of Apollonius' work on Inclinations, also a neat edition, in Latin, of Euclid's Elements, besides other works on geometry. For farther information relative to the history of geometry, the reader may consult the articles ANALYSIS, ARITHMETIC OF SINES, CONIC SECTIONS, CURVES, DIALLING, EPICYCLOID, and other branches of mathematics that are to follow the present article; also the biographical accounts of mathematicians contained in our work. We shall now give a select catalogue of the principal works which have been written on geometry, particularly those which exhibit the progress of its improvement. Such as relate to conics have been already enumerated in CONIC SECTIONS, and those that treat of TRIGONOMETRY, will be indicated in that article.

Lawson. Horsley. Born 1732. Died 1806.

On the history of geometry, consult Montucla, *Histoire de Mathematiques,* (2d edit.) Bossut's General History of Mathematics in French, of which there is an English translation, and Dr Hutton's Dictionary, (2d edit. 1815.)

List of Writers on Geometry.

Euclid, *The Elements of Geometry.* Of this there are very many editions; the first is that of Ratdolt, 1482. There is an elegant Greek and Latin edition of his works by Dr Gregory, Oxford 1703. Perhaps the most valuable is that of Peyrard, in Greek, Latin, and French, of which the first six books are now published. Dr Barrow's edition of all the books, and the *Data,* and Dr Horsley's of the first 12, from the Latin versions of Commandine and Gregory, and the *Data,* are valuable. Simson's edition of the first six, and the 11th and 12th books, and the *Data;* and Playfair's edition, the first six, (the same as Simson's,) and three additional books on solids, are most commonly used.

Euclid's *Porisms* have been restored by Dr Simson in his *Opera Reliqua,* 1776.

Archimedes; the best editions are Torelli's in Greek and Latin, Oxford, 1792; and Peyrard's French translation, Paris, 1808. The first edition of the Greek text was that of Venatorius in 1544.

Apollonius; the writings that have been recovered of this celebrated geometer are:—

1. *The Section of a Ratio;* and, 2. *The Section of a Space.* These have been restored by Snellius, 1607; and by Dr Halley, 1706.

3. *Determinate Section;* Snellius restored these in his *Apollonius Batavus,* 1601. There is an English translation by Lawson, to which is added a new restoration by Wales, 1772. Simson has restored this work in his *Opera Reliqua,* 1776; and Giannini, an Italian geometer, in 1773.

4. *Tangencies;* Vieta restored this in his *Apollonius Gallus,* 1600. Some additions were made by Ghetaldus, and others by Alexander Anderson, in 1612. The labours of Vieta and Ghetaldus have been given in English by Lawson, 1771.

5. *The Plane Loci;* these have been restored by

History.

Schooten, 1656; and Fermat, 1679; but the best restoration is that of Dr Simson, 1749.

6. *The Inclinations*; these were restored by Ghetaldus, in his *Apollonius Redivivus*, 1607: To this there is a Supplement by Anderson, 1612. There is also a restoration by Dr Horsley, 1770; and another by Reuben Burrow, 1779.

Theodosius and Menelaus: These were published by Maurolicus in 1558, and Burrow gave Theodosius in 1675. There is also an Oxford edition by Hunter, in 1707.

Proclus, *Commentariorum in Primum Euclidis librum Libri* iv. *Latine vertit F. Baroccius*, 1560. Proclus has also been given in English by Taylor, 1788.

Eratosthenes, *Geometria, &c. cum annot.* 1672.

Veterum Mathematicorum Athenæi, Bitonis, Apollodori, Heronis, Philonis, et aliorum, Opera Gr. et Lat. 1693.

Lucas de Burgo, *Summa de Arithmetica, Geometria*, &c. 1494.

Albert Durer, *Institutiones Geometricæ*, 1532.

Buteo, *De Quadratura Circuli*, 1559.

Ramus, *Arithmeticæ*, lib. ii. *Geometricæ*, lib. xxvi. 1580.

Vieta, *Opera Mathematica*, 1589.

Vieta, *Variorum de reb. math. responsorum*, lib. viii. 1596.

Lucas Valerius, *De centro Gravitatis Solidorum*, 1604.

Metius, *Arithmet. et Geomet. pract.* 1611.

Anderson, *Supplementum Apollonii Redivivi*, 1612.

——— Αιτιολογια *Pro Zetetico Apolloniani problematis a se jam pridem edito in Sup. Apol. Red.* 1615.

——— *Theoremata* Καθολικοτερα *A. Fr. Vieta Fonteracensi excogitata*, &c. 1615.

——— *Vindiciæ Archimedis*, &c. 1616.

——— *Exer. Mathemat.* &c. 1619.

Kepler, *Nova Stereometria*, &c. 1618.

Van Ceulen, *De Circulo et adscriptis*, 1619.

Snellius, *Cyclometricus*, 1621.

La Faille, *Theoremata de centro Gravitatis partium circuli et ellipsis*, 1632.

Guildin, *De Centro Gravitatis*, &c. 1635.

Cavallerius, *Geometria indivisibilium continuorum novâ quâdam ratione promota*, 1635.

Cavallerius, *Exercitationes Geometricæ*, 1647.

Des Cartes, *Geometrie*, 1637.

Toricelli, *Opera Geometrica*, 1644.

Gregory St Vincent, *Opus Geometricum quadraturæ circuli et Sectionum Coni*, 1647.

Oughtred, *Clavis mathematica*, 1653.

Schooten, *Exer. Mathematicorum*, lib. v. 1657.

Pascal, *A. Dettonville Lettres* (on the Cycloid) 1659.

Ricci, *Exercit. Geom. de max. et minimis*, 1666.

James Gregory, *Vera Circuli et Hyperbolæ Quadratura*, 1667.

James Gregory, *Geometriæ Pars Universalis*, 1668.

James Gregory, *Exercitationes Geometricæ*, 1668.

Tacquet, *Opera Omnia Mathematica*, 1669.

Huygens, *Opera*, collected by s'Gravesande, 1751.

Barrow, *Lectiones Opticæ et Geometricæ*, 1674.

Barrow, *Lectiones Mathematicæ*, 1683.

David Gregory, *Exer. de dimen. Figurarum*, 1684.

David Gregory, *Practical Geometry*, 1745.

De Omerique, *Analysis Geometrica*, 1698.

Sharp, *Geometry Improved*, &c. 1718.

Stewart, *General Theorems*, 1746.

Stewart, *Propositiones Geometricæ*, 1763.

R. Simson, *Opera quædam Reliqua*, 1776.

Traill, *Life of R. Simson*, 1812.

Thomas Simpson, *Elements of Geometry*, 1747, and 1760.

Thomas Simpson, *Select Exercises*, 1752.

Boscovich, *Elementa Universæ Matheseos*, 1754.

Montucla, *Histoire des Recherches sur la quadrature de Cercle*, 1754.

Emerson, *Elements of Geometry*, 1763.

Lawson, *A Dissertation on the Geometrical Analysis of the Ancients.*

Lawson, *A Synopsis of Data for constructing Triangles*, 1773.

West, *Elements of Mathematics*, 1784.

L'Huillier, *Polygonometrie.*

Lacroix, *Elemens de Geometrie descriptive*, 1795.

Mascheroni, *Geometrie du Compas*, 1798.

Mascheroni, *Traité d'Arpentage*

Monge, *Geometrie Descriptive*, 1799.

Playfair, *Origin and Investigation of Porisms.* Edin. Trans. vol. iii.

Wallace, *Geometrical Porisms.* Edin. Trans. vol. iv.

Carnot, *Geometrie de Position*, 1803.

Legendre, *Elements de Geometrie*, ninth edit. 1812.

Leslie, *Elements of Geometry, Geometrical Analysis, and Plane Trigonometry*, 2d edit. 1811.

The three books which Mr Leslie has given on the Geometrical Analysis, are a great acquisition to elementary geometry.

Creswell, *On Geometrical Maxima and Minima.*

To such as are entering on the study of geometry, we would recommend any one of the following works: Simson's Euclid, Playfair's Geometry, Legendre *Geometrie*, Leslie's Geometry. Indeed, we would recommend the perusal of Legendre's work with any of the others. We have chiefly kept it in view in drawing up the following article.

Every one has a distinct idea of a body, or *solid*. It is extended in three directions, that is, it has length, breadth, and thickness. We easily conceive that there is something which bounds a solid, or which separates the space it fills from space in general; that boundary is a *surface*, which can manifestly have only two dimensions, viz. length and breadth.

A surface again has a boundary, or something that may separate a portion of it from the remainder, that is a *line*, which can have but one dimension.

Again, there is something that terminates a line, or which indicates where one portion of it ends, and another begins; this is a *point*, which can neither have length, breadth, nor thickness. Here, then, we have three different species of magnitude, viz. solids, surfaces, and lines, which form the object of geometrical discussion.

The elements of geometry are commonly divided into two Parts; one treats of the properties of lines and figures described upon a *plane* surface; and the other relates to the properties of solids: the former is sometimes called *Plane*, and the latter *Solid* geometry.

Part I. OF LINES AND FIGURES UPON A PLANE.

ples.

We have seen how the general ideas of a surface, a line, and a point, may be acquired from the consideration of a solid. The *elements* of geometry admit of only two lines, the *straight line*, and the *curve*. The straight line serves to determine the nature of the surface called a *plane;* and from both we get a correct notion of a circle. But the nature of these, and the other things to be discussed, will be particularly explained in the following Sections by precise definitions.

SECTION I.

The Principles of Geometry.

Definitions.

itions.

1. A *point* is that which has position, but not magnitude.

2. A *line* is length without breadth.

Cor. The extremities of a line are points, and the intersections of one line with another are also points.

3. A straight line is the shortest way from one point to another.

4. Every line which is neither straight, nor composed of straight lines, is a curve line.

E XX.

Thus, in Fig. 1. Plate CCLXX. AB is a straight line, and ACB a curve line.

5. A *surface,* or *superficies,* is that which has only length and breadth.

Cor. The extremities of a superficies are lines, and the intersections of one superficies with another are also lines.

6. A *plane* superficies is that in which any two points being taken, the straight line between them lies wholly in that superficies.

7. Every surface which is neither a plane, nor composed of plane surfaces, is a *curve* surface.

8. A *plane rectilineal angle* is the inclination of two straight lines to one another, which meet together, but are not in the same straight line. The point in which the lines meet one another is called the *vertex* of the angle; and the lines are called its *sides.* *

N. B. When several angles are at a point A (Fig. 6.) any one of them is expressed by three letters, of which the letter that is at the *vertex* of the angle is put between the other two, and one of these is somewhere upon one of the straight lines, and the other upon the other line. Thus, the angle which is contained by AB and AC is named the angle CAB or BAC; that which is contained by AB and AD is named the angle DAB or BAD; and that which is contained by AC and AD is called the angle CAD or DAC. But if there be only one angle at a point, as in Fig. 2. it may be expressed by a letter placed at that point, as the angle at A, or the angle A.

Principles.

Fig. 7.

9. When a straight line standing on another straight line makes the adjacent angles equal to one another, each of the angles is called a *right* angle; and the straight line which stands on the other is called a *perpendicular.* (Fig. 7.)

Figs. 8. and 9.

10. An *obtuse* angle is that which is greater than a right angle (Fig. 8.); and an *acute* angle is that which is less than a right angle (Fig. 9.)

Fig. 10.

11. *Parallel* straight lines are such as are in the same plane, and which being produced ever so far both ways, do not meet. (Fig. 10.)

Figs. 11, 12, &c. to Fig. 22.

12. A *plane figure* is that which is enclosed by one or more lines on a plane. If the lines are straight, the space they enclose is called a *rectilineal* figure, and the lines themselves are called its *perimeter.* See Fig. 11, 12, &c. to Fig. 22.

13. A rectilineal figure having three sides is named a *triangle;* a figure of four sides is called a *quadrilateral;* that of five sides is a *pentagon;* that of six sides is a *hexagon,* and so on. Figures of more than four sides are likewise called *polygons.*

Figs. 11, 12, and 13.

14. An *equilateral* triangle is that which has its three sides equal (Fig. 11.) An *isosceles* triangle is that which has only two equal sides (Fig. 12.), and a *scalene* triangle that which has all its sides unequal. (Fig. 13.)

Fig. 14.

15. A *right angled* triangle is that which has a right angle. The side opposite to the right angle is called the *hypothenuse* (Fig. 14.)

Fig. 15.

An *obtuse angled triangle* is that which has an obtuse angle (Fig. 15.)

Fig. 16.

An *acute angled* triangle is that which has all its angles acute (Fig. 16.)

16. Among four-sided figures the following are distinguished by particular names:

Fig. 17.

A *square* is that which has all its sides equal, and all its angles right angles (Fig. 17.)

Fig. 18.

A *rectangle* is that which has its angles right angles, but its sides not equal (Fig. 18.)

Fig. 19.

A *rhombus* is that which has all its sides equal, but its angles are not right angles (Fig. 19.)

Fig. 20.

A *parallelogram,* or *rhomboid,* is that which has its opposite sides parallel (Fig. 20.)

Fig. 21.

A *trapezium* is that of which the opposite sides are not parallel (Fig. 21.)

Fig. 22.

A *trapezoid* is that of which only two of the opposite sides are parallel (Fig. 22.)

Fig. 48.

17. The *diagonal* of a figure is a straight line which joins the vertices of two angles which are not adjacent. Thus, in Fig. 48. AC, AD, AE, &c. are diagonals of the figure ABCDEFG.

18. An *equilateral* polygon is that which has all its

* To get an accurate notion of the nature of an angle, we may suppose that the angle contained by the straight lines AB and AC (Fig. 2.) is successively compared with the angles contained by the lines DE and DF (Fig. 3.); and D′E′ and D′F′ (Fig. 4. and 5.) First, suppose that the line AC (Fig. 2.) is placed on the line DF (Fig. 3.), so that the point A may fall on D; then, if AC coincide with DF, the angle contained by AB and AC is equal to the angle contained by DE and DF. But if, when AC is placed on D′F′ (Fig. 4. and Fig. 5.) and A on D′, the line AB do not fall on D′E′, but has another position DG; then the angle contained by AB and AC is not equal to the angle contained by D′E′ and D′F′: It is greater if D′E′ fall between DG and D′F′, as in Fig. 4; but it is less if DG fall between D′E′ and D′F′, as in Fig. 5.

An angle may be made up of several angles; thus, in Fig. 6. the angle contained by the lines AB and AD is the sum of the two angles contained by AB and AC, and by AC and AD. If these are equal, it is double any one of them.

Hence it appears, that like other quantities, angles admit of addition, subtraction, multiplication, and division.

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sides equal; an *equiangular* polygon is that of which all the angles are equal.

19. Two polygons are *equilateral* between themselves when their sides are equal each to each, taken in the same order; that is, when going round the two figures, a side of the one is equal to a side of the other, the next side of the one to the next side of the other, and so on. In a like sense, polygons are *equiangular*. In either case, the equal sides or angles are called *homologous* sides or angles.

Explanation of Terms and Signs.

An *axiom* is a self-evident truth.

A *theorem* is a truth which becomes evident by a process of reasoning called a *demonstration.*

A *problem* is something proposed to be done; or it is a question that requires a solution.

A *lemma* is a truth premised to facilitate the demonstration of a theorem, or the solution of a problem.

The common name *proposition* is given indifferently to a theorem, a problem, or a lemma.

A *corollary* is a consequence which follows from one or several propositions.

A *scholium* is a remark upon one or several propositions going before, tending to explain their connection, their utility, their restriction, or their extension.

A *hypothesis* is a supposition made either in the enunciation of a proposition, or in the course of a demonstration.

For the sake of brevity, it is convenient to employ, to a certain extent, the signs of algebra in geometry. Those we shall chiefly employ are of the most simple nature, viz. the signs $+$, $-$, $=$, $>$, $<$. Their meaning is fully explained in the beginning of ALGEBRA, articles 19, 20, 21, 22, and 23; and to that place we refer the reader. Others that may occur will be explained as we proceed.

AXIOMS.

1. Things which are equal to the same thing are equal to one another.
2. If equals be added to equals, the wholes are equal.
3. If equals be taken from equals, the remainders are equal.
4. If equals be added to unequals, the wholes are unequal.
5. If equals be taken from unequals, the remainders are unequal.
6. Things which are double of the same, are equal to one another.
7. Things which are halves of the same are equal to one another.
8. Magnitudes which coincide with one another, that is, which exactly fill the same space, are equal to one another.
9. The whole is greater than its part.
10. Only one straight line can be drawn from one point to another.
11. Two straight lines cannot be drawn through the same point parallel to the same straight line, without coinciding with one another.

POSTULATES.

1. Let it be granted, that a straight line may be drawn from any one point to any other point.
2. That a terminated straight line may be produced to any length in a straight line.
3. And that a circle may be described on any centre at any distance from that centre. *

NOTE. The references in the following treatise are to be understood thus: (4.) means the 4th Prop. of the section in which it occurs. (Cor. 4.) means the corollary to the 4th Prop. (2. Cor. 4.) means the 2d Cor. to Prop. 4. (4. 3.) means the 4th Prop. in the 3d section of the Part in which it occurs. Again, (5. 4. P. I.) means the 5th Prop. of the 4th section of Part I. and so on.

PROPOSITION I. THEOREM.

All right angles are equal among themselves.

Let the straight line CD be perpendicular to AB, and GH to EF; the angles ACD, EGH shall be equal to one another. Take the four equal distances CA, CB, GE, GF; then AB shall be equal to GF. Suppose now the line EF to be placed upon AB, so that E may coincide with A, and F with B; the lines EF, AB must coincide; for otherwise, two different straight lines might be drawn from one point to another, which is impossible, (Ax. 10.) Therefore the point G, the middle of EF, will fall upon the point C, the middle of AB. Now, the line GE thus coinciding with the line CA, the line GH will coincide with CD; for if it could have any other position, as CK, then because the angle EGH is equal to HGF, by hypothesis, (Def. 9.), it would follow that the angle ACK would be equal to KCB, and consequently the angle ACD would be less than BCK, and therefore much less than BCD, which is impossible, because the angle ACD ought to be equal to the angle BCD, (Def. 9.) Therefore it would be absurd to suppose that GH did not coincide with CD, consequently the angle ACD is equal to EGH. Fig.

PROP. II. THEOR.

Any straight line CD which meets another straight line AB makes with it two adjacent angles ACD, BCD, which taken together are equal to two right angles. Fig.

At the point C, let a straight line CE be drawn perpendicular to AB. The angle ACD is the sum of the angles ACE, ECD; therefore, ACD $+$ DCB shall be the sum of the three angles ACE, ECD, DCB, (axiom 2); the first of these is a right angle, and the two others make together a right angle: therefore, the sum of the two angles ACD, BCD is equal to two right angles.

COROLLARY 1. If one of the angles ACD, BCD is a right angle, the other is also a right angle.

COR. 2. (Fig. 25.) All the angles BAC, CAD, DAE, EAF, which any number of straight lines make with another line BF are together equal to two right angles. Fig. 25.

* According to the strict method of Euclid, before any line is supposed to be drawn, or any figure constructed, the manner of doing it should be shewn. There is, however, some convenience in abating a little of this rigour, so far as to take for granted, that, for the purpose of demonstrating a theorem, lines may be drawn in a proposed manner, and certain figures constructed, although the manner of drawing the lines and constructing the figures may not have been explained. This concession, however, is to be confined entirely to the theorems, and by no means to be extended to the problems.

The three postulates in the text are all that are absolutely requisite in a system of geometry.

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For their sum is equal to the two angles BAD and DAF, which together make two right angles.

Fig. 26. Cor. 3. (Fig. 26.) All the angles which any number of lines AB, AC, AD, AE, &c. make about a point, are equal to four right angles. For through A draw a straight line PQ, then all the angles which the lines make on each side of PQ, are equal to two right angles: therefore, all the angles on both sides, which make up the angles about A, are equal to four right angles.

Prop. III. Theor.

Fig. 27. If two adjacent angles ACD, DCB are together equal to two right angles, the two exterior sides AC, CB form one continued straight line.

For, if CB be not the continuation of CA, suppose CE to be its continuation; then the sum of the angles ACD, DCE is equal to two right angles, (2.) But by hypothesis, the sum of the angles ACD, DCB is equal to two right angles; therefore ACD + DCE = ACD + DCB (Ax. 1.) And taking from each the angle ACD, there remains the angle DCE equal to the angle DCB (Ax. 3.), a part equal to the whole, which is impossible, (Ax. 9.)

Prop. IV. Theor.

Fig. 28. If two straight lines AB, DE cut each other, the vertical or opposite angles shall be equal.

For because DE is a straight line, the sum of the two angles ACD, ACE is equal to two right angles, (2.); and because AB is a straight line, the sum of the angles ACE. ECB is equal to two right angles, (2.); therefore the sum of the angles ACD, ACE is equal to the sum of the angles ACE, ECB; and taking away from each the common angle ACE, there remains the angle ACD equal to the vertical or opposite angle ECB.

Prop. V. Theor.

Two straight lines which have two common points coincide entirely throughout their whole extent, and form but one and the same straight line.

Fig. 29. Let A and B be the common points; in the first place, the two lines can make but one, from A to B (Ax. 10.) If it were possible that they could separate at C, let us suppose that the one takes the direction CD, and the other the direction CE. At the point C, suppose CF to be drawn perpendicular to AC; then, because ACD is by hypothesis a straight line, the angle FCD is a right angle, (Def. 9.); in like manner, because ACE is supposed a straight line, the angle FCE is a right angle; therefore, the angles FCD, FCE are equal, (1.); but this is impossible, (Ax. 9.); therefore, the straight lines which have two common points A, B cannot separate, but must form one continued line.

Prop. VI. Theor.

Two triangles are equal, when an angle, and the two sides which contain it in the one are equal to an angle, and the two sides which contain it in the other, each to each.

Let the angle A be equal to the angle D, the side AB equal to the side DE, and the side AC equal to the side DF; the triangles ABC, DEF shall be equal. Fig. 30.

Suppose the triangle ABC to be placed upon the triangle DEF, so that AB may be on DE; then, because the angles A and D are equal, AC will fall on DF, and because AB = DE, and AC = DF, the points B, C will fall on the points E, F; therefore the base BC will coincide with the base EF (5.); and the triangles will coincide entirely; therefore they are equal, (Ax. 8.)

Cor. Hence it follows, that the bases or third sides BC, EF are equal, and that the remaining angles B, C of the one, are equal to the remaining angles E, F of the other, each to each, viz. those to which the equal sides are opposite.

Prop VII. Theor.

Two triangles are equal, when a side and two adjacent angles of the one are equal to a side and two adjacent angles of the other, each to each.

Let the side BC be equal to the side EF, the angle B equal to the angle E, and the angle C equal to the angle F; the triangles shall be equal. Fig. 30.

For suppose the triangle ABC to be placed upon DEF, so that their equal bases BC, EF may coincide; then because the angles B, E are equal, the line BA will fall on ED; and because the angles C, F are equal, the line CA will fall on FD; therefore the three sides of the one triangle will coincide with the three sides of the other, and the triangles will be equal.

Cor. Hence it appears that the remaining angles A, D of the triangles are equal, and that the remaining sides AB, AC of the one are equal to the remaining sides DE, DF of the other each to each, viz. those to which the equal angles are opposite.

Prop. VIII. Theor.

Any two sides of a triangle are together greater than the third.

For, in the triangle ABC, the straight line BC is the shortest line that can be drawn from B to C, therefore BC is less than BA + AC. Fig. 30.

Prop. IX. Theor.

If from any point O within a triangle ABC, straight lines OB, OC are drawn to the extremities of the base BC, their sum is less than the sum of the two sides AB, AC. Fig. 31.

Produce BO until it meet AC in D; the line OC is less than OD + DC, (8.), and adding to these unequals BO, we have $BO + OC < BO + OD + DC$, (Ax. 4.); that is $BO + OC < BD + DC$.

In like manner, $BD < BA + AD$; and adding DC, $BD + DC < BA + AD + DC$, that is $BD + DC < BA + AC$; but we have found $BO + OC < BD + DC$; much more then is $BO + OC < BA + AC$.

Prop. X. Theor.

If two sides AB, AC of a triangle ABC are equal to Figs. 32, 33, 34.

Principles. two sides DE, DF of another triangle DEF, each to each, and if the angle BAC contained by the former be greater than the angle EDF contained by the latter; the base BC of the triangle which has the greater angle, shall be greater than the base EF of the other triangle.

Make the angle CAG = D, take AG = DE or AB, and join CG; and because the triangles CAG, DEF have an angle of the one equal to an angle of the other, and the sides which contain these angles equal; CG shall be equal to EF, (6.) Now there may be three cases, according as the point G falls without the triangle ABC, or on the side BC, or within the triangle.

Fig. 32. Case 1st, (Fig. 32.) Because GC is less than GI + IC, and AB less than AI + IB, therefore GC + AB is less than GI + AI + IC + IB, that is, GC + AB $<$ AG + BC; from these unequal sums take away AB, or its equal AG, and there remains GC $<$ BC; but GC = EF, therefore EF $<$ BC.

Fig. 33. Case 2d, (Fig. 33.) If the point G fall on BC, it is evident that GC, or its equal EF, is less than BC.

Fig. 34. Case 3d, (Fig. 34.) Lastly, if the point G fall within the triangle, by Prop. 9. we have AG + GC $<$ AB + BC; and taking away AG from one of these unequals, and AB = AG from the other, we have GC $<$ BC.

Prop. XI. Theor.

Two triangles are equal when the three sides of the one are equal to the three sides of the other, each to each.

Fig. 30. Let the side AB = DE, AC = DF, and BC = EF, then shall the angle A = D, B = E, C = F. For if the angle A were greater than D; then, as the sides AB, AC are equal to the sides DE, DF, each to each, it would follow (10.) that the side BC would be greater than EF: And if the angle A were less than D, then BC would be less than EF: but BC is equal to EF, therefore the angle A can neither be greater nor less than D; therefore A = D. In like manner it may be proved that B = E and that C = F.

Scholium. It appears that in two equal triangles, the equal angles are opposite to the equal sides, for the equal angles A and D are opposite to the equal sides BC, EF.

Prop. XII. Theor.

In an isosceles triangle, the angles opposite to the equal sides are equal.

Fig. 35. Let the side AB = AC, then shall the angle C = B. For suppose AD to be drawn from the vertex A to D, the middle of the base BC: Then the two triangles ADB, ADC will have the sides of the one equal to the sides of the other, each to each, viz. AB = AC, BD = CD, and AD common to both; therefore (11.) the angle ABD shall be equal to the angle ACD.

Cor. An equilateral triangle is also equiangular.

Scholium. It appears by the demonstration, that the angles BAD, CAD are equal; also that the angles BDA, CDA are equal, and consequently right angles (Def. 9.): Therefore *a straight line drawn from the vertex of an isosceles triangle to the middle of the base bisects the vertical angle, and is perpendicular to the base.*

Note. In a triangle not isosceles, any side is taken for the *base*, and the opposite angle is the *vertex*; but in the isosceles triangle, the base is the side which is not equal to the others. Principles.

Prop. XIII. Theor.

Conversely, if two angles of a triangle are equal, the opposite sides are equal, and the triangle is isosceles.

Let the angle ABC = ACB; the side AC shall be equal to the side AB. Fig. 36.

For if the sides are not equal, let AB be the greater of the two. Take BD = AC, and join DC: The angle DBC is by hypothesis equal to ACB, and the two sides DB, BC are equal to the two sides AC, CB; therefore (6.) the triangle DBC is equal to ACB: now this is impossible, (Ax. 9.) for the triangle DBC is only a part of the triangle ACB, therefore AB is not unequal to AC, that is AB = AC.

Prop. XIV. Theor.

Of two sides of a triangle, that is the greater which is opposite to the greater angle; and conversely, of two angles of a triangle, that is the greater which is opposite to the greater side.

1. Let the angle ACB be greater than B; the side AB opposite to the angle C is greater than the side AC opposite to B. For make BCD = B; then in the triangle BCD, because the angles DCB and B are equal, we have DC = DB (12.); but AC is less than AD + DC (8.), and AD + DC = AD + DB = AB; therefore AB is greater than AC. Fig. 37.

2. Next let the side AB be greater than AC; the angle ACB opposite to AB shall be greater than B which is opposite to AC. For if ACB could be less than B; then AB would be less than AC, which is contrary to the hypothesis of the proposition: And if ACB could be equal to B, then AB would be equal to AC, which is also contrary to the hypothesis; therefore ACB must be greater than ABC.

Prop. XV. Theor.

From a point A without a straight line DE, only one perpendicular can be drawn to that line. Fig. 38.

For suppose it possible to draw two, AB, AC; produce one of them, so that BF may be equal to AB, and join FC; and because AB = BF, and BC is common to the triangles ABC, FBC, and the angles ABC, FBC are equal; the angle ACB is equal to FCB (6.) therefore AC and CF must form one continued line (3.); and so, through two points A, F, two straight lines AF and ACF may be drawn, that do not coincide, which is impossible: Therefore it is equally impossible that two perpendiculars can be drawn from the same point to the same straight line.

Scholium. Through the same point C, in a straight line AB (Fig. 24.), it is impossible to draw two perpendiculars to that line: For if CE and CD could be both perpendicular to AB; then ECB and DCB would be both right angles, and equal to one another (1.) which is absurd (Ax. 9.) Fig. 24.

Prop. XVI. Theor.

If from a point A without a straight line DE, a per- Fig. 39.

Principles.

pendicular AB be drawn to that line; and different oblique lines AE, AC, AD, &c. to different points of that line.

1st, The perpendicular AB is shorter than any oblique line.

2d, The two oblique lines AC, AE on opposite sides of the perpendicular, and at equal distances BC, BE, are equal.

3d, Of any two oblique lines AC, AD, or AE, AD, that which is farther from the perpendicular is the greater of the two.

Produce the perpendicular, so that BF = AB, and join FC, FD.

1. The triangles BCF, BCA are equal (6.), for BF= BA, and BC is common, and the angles at B are right angles; therefore CF = CA. Now AF is less than AC+CF, (8.) therefore, taking the halves, AB is less than AC; that is, the perpendicular is the shortest line that can be drawn from A to DE.

2. Next suppose BE=BC; then the triangles ABE, ABC will be equal (6.); for they have also BA common, and the angles ABE, ABC equal, therefore AE=AC; that is two oblique lines equally distant from the perpendicular on opposite sides are equal.

3. In the triangle ADF, the sum of AC and CF is less than the sum of AD and DF (9.); therefore AC the half of AC+CF, is less than AD, the half of AD+DF; that is the oblique line farther from the perpendicular is greater.

Cor. 1. The perpendicular from a point on a line measures its distance from the line.

Cor. 2. From the same point no more than two equal straight lines can be drawn to terminate in that line.

Prop. XVII. Theor.

Fig. 39. If through the point C, the middle of the straight line AB, a perpendicular be drawn to that line.

1st, Every point in the perpendicular is equally distant from the extremities of the line AB.

2d, Every point out of the perpendicular, is unequally distant from the extremities of the line.

1. Because AC=CB, the two oblique lines AD, DB, which are equally distant from the perpendicular, are equal (16). The same is also true of the two oblique lines AE, EB, and of the two oblique lines AF, FB, &c. Therefore, every point in the perpendicular is equally distant from the ends of the line.

2. Let I be a point out of the perpendicular. If IA, IB be joined, one of them will cut the perpendicular in D; therefore, drawing DB, we have DB=DA. But IB is less than ID+DB, and ID+DB=ID+DA=IA, therefore IB is less than IA; that is, any point out of the perpendicular is unequally distant from the extremities A, B.

Prop. XVIII. Theor.

Two right angled triangles are equal, if the hypothenuse and a side of the one be equal to the hypothenuse and a side of the other.

Fig 40. Let the hypothenuse AC=DF, and the side AB=DE; the right angled triangle ABC shall be equal to the right angled triangle DEF.

The proposition will evidently be true, if it can be proved that BC=EF (11). Let us suppose, if it be possible, that these sides are unequal, and that BC is the greater. Take BG=EF, and join AG. The triangles ABG, DEF, having AB=DE, and BG=EF (by hypothesis), and also having the angle ABG equal to DEF, they will be equal (6); therefore AG=DF, but DF=AC; therefore AG=AC; that is, two oblique lines, one more remote from the perpendicular than the other, are equal, which is impossible (16); therefore BC is not unequal to EF: and hence the triangle ABC is equal to the triangle DEF.

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Prop. XIX. Theor.

If two straight lines AC, BD, are perpendicular to a third AB, these two lines are parallel; that is, although produced ever so far both ways, they will not meet, (Def. 11.) Fig. 41.

For if they could meet in a point O, on either side of AB, then two perpendiculars OA, OB might be drawn from the same point O, to the same straight line AB, which is impossible, (15.)

Prop. XX. Theor.

If two straight lines AC, BD, make with a third AB two interior angles CAB, ABD, the sum of which is equal to two right angles, these two straight lines are parallel. Fig. 42.

From G, the middle of AB, draw EGF perpendicular to AC; then, because the sum ABD+ABF is equal to two right angles (2.), and by hypothesis the sum ABD+BAC is equal to two right angles, therefore ABD+ABF=ABD+BAC; and taking away the common angle ABD, there remains ABF=BAC; that is GBF =GAE. Besides, the angles BGF, AGE are equal (4.), and BG=GA; wherefore the triangles BGF, AGE have a side and two adjacent angles of the one equal to a side and two adjacent angles of the other; they are therefore equal (7.), and the angle BFG= AEG; but AEG is by construction a right angle; therefore BFG is a right angle; and since GEC is a right angle, the straight lines EC, FD are perpendicular to EF, and are therefore parallel to one another. (19.)

Cor. 1. If two straight lines AC, BD make with a third HK the alternate angles AHK, HKD equal, the two lines are parallel. For then, adding KHC, we have AHK + KHC = HKD + KHC; but the former sum is equal to two right angles (2.), therefore the latter is equal to two right angles; and consequently AC is parallel to BD. Fig. 43.

Cor. 2. If two straight lines AC, BD are cut by a third FG, so as to make the exterior angle FHC equal to the interior and opposite angle HKD on the same side; the two lines are parallel: For since FHC=AHK (4.), then we have AHK = HKD; that is, the alternate angles equal, therefore AC is parallel to BD.

Prop. XXI. Theor.

If a straight line EF meet two parallel straight lines AC, BD, the sum of the inward angles CEF, EFD on the same side, will be equal to two right angles. Fig. 44.

For if not, suppose EG to be drawn through E, so that the sum of GEF and EFD may be two right angles; then EG will be parallel to BD (20.); and thus through the same point E two straight lines EG, EC

Principles are drawn, each parallel to BD, which is impossible, (Ax. 11.); therefore no straight line that does not coincide with AC is parallel to BD, therefore the straight line AC is parallel to BD.

Cor. 1. If a straight line is perpendicular to one of two parallel straight lines, it is also perpendicular to the other.

Fig. 43. Cor. 2. (Fig. 43.) If a straight line HK meet two parallel straight lines AC, BD, the alternate angles AHK, HKD shall be equal.

For the sum CHK+HKD is equal to two right angles; and the sum CHK+AHK is also equal to two right angles (2.), therefore the angle HKD must be equal to AHK.

Cor. 3. (Fig. 43.) If a straight line FG cut two parallel straight lines AC, BD, the exterior angle FHC is equal to the interior and opposite angles HKD.

For since FHC = AHK (4.), and AHK = HKD; therefore FHC = HKD.

Fig. 44. Scholium. If a straight line EF meet two other straight lines EG, FD, and make the two interior angles EFD, FEG on the same side less than two right angles, the lines EG, FD meet, if produced, on the side of EF, on which the angles are less than two right angles. For if they do not meet on that side, they are either parallel, or else they meet on the other side. Now they cannot be parallel, for then the two interior angles would be equal to two right angles, instead of being less. Again, to shew that they cannot meet on the other side, suppose EA to be parallel to DFB; then because the sum EFD + FEG is (by hypothesis) less than two right angles, that is, less than FEK + FEG (2.); and EFD = FEA (Cor. 2. of this Prop.); therefore the sum FEA + FEG is less than FEK + FEG; and, taking FEG from both, FEA is less than FEK; hence FB and EK must be on opposite sides of EA, and therefore can never meet.

The truth of this proposition is assumed as an axiom in the Elements of Euclid, and made the foundation of the theory of parallel lines.

Prop. XXII. Theor.

Fig. 45. Two straight lines AB, CD, parallel to a third EF, are parallel to one another.

Draw the straight line PQR perpendicular to EF. Because AB is parallel to EF, the line PR shall be perpendicular to AB (1. Cor. 21.) And because CD is parallel to EF, the line PR is also perpendicular to CD; therefore AB and CD are perpendicular to the same straight line PQ; hence they are parallel. (19.)

Prop. XXIII. Theor.

Two parallel straight lines are every where equally distant.

Fig. 46. Let AB, CD be two parallel straight lines. From any points E and F in one of them, suppose perpendiculars EG, FH to be drawn; these, when produced, will meet the others at right angles in H and G (1. Cor. 21.): Join FG; then, because FH and EG are both perpendicular to AB, they are parallel, (19.); therefore the alternate angles HFG, FGE which they make with FG, are equal, (2. Cor. 21.): And because AB is parallel to CD, the alternate angles GFE, FGH are also equal; therefore the triangles GEF, FHG have two angles of the one equal to two angles of the other, each to each; and the side FG adjacent to the equal angles common; the triangles are therefore equal, (7.); and FH is equal to EG, that is, any two points F, E, on one of the lines, are equally distant from the other line. Principles.

Prop. XXIV. Theor.

In any triangle, if one of the sides be produced, the exterior angle is equal to both the interior and opposite angles; and the three interior angles are equal to two right angles.

Let ABC be a triangle; produce any one of its sides, AC towards D, and from the point A, let AE be drawn parallel to BC: And because of the parallels CB, AE, the angle EAD = C, and the angle EAB = B, (Cor. 2. and 3. of Prop. 21.); therefore EAD + EAB = C + B; that is, BAD = B + C: Hence the outward angle is equal to the two inward and opposite angles. Fig. 47.

Again, because BAD = B + C, to each add BAC, and we have BAD + BAC = B + C + BAC, that is, equal to the sum of the three angles of the triangle; but the sum BAD + CAB is equal to two right angles (2.); therefore the sum of the three angles of the triangle ABC is equal to two right angles.

Cor. 1. If two angles of one triangle are equal to two angles of another triangle, each to each, the third angle of the one shall be equal to the third angle of the other, and the triangles shall be equiangular.

Cor. 2. A triangle can have only one right angle.

Cor. 3. In any right angled triangle, the sum of the two acute angles is equal to a right angle.

Cor. 4. In an equilateral triangle, each of the angles is one-third of two right angles, or two-thirds of one right angle.

Prop. XXV. Theor.

The sum of all the interior angles of a polygon is equal to twice as many right angles, wanting four, as the polygon has sides.

Let ABCDE, &c. be a polygon; if from the vertex of any one of its angles A, diagonals AC, AD, AE, &c. be drawn to the vertices of all the other angles, it is evident that the polygon will be divided into five triangles if it have seven sides; and into six triangles if it have eight sides; and, in general, the number of triangles will be two less than the number of sides. It is also evident, that the sum of all the angles of these triangles make up all the angles of the polygon; now, all the angles of each triangle are together equal to two right angles; therefore all the angles of the triangles, that is all the angles of the polygon, will be equal to two right angles taken as often, except two, as the figure has sides, and consequently all the angles of the polygon will be equal to twice as many right angles wanting four as the figure has sides. Fig. 48.

Cor. The sum of the angles of a quadrilateral will be four right angles.

Scholium. The proposition will only apply to such polygons as have their angles *salient*, that is when the straight line that joins any two adjacent angles falls within the polygon. When some of the angles are *re-entrant*, the proposition must have a different form.

Prop. XXVI. Theor.

The opposite sides of a parallelogram are equal, as well as the opposite angles.

Draw the diagonal BD. The triangles ADB, DBC have the common side DB; also because of the parallels AB, CD, the angle ABD = CDB, (2 Cor. 21.) and because of the parallels AD, BC, the angle ADB = DBC; therefore the triangles are equal, (7.); and the sides AB, DC, which are opposite the equal angles, are equal. In like manner AD and BC are equal; therefore the opposite sides of a parallelogram are equal.

Again, from the equality of the triangles, it follows that the angle at A is equal to the angle at C; and it has been shewn, that the angles ADB, BDC are respectively equal to the angles CBD, DBA; therefore the whole angle ADC is equal to the whole angle ABC; thus the opposite angles are equal.

Cor. Two parallels AB, CD comprehended between two other parallels AD, BC are equal.

Prop. XXVII. Theor.

If in a quadrilateral ABCD, the opposite sides are equal, so that AB = CD, and AD = BC; the sides are parallel, and the figure is a parallelogram.

For, drawing the diagonal DB, the triangles ABD, BDC have the three sides equal, each to each; therefore the angle ADB, opposite to the side AB, is equal to the angle CBD, opposite to the side CD, (11.); hence the side AD is parallel to BC, (1. Cor. 20.) For a like reason AB is parallel to CD; therefore the quadrilateral ABCD is a parallelogram.

Prop. XXVIII. Theor.

If two opposite sides AB, CD of a quadrilateral are equal and parallel; the other two sides are equal and parallel, and the figure ABCD is a parallelogram.

For, having drawn the diagonal BD, since AB is parallel to CD, the angle ABD = BDC (2. Cor. 21.); besides the side AB = DC, and the side DB is common; therefore the triangle ABD is equal to the triangle DBC, (6.); therefore the side AD = BC, the angle ADB = DBC; and consequently AD is parallel to BC; therefore the figure ABCD is a parallelogram.

SECT. II.

Of a Circle.

Definitions.

1. The *circumference of a circle* is a curve line, every point of which is equally distant from a certain point within it called the *centre*. The *circle* is the space bounded by that curve line.

Note. Sometimes the circumference of a circle is called *the circle*; but it is easy to avoid ambiguity, by recollecting that the circumference is a *line*, and the circle a *space*.

2. Every straight line, CA, CE, CD, &c. drawn from the centre to the circumference, is called a *radius* or *semidiameter*; and every straight line, as AB, which passes through the centre, and is terminated both ways by the circumference, is called a *diameter*. Of the Circle.

Cor. All the radii are equal; also the diameters are all equal, and each is double of the radius.

3. An *arc* of a circle is any portion of the circumference, as FHG.

The *chord* or *subtense* of an arc is the straight line FG which joins its extremities.

4. A *segment* is the space comprehended between an arc and its chord.

Note. The same chord FG corresponds to two arcs FHG, FKG, also to two segments; but it is always the least of the two that is meant, unless otherwise expressed.

5. A *sector* is a part of a circle comprehended by an arc DE, and the two radii CD, CE drawn to its extremities.

6. A straight line is said to be *placed* in a circle, when its extremities are in the circumference, as FG.

7. An angle is said to be in a segment of a circle, when its vertex is on the arc of the segment, and the lines which contain it terminate in the extremities of the chord.

8. A rectilineal figure is said to be *inscribed* in a circle, when all its angles are on the circumference of the circle. The circle is then said to be *described* about the figure.

9. A straight line is said to *touch* a circle, and is called a *tangent*, when it meets the circumference, and being produced does not cut it; as the line IKL. The point K in which the straight line meets the circle is called the *point* of *contact*.

10. Two circumferences of circles are said to touch each other, when they meet in one point only.

11. A rectilineal figure is said to *circumscribe* a circle, when all its sides are tangents to the circumference; the circle is then said to be *inscribed* in the figure.

Prop. I. Theor.

Any diameter AB of a circle, divides the circumference into two equal parts. Fig. 51.

For if the figure AEB be applied upon AFB, so that they may coincide in their common base AB; it is manifest that they must entirely coincide; for were it otherwise, some parts of the circumference would be farther from the centre than others, contrary to the definition of a circle. (Def. 1. Sect. 2.)

Prop. II. Theor.

Every chord is shorter than the diameter.

For if the radii AC, CD be drawn to the extremities of the chord AD, then AD will be less than AC + CD (8. 1.) that is less than the diameter. Fig. 51.

Prop. III. Theor.

A straight line cannot cut a circle in more than two points.

For if it could cut it in three, these would be all equally distant from the centre; and so three equal straight lines might be drawn from the same point to terminate in the same straight line, which is impossible, (16. 1.)

Of the Circle.

Prop. IV. Theor.

In the same circle, or in equal circles, equal arcs are subtended by equal chords; and conversely, equal chords subtend equal arcs.

Fig. 52. If the radii AC, EO are equal, and the arc AMD is equal to the arc ENG; the chord AD shall be equal to the chord EG. For the semicircle AMDB may evidently be applied exactly upon the semicircle ENGF; and then the curve line AMDB will coincide entirely with the curve ENGF; but we suppose the arc AMD = arc ENG; therefore the point D will fall on G, and the chord AD on the chord EG.

Conversely, if the chord AD be equal to the chord EG, then the arc AMD = arc ENG. For, drawing the radii CD, OG; the triangles ACD, EOG have AC = EO, CD = OG, AD = EG; therefore they are equal, (11. 1.); and the angle ACD = EOG; consequently, if the semicircle ADB be placed on the equal semicircle EGF; so that AC may coincide with EO; the point D will manifestly fall on G, and the arc AMD will be equal to ENG.

Prop. V. Theor.

In the same, or in equal circles, a greater arc is subtended by a greater chord, and conversely; provided that the arcs are each less than a semicircumference.

Fig. 52. Let the arc AH be greater than the arc AD, and let the chords AD, AH, and the radii CD, CH be drawn. The two sides AC, CH of the triangle ACH are equal to the two sides AC, CD of the triangle ACD; and the angle ACH is greater than the angle ACD; therefore AH > AD (10. 1.) Thus it appears, that the chord that subtends the greater arc is the greater.

Conversely, if the chord AH is supposed greater than AD, it may be inferred from the same triangles, that the angle ACH is greater than the angle ACD, and therefore that the arc AH is greater than AD.

Scholium. If the arcs, instead of being less, were greater than a semicircumference, the opposite property would hold true; that is, the greater the arc, the smaller the chord.

Prop. VI. Theor.

Fig. 53. The radius CG, which is perpendicular to a chord AB, bisects the chord, and the arc it subtends; that is, divides each into two equal parts.

Draw the radii CA, CB; these, with respect to the perpendicular CD, are two equal oblique lines; therefore they meet AB at equal distances from the perpendicular (16. 1.); that is, AD = DB.

Next, if AD = DB; then, because CG is a perpendicular to AB, every point in CG is equally distant from A and B (17. 1.); therefore, if AG and BG be drawn, the chord AG = chord BG; hence the arc AG = arc BG (4.)

Scholium. From this proposition, it appears that the centre C, the middle D of the chord, and the middle G of the arc, are three points situated in a straight line perpendicular to the chord. Now, two points are sufficient to fix the position of a straight line. Therefore, any straight line which passes through two of these points will necessarily pass through the third, and be perpendicular to the chord.

Hence it also follows, *that the perpendicular to the middle of a chord passes through the centre and the middle of the arc subtended by the chord.*

Prop. VII. Theor.

One circle, and only one, can be described through three given points A, B, C, which are not in a straight line. Fig. 5

Join AB, BC, and divide these lines each into two equal parts by the perpendiculars DE, FG. Now, if ABC, or DBF, be a right angle; then, if the points D, F be joined, DBF will be a right angled triangle, and therefore each of the angles BFD, BDF will be less than a right angle (2. Cor. 24. 1.); and consequently, each of the angles FDE, DFG will be less than a right angle, and their sum will be less than two right angles: hence DE, FG will meet, if produced in a point O (Schol. 21. 1.) But if DBF is not a right angle, the two lines GF, AB will make with BF two angles on one side, which will be less than two right angles; therefore those lines will meet in a point K; and as BFK is a right angle, BKF will be less than a right angle (2. Cor. 24. 1.); therefore EDK and GKD will be together less than two right angles, and consequently will meet at a point O, as in the other case. Now this point O, considered as in the perpendicular DE, will be equally distant from A and B (17. 1.); and considered as in the perpendicular FG, it will be equally distant from C and B: therefore it will be equally distant from A, B, and C, and these three points will be in the circumference of a circle, of which O is the centre.

Again, every circle that passes through A and B must have its centre in DE; and every circle that passes through C and B must have its centre in FG (Schol. 6.); but these two lines can only have one common point; therefore only one circle can pass through the points A, B, C.

Cor. Two circles cannot cut each other in more than two points; for, if they could have three common points, they would have the same centre, and would coincide.

Prop. VIII. Theor.

Two equal chords are equally distant from the centre; and of two unequal chords, the shortest is farthest from the centre.

1. Let the chord AB=DE; suppose them divided into two equal parts by the perpendiculars CF, CG from the centre; and draw the radii CA, CD. The right angled triangles CAF, CDG have equal hypothenuses CA, CD; also AF, the half of AB, equal to DG, the half of DE; therefore the triangles are equal (18. 1.), and CF=CG; therefore AB, DE are equally distant from the centre. Fig.

2. Next let the chord AH be greater than the chord DE, so that the arc AKH is greater than the arc DME. In AKH take AKB equal to DME; draw the chord AB, and CF a perpendicular from the centre upon AB, meeting AH in O; and CI a perpendicular upon AH. It is evident that CF is greater than CO, and CO greater than CI (16. 1.); much more then is CF > CI: But CF=CG, since the chords AB, DE are equal;

therefore CG > CI; therefore of two unequal chords, the smaller is the farthest of the two from the centre.

Prop. IX. Theor.

A straight line BD, drawn perpendicular to the extremity of a radius CA, is a tangent to the circumference.

For every oblique line CE is longer than the perpendicular CA (16. 1.); therefore the point E must be without the circle; and as this holds true of every point in the line BD, except the point A, the line BD is a tangent (9. Def.)

Scholium. Only one tangent AD can be drawn from a point A in the circumference. For if it were possible to draw another tangent, as AG, then as CA would not be perpendicular to AG, another line CF would be perpendicular to AG; and so, CF would be less than CA (16. 1.); therefore F would fall within the circle, and AF, if produced, would cut the circumference.

Prop. X. Theor.

Two parallel chords AB, DE in a circle intercept equal arcs AD, BE.

Draw the radius CH perpendicular to AB; it will also be perpendicular to DE (1. Cor. 21. 1.) Therefore H will be at the same time the middle of the arcs AHB and DHE: Hence we have DH=HE and AH=HB; and therefore DA=BE.

Prop. XI. Theor.

If two circumferences cut each other, the straight line which passes through their centres shall be perpendicular to the chord which joins the points of intersection, and shall divide it into two equal parts.

For the line AB, which joins the point of intersection, being a common chord of the two circles; if, through the middle of this chord, a perpendicular be drawn, it will pass through C and D, the centres of both the circles. But only one line can be drawn through two given points; therefore the straight line which passes through the centres is a perpendicular at the middle of the common chord.

Prop. XII. Theor.

If the distance of the centres be less than the sum of their radii; and if, at the same time, the greater radius is less than the sum of the lesser and the distance of the centres, the two circles will cut each other.

For that the circles may intersect each other, the triangle CAD must be possible; therefore, it is necessary not only that CD be less than AC+AD, but also that the greater radius AD be less than AC+CD (8. 1). Now it is evident, that when the triangle CAD can be constructed, the circles described on C and D as centres will intersect on A and B.

Prop. XIII. Theor.

If the distance CD of the centres of two circles be equal to the sum of their radii CA, AD, the two circles touch each other externally.

It is evident that they will have a common point A, but they cannot have another common point; for if they had two common points, (as in Fig. 58.) it would be necessary that the distance of their centres should be less than the sum of their radii. Of the Circle.

Prop. XIV. Theor.

If the distance of the centres be equal to the difference of the radii CA, AD, the two circles will touch each other internally. Fig. 61.

In the first place, it is evident that they have a common point A, and they cannot have another; for, that this might be possible, it would be necessary that the greater radius AD should be less than the sum of the lesser and the distance of the centres C, D, which is inconsistent with the hypothesis.

Cor. Therefore, if two circles touch each other, either externally or internally, their centres and the point of contact are in the same straight line.

Prop. XV. Theor.

In the same circle, or in equal circles, equal angles ACB, DCE at the centre, intercept equal arcs AB, DE on the circumference; and conversely, if the arcs AB, DE be equal, the angles ACB, DCE are also equal. Fig. 62.

1. If the angle ACB=DCE, these two angles may be placed on each other, and as their sides are equal, the point A will fall on D, and the point B on E; but then the arc AB must also fall on the arc DE; for if the two arcs did not coincide, there would be in the one or the other points unequally distant from the centre, which is impossible: therefore the arc AB=DE.

2. Next if the arc AB=DE, the angle ACB shall be equal to DCE; for if they are not equal, let ACB be the greater. Take ACI=DCE, then by what has been demonstrated AI=DE; but by hypothesis, the arc AB=DE; therefore the arc AI=AB, which is impossible; wherefore the angle ACB=DCE.

Prop. XVI. Theor.

An angle ACB at the centre of a circle, is double of the angle ADB at the circumference, upon the same arc AB. Figs. 63, 64.

Draw DC, producing it to E. First, let the angle at the centre be within the angle at the circumference, (Fig. 63,) then the angle ACE=CAD+CDA, (24. 1); but because CA=CD, the angle CAD=CDA, (12. 1,) therefore the angle ACE=2 CDA. For the same reason, the angle BCE=2 CDB: Therefore, the whole angle ACB is double the whole angle ADB. Fig. 63.

Next, let the angle at the centre be without the angle at the circumference, (Fig. 64). It may be demonstrated as in the first case, that the angle ECB=2 EDB; and that the angle ECA a part of the first, is equal to 2 EDA a part of the second; therefore the remainder ACB is double the remainder ADB. Fig. 64.

Prop. XVII. Theor.

The angles ADB, AEB, in the same segment AEB of a circle, are equal to one another. Figs. 65, 66.

Let C be the centre of the circle, and first let the seg-

Of the Circle.

ment AEB be greater than a semicircle, (Fig. 65). Draw CA, CB to the ends of the base of the segment, then each of the angles ADB, AEB will be half of the angle ACB, (16.); therefore the angles ADB, AEB are equal.

Fig. 65.

Fig. 66.

Next, let the segment AEB be less than a semicircle; draw the diameter DCF, and join EF; and because the segment ADEF is greater than a semicircle by the first case, the angle ADF=AEF. In like manner, because the segment BEDF is greater than a semicircle, the angle BDF is equal to the angle BEF; therefore the whole angle ADB is equal to the whole angle AEB.

Prop. XVIII. Theor.

Fig. 67.

The opposite angles of any quadrilateral ABCD inscribed in a circle, are together equal to two right angles.

Draw the diagonals AC, BD. In the segment ABCD, the angle ABD=ACD; and in the segment CBAD, the angle CBD=CAD, (17.); therefore the whole angle ABC is equal to the sum ACD+CAD; and adding ADC, we get the sum ABC+ADC equal to the sum ACD + CAD + ADC; now these three angles are the angles of the triangle ADC, and therefore equal to two right angles, (24. 1.): Therefore the sum of the angles ABC, ADC is equal to two right angles. In like manner it may be demonstrated, that the sum of the angles BAD, BCD is equal to two right angles.

Prop. XIX. Theor.

Fig. 68.

An angle ABD in a semicircle is a right angle; an angle BAD in a segment greater than a semicircle, is less than a right angle; and an angle BED in a segment less than a semicircle, is greater than a right angle.

Produce AB to F, and draw BC to the centre; and because CA=CB, the angle CBA=CAB, (12. 1.), in like manner, because CD=CB, the angle CBD=CDB, therefore the sum CBA+CBD=CAB+CDB; that is, ABD=CAB+CDB; but this last sum is equal to the angle DBF, (24. 1.) therefore the angle ABD=DBF. Hence each is a right angle, (9. def 1.); therefore the angle ABD in a semicircle is a right angle.

And because in the triangle ABD the angle ABD is a right angle; therefore BAD, which is manifestly in a segment less than a semicircle, is less than a right angle, (2. Cor. 24. 1.). Again, because ABED is a quadrilateral in a circle, we have A+E= two right angles, (18.); but A is less than a right angle; therefore E, which is in a segment greater than a semicircle, is greater than a right angle.

Prop. XX. Theor.

Fig. 69.

The angle BAE, contained by a tangent AE to a circle, and a chord AB drawn from the point of contact, is equal to the angle AGB in the alternate segment.

Let the diameter ACF be drawn, and GF be joined; and because FGA and FAE are right angles, (19. and 9.), and of these, FGB a part of the one, is equal FAB a part of the other, (17.). The remainders BAE, BGA are equal.

Problems relating to the two First Sections.

Prob

Geometrical problems, like geometrical theorems, may be multiplied without end. They are divided into classes, according to the nature of the lines employed in their solution. The most simple, called *Plane Problems*, require only straight lines, and circles, and they may be all ultimately reduced to three.

1. To draw a straight line from one given point to another given point.
2. To prolong a straight line.
3. To describe a circle on any point as a centre, with any given radius.

These are resolved by the mechanical contrivances of a ruler and compasses, which are commonly known; and they belong rather to mechanics than to geometry, which does not teach how to resolve them, but takes for granted that the manner of solving them is known. This assumption is formally made in the *postulates*, (beginning of Sect. I.)

The elements of geometry treat only of the more simple plane problems, to which the complex may be reduced. Some of these are now to be considered.

Problem I.

From the greater CD of two unequal lines AB, CD, to cut off a part equal to the less. Fig.

From C as a centre, with a radius equal to AB, let the circumference of a circle be described cutting CD in E, (3d Postulate), and the thing is done.

Prob. II.

At a given point A to draw a line equal to a given line CD. Fig

Draw the indefinite line AF (Post. 1. and 2.); from which cut off AB=CD, (Prob. 1.)

Prob. III.

To bisect a given straight line AB, that is to divide it into two equal parts. Fig

On A and B as centres, with any radius greater than the half of AB, describe two arcs of circles to meet in D, (Post. 3. and Prop. 12.), this point will be equally distant from A and B. In like manner, find another point E, either on the same or on the other side of the line, which may be equally distant from A and B. Through D and E draw a straight line to meet AB in C; the point C will be the middle of AB.

For the points D and E are in a straight line, perpendicular to the middle of AB (17. 1.); therefore the line DCE is that perpendicular, and C is the middle of the line.

Prob. IV.

To draw a perpendicular to a given line BC from a given point A in that line. F

Take the points B and C at equal distances from A; and on B and C as centres, with a radius greater than BA, describe arcs to meet in D. Draw AD, which will be the perpendicular required.

Problems.

For D being equally distant from B and C, it must be in a line perpendicular to the middle of BC. Therefore AD is the perpendicular required.

PROB. V.

Fig. 74. To draw a perpendicular to a given line BD from a given point A without that line.

On A as a centre, with a sufficiently great radius, describe an arc to cut the line in B and D. Find next a point E equally distant from A and B; join AE, meeting BD in C, and AC will be the perpendicular required.

For the two points A, E are each equally distant from B and D; therefore AE is perpendicular to BD.

PROB. VI.

Fig. 75. At a given point A in a given line AB to make an angle equal to a given angle K.

On K as a centre, with any radius, describe an arc IL, to terminate in the sides of the angle. On A as a centre, with the same radius, describe an indefinite arc BO. On B as a centre with a radius equal to the chord of the arc LI, describe an arc to cut the arc BO in D; draw AD, and the angle DAB shall be equal to the given angle K.

For IL, BD are equal chords in equal circles, therefore the arc IL = arc BD (4.), and the angle K = angle A, (15.)

PROB. VII.

To divide a given angle, or an arc, into two equal parts.

Fig. 76. 1. If it is an arc AB whose centre is C, which is to be divided, on A and B as centres, with the same radius describe arcs to meet in D; through C and D draw a straight line CD, which will bisect the arc AB at the point E.

For C and D are each at the same distance from the extremities of the chord AB; therefore CD is perpendicular at the middle of the chord (17. 1.), and consequently must bisect the arc AEB, (Schol. 6.)

2. If the angle ACB is to be bisected; in the first place, an arc AEB is to be described on C the vertex of the angle as a centre; then a point D must be found equally distant from A and B as before, and a line drawn from C through D will bisect the angle.

For if the chord AB be drawn, CD will be perpendicular at the middle of AB; therefore CD bisects the arc AB (6.), and consequently bisects the angle ACB, (15.)

PROB. VIII.

Fig. 77. Through a given point A, to draw a straight line parallel to a given line BC.

On A as a centre, with a radius sufficiently great, describe an indefinite arc EO; on E as a centre, with the same radius, describe an arc AF; also on E as a centre with the chord of the arc AF as a radius, describe an arc to meet EO in D; draw a line from A through D, and AD will be the parallel required.

For AF and DE are manifestly equal arcs of equal circles; therefore the angles BEA, DAE are equal; and hence BC is parallel to AD, (Cor. 1. 20. 1.)

Problems.

PROB. IX.

To describe a triangle, the sides of which shall be equal to three given straight lines A, B, C. Fig. 78.

Draw a straight line DE equal to one of the lines A; on E as a centre, with a radius equal to another of the lines B, describe an arc; on D as a centre, with a radius equal to the remaining line C, describe another arc, cutting the former in F; draw DF, EF; and DEF shall be the triangle required, as is sufficiently evident.

SCHOLIUM. The problem is only possible when the sum of any two of the given lines is greater than the third, (8. 1.)

PROB. X.

To construct a parallelogram, the adjacent sides of which may be equal to two given lines A, B, and the angle which they contain equal to a given angle C. Fig. 79.

Draw a straight line DE = A; at the point D, make an angle FDE = C, and take DF = B; describe two arcs, one on F as a centre, with DE or A as a radius, and the other on E as a centre with B as a radius. From the point G, where these arcs cut each other, draw GF, GE, and DEGF will be the parallelogram required.

For by the construction, the opposite sides are equal; therefore the figure is a parallelogram, (27. 1.)

COR. If the given angle were a right angle, the figure would be a rectangle; and if the sides were equal, the figure would be a square.

PROB. XI.

To find the centre of a circle, or of a given arc.

Take any three points A, B, C in the circumference of the circle, or in the arc; join them by the lines AB, BC, (or suppose these lines drawn), and bisect AB, BC by the perpendiculars DE, FG (Prob. 3.); the point O where these lines meet each other shall be the centre sought, as is evident from Prop. 7. Fig. 80.

SCHOLIUM. By this construction, a circle may be described through three given points; or may be described about a given triangle ABC.

PROB. XII.

Through a given point A, to draw a tangent to a given circle. Figs. 81, 82.

If the given point A is in the circumference (Fig. 81.), draw the radius CA, and draw AD perpendicular to CA; and DA shall be the tangent required, (9. 2.) Fig. 81.

If the point A is without the circle, (Fig. 82.), draw AC to the centre, bisect AC in O; and on O as a centre, with OC as a radius, describe a circle which may cut the given circle in B; draw AB, and AB shall be the tangent required. Fig. 82.

For join CB, and the angle ABC in a semicircle will be a right angle (19.); therefore AB, a perpendicular to the radius at its extremity B, is a tangent to the circle, (9.)

Problems.

SCHOLIUM. When the point A is without the circle, there may be two equal tangents AB, AD drawn, which shall pass through the point A. For the right angled triangles ABC, ADC have a common hypothenuse AC, and a side BC equal a side CD; therefore AB = AD, (18. 1.)

PROB. XIII.

Fig. 83. To inscribe a circle in a given triangle ABC.

Bisect the angles A and B, (Prob. 7.) by the straight lines AO, BO, which will meet at a point O, because the angles CBA and BAC are less than two right angles; and therefore OAB and OBA are also less than two right angles, (Schol. 21. 1.) Draw OD, OE, OF, perpendicular to the sides of the triangle: And because the triangles OAD, OAF have the angle OAD = OAF, and the angle ODA = OFA; the remaining angle AOD shall be equal to the remaining angle AOF, (1 Cor. 24. 1.) Besides the side AO, adjacent to the equal angles, is common to both; therefore the triangles are equal, (7. 1.) and OD = OF: In like manner it may be demonstrated, that the triangles BOD and BOE are equal, and therefore OD = OE; therefore the three lines OD, OE, OF are equal; and a circle described on O as a centre, with any one of them as a radius, will pass through the extremities of the other two; and because the angles at D, E, F are right angles, the circle will touch the sides of the triangle (9.), and be inscribed in it.

PROB. XIV.

Fig. 84. Upon a given straight line AB, to describe a segment of a circle that may contain an angle equal to a given angle C.

Produce AB towards D, and at the point B make the angle DBE = C; draw BO perpendicular to BE, and GO a perpendicular upon the middle of AB. On the point of concourse O as a centre, with the radius OB, describe a circle which will evidently pass through A; the segment required shall be AMB. For since BE is perpendicular to the extremity of the radius OB, BE is a tangent; therefore the angle EBD, which is equal to C by construction, is equal to any angle AMB in the alternate segment.

SCHOLIUM. If the given angle were a right angle, the segment sought would be a semicircle described on the diameter AB.

SECT. III.

OF PROPORTION.

Of proportion.

THE theory of proportion treats of the *ratios* of quantities; that is, the relations they have to each other in respect of magnitude. As it applies alike to quantities of every kind, we have explained it in our article ALGEBRA, Sect. III.; and some foreign writers on geometry, particularly Legendre, even regard this subject as altogether an arithmetical or algebraical theory. In this country it has been usual to introduce it into geometry, just before its application is wanted; although perhaps it might with propriety be inserted, rather as a preliminary theory, than as forming a part of geometry. However, in compliance with custom, we shall treat it, (but somewhat differently,) also in this place.

Proport.

Definitions.

Definitio

1. When one quantity contains another, a certain number of times exactly, the former is called a *multiple* of the latter; and the latter is said to be a *part* of the former.

2. When several magnitudes are multiples of as many others, and each contains its part the same number of times, the former are called *equimultiples* of the latter, and the latter *like parts* of the former.

3. If there be four quantities, which we shall call A, B, C and D, and if A contain some part of B, exactly as often as C contains a like part of D, then A is said to have to B the same *ratio* that C has to D; or the *ratio* of A to B is said to be *equal* to the ratio of C to D.

COR. Hence if A contain B exactly as often as C contains D, then the ratio of A to B is equal to the ratio of C to D.

Note. Each pair of quantities is supposed to be of the same kind as both lines or both surfaces, &c. but A and B may be of one kind, and C and D of any other kind.

4. Each set of quantities compared, as A and B, is called the *terms* of the ratio; the first is called the *antecedent*, and the second the *consequent*.

5. The terms of two equal ratios are called *proportionals*.

To indicate that the ratio of A to B is equal to the ratio of C to D, they are usually written thus; A : B :: C : D; and sometimes thus, A : B = C : D; also thus $\frac{A}{B}=\frac{C}{D}$; each expression is read thus; A *is to* B *as* C *to* D, and is called a *proportion*.

6. Of four proportional quantities, the last term is called a *fourth proportional* to the other three taken in order

7. When there is any number of quantities greater than two, of which the first has to the second the same ratio which the second has to the third, and the second to the third the same ratio which the third has to the fourth, and so on, the magnitudes are said to be *continual proportionals*.

8. When three quantities are continual proportionals, the second is said to be a *mean proportional* between the other two; and the last a *third proportional* to the first and second.

9. In proportionals, the antecedent terms are called *homologous* to one another, and also the consequents to one another.

10. When there is any number of quantities of the same kind, the first is said to have to the last of them the ratio *compounded* of the ratio which the first has to the second, and of the ratio which the second has to the third, and so on unto the last magnitude. For example, if there be four quantities A, B, C, D, the first A is said to have to the last D the ratio compounded of the ratio of A to B, and of the ratio of B to C, and of the ratio of C to D.

And if A : B :: E : F, and B : C :: G : H; and C : D :: K : L; then, since the ratio of A to D is compounded of the ratios of A to B, B to C, C to D; A may also be said to have to D the ratio compounded of the ratios, which are the same with the ratios of E to F, G to H, and K to L.

11. A ratio which is compounded of two equal ratios, is said to be *duplicate* of either of these ratios.

COR. Hence if three magnitudes A, B, and C are continual proportionals, the ratio of A to C is *duplicate* of that of A to B. For the ratio of A to C is compounded of the ratios of A to B, and of B to C; but by Def. 7. the ratio of A to B is equal to the ratio of B to C; therefore, by this definition, the ratio of A to C is duplicate of the ratio of A to B, or of B to C.

12. A ratio which is compounded of three equal ratios, is said to be *triplicate* of any one of them. By a like mode of proceeding, a ratio *quadruplicate* of another is formed, and so on.

Cor. If four magnitudes A, B, C, D be continual proportionals, the ratio of A to D is triplicate of the ratio of A to B, or of B to C, or of C to D.

13. *Ratio* of *equality* is that which equal magnitudes bear to each other.

Geometers make use of the following technical words to signify certain ways of changing either the order or magnitude of proportionals, so that they still continue to be proportional.

14. If four quantities be proportionals, they are said to be proportionals by *inversion*, when it is inferred that the second is to the first as the fourth to the third. (See Prop. 2.)

15. They are said to be proportionals by *alternation*, when it is inferred that the first is to the third as the second to the fourth. (Prop. 3.)

16. They are proportionals by *composition*, when the sum of the first and second is to the second as the sum of the third and fourth is to the fourth. (Prop. 4.)

17. And by *division*, when the difference of the first and second is to the second as the difference of the third and fourth is to the fourth. (Prop. 5.)

18. They are proportionals by *conversion*, when the first is to the difference of the first and second, as the third to the difference of the third and fourth. (Prop. 6.)

In this Section, the letters A, B, C, &c. are used to denote quantities of any kind; the letters m, n, p, q, &c. are used to denote numbers only.

In addition to the characters which denote addition and subtraction, we shall now also employ those which express multiplication and division; they are explained in Algebra, Art. 27, 28, and 29.

Axioms.

1. Equal quantities have the same ratio to the same quantity; and the same quantity has the same ratio to each of any number of equal quantities.

2. Quantities having the same ratio to the same quantity, or to equal quantities, are equal among themselves; and these quantities, to which the same quantity has the same ratio, are equal.

3. Ratios equal to one and the same ratio, are also equal one to the other.

4. If two quantities be composed of parts that are equal among themselves, then will the whole of the one have the same ratio to the whole of the other, as the number of parts in the one has to the number of equal parts in the other.

Prop. I. Theor.

Quantities have to one another the same ratio which their equimultiples have.

Let A and B be two quantities, and supposing m to denote any number, let mA and mB, (that is m times A, and m times B,) be any equimultiples of these quantities; the ratio of A to B shall be equal to the ratio of mA to mB, or $A : B :: mA : mB$.

For let us suppose that A contains three such parts, each equal to X, as B contains four, so that

$$A = X + X + X; \qquad B = X + X + X + X;$$

Then $mA = mX + mX + mX$;

$$mB = mX + mX + mX + mX;$$

because a whole quantity taken any number of times, is manifestly equivalent to the aggregate of each of its parts taken the same number of times: Now as A contains one-fourth of B three times, and mA evidently contains one-fourth of mB also three times, A contains a part of B exactly as often as mA contains a like part of mB; therefore (Def. 3.) the ratio of A to B is equal to the ratio of mA to nB.

If instead of supposing A to contain three such parts as B contains four, we had taken general symbols, and suppose A to contain p, such equal parts as B contained q, the reasoning and result would have been exactly the same. A like remark is to be made on the subsequent propositions.

Cor. Like parts of quantities have to each other the same ratio as the wholes; for A and B are like parts of mA and mB.

Prop. II. Theor.

If four quantities be proportionals, they shall also be proportionals by inversion.

Let A, B, C, D be four quantities, such that $A : B :: C : D$; then also $B : A :: D : C$.

For suppose that A contains two such equal parts as B contains three, and consequently, (Def. 3.) that C contains two such equal parts as D contains three; then B will contain three such parts as A contains two, and D will contain three such parts as C contains two; so that B will contain a part of A, exactly as often as D contains a like part of C, therefore (Def. 3.) $B : A :: D : C$.

Prop. III. Theor.

If four quantities of the same kind be proportionals, they shall also be proportionals by alternation.

Let $A : B :: C : D$; then, alternately, $A : C :: B : D$.

For let us suppose that A contains three such equal parts as B contains four, then, (Def. 3.) C will also contain three such equal parts as D contains four: let each of the equal parts contained in A and B be X, and let each of the equal parts contained in C and D be Y; then

$$A = 3X \qquad B = 4X$$
$$C = 3Y \qquad D = 4Y$$

Because X is contained three times in A, and Y is contained three times in C; A and C are equimultiples of X and Y, (Def. 2.): and in like manner, it appears that B and D are equimultiples of X and Y; threfore (Prop. 1.) $A : C :: X : Y$; also, $B : D :: X : Y$; and since the ratios of A to C, and of B to D are each equal to the ratio of X to Y, it follows, (Ax. 3.) that $A : C :: B : D$.

Cor. If the first of four proportionals be greater than the third, the second is greater than the fourth; and if the first be equal to the third, the second is equal to the fourth; and if the first be less than the third, the second is less than the fourth.

PROP. IV. THEOR.

If four quantities be proportionals, they shall also be proportionals by composition.

Let A : B : : C : D; then by composition A : A + B : : C : C+D.

For let us suppose that A contains five such equal parts as B contains three, then also, (Def. 3.) C will contain five such equal parts as D contains three. Let each of the parts in A and B be X, and let each of the parts in C and D be Y; then because

$A=5X$; $B=3X$; $C=5Y$; $D=3Y$.

It follows that

$A+B=8X$ $\quad C+D=8Y$.

Here it is evident that A+B contains one third of B eight times; and that C + D contains one third of D also eight times; and in general, that A+B will contain some part of B exactly as often as C+D contains a like part of D; therefore (by Def. 3.) A+B : B : : C+D : D.

PROP. V. THEOR.

If four quantities be proportionals, they will also be proportionals by division.

Let A : B : : C : D; then by division, A—B : B : : C—D : D.

For making the same supposition as in last proposition, so that

$A=5X$, $B=3X$, $C=5Y$, $D=3Y$; we have $A-B=2X$, and $C-D=2Y$, therefore A—B contains one third of B twice, and C—D contains one-third of D also twice: and in general, it is evident that A—B will in every case contain a part of B exactly as often as C—D contains a like part of D: therefore (Def. 3.) A—B : B : : C—D : D.

PROP. VI. THEOR.

If four quantities be proportionals, they are also proportionals by conversion.

Let A : B : : C : D; then, by conversion, A : A—B : : C : C—D.

For, making the same supposition as in the two last propositions, because

$A=5X$, $B=3X$, $C=5Y$, $D=3Y$;
therefore $A-B=2X$, and $C-D=2Y$;

Hence it appears that A contains one half of A—B five times, and that C contains one half of C—D also five times, therefore A contains a part of A—B as often as C contains a like part of C—D; therefore A : A—B : : C : C—D. (Def. 3.)

PROP. VII. THEOR.

If four quantities be proportionals, and there be taken any equimultiples of the antecedents, and also any equimultiples of the consequents; the resulting quantities will also be four proportionals.

Let A : B : : C : D; and supposing *m* and *n* to be any two numbers, let the antecedents A and C be taken each *m* times, and the consequents B and D each *n* times; then shall *m* A : *n* B : : *m* C : *n* D.

For suppose that A contains two such equal parts as B contains three: and consequently that C contains two such equal parts as D contains three. (Def. 3.) Let each of the parts contained in A and B be X, and each of the parts contained in C and D be Y; so that

$A=2X$, $\quad B=3X$,
$C=2Y$, $\quad D=3Y$;

Then, multiplying the antecedents by the number *m*, and the consequents by *n*, and observing that $m\times 2=2\times m$, and that $n\times 2=2\times n$, we have

$mA=2\times mX$, $\quad nB=3\times nX$,
$mC=2\times mY$, $\quad nD=3\times nY$.

Here it is evident that *m* A contains one third of *n* B twice; and that *m* C contains one third of *n* D also twice; therefore *m* A : *n* B : : *m* C : *n* D. (Def. 3.)

PROP. VIII. THEOR.

If there be any number of magnitudes, and as many others, which taken two and two have the same ratio; the first shall have to the last of the first series, the same ratio which the first has to the last of the other series.

A, B, C.
H, K, L.

First, let there be three magnitudes A, B, C, and other three H, K, L, such, that A : B : : H : K, and B : C : : K : L, then, A : C : : H : L.

For let us suppose that A contains 2 such parts, each equal to X, as B contains 3, and as C contains 7; then, (Def. 3.) H will contain 2 such parts (each of which we shall denote by Y) as K contains 3, and as L contains 7; so that we have

$A=2X$, $B=3X$, $C=7X$,
then, $H=2Y$, $K=3Y$, $L=7Y$.

Here it is evident that A will contain one seventh of C twice, and that H will contain one seventh of L also twice; therefore (Def. 3.) A : C : : H : L.

A, B, C, D.
H, K, L, M.

Next, let there be four quantities A, B, C, D, and other four H, K, L, M, such, that A : B : : H : K, and B : C : : K : L, and C : D : : L : M; then shall A : D : : H : M. For by the first case it is evident that A : C : : H : L; and because C : D : : L : M; therefore, as before, A : D : : H : M. The demonstration applies in the same manner to any number of quantities.

Note. Quantities which are proportionals, according to the hypothesis of this theorem, are said to be so from *equality of distance directly*, and the theorem is usually cited by the words *ex æquali*, or *ex æquo*.

PROP. IX. THEOR.

If there be any number of quantities, and as many others, which taken two and two in a cross order have the same ratio; the first shall have to the last of the first series the same ratio that the first has to the last of the other series.

A, B, C.
H, K, L.

First, let there be three quantities A, B, C, and other three H, K, L, such, that A : B : : K : L, and B : C : : H : K; then A : C : : H : L.

For suppose A to contain two such equal parts as B contains three, then K will contain two such equal parts as L contains three, (Def. 3.); let each of the equal parts contained in A and B be X, and let each of the equal parts contained in K and L be Y, so that

$A=2X$, $B=3X$, $K=2Y$, $L=3Y$.

Also let Z be the same part of C that Y is of L, and let V be the same part of H that X is of A; so that we have

$C=3Z$, $H=2V$.

Then, because B : C : : H : K; that is 3X : 3Z : : 2V :

 2Y, and because 3X : 3Z : : X : Z, and 2V : 2Y : : V : Y, (1.); therefore X : Z : : V : Y, (Ax. 3.); hence, (by Prop. 7.) 2X : 3Z : : 2V : 3Y; but 2X=A, 3Z=C, 2V =H, 3Y=L; therefore A : C : : H : L.

Next, let there be four quantities, A, B, C, D, and other four H, K, L, M, such that A : B : : L : M, and B : C : : K : L, and C : D : : H : K; then A : D : : H : M; for it is evident by the first case, that A : C : : K : M; and because C : D : : H : K, therefore, as before, A : D : : H : M. The same mode of demonstration will apply to any number of quantities.

A, B, C, D.
H, K, L, M,

Note. The quantities in this proposition are said to be proportional from *equality of distance*, but in a cross order; and the theorem is usually cited by the words *ex æquali in proportione perturbata*, or *ex æquo perturbate.*

PROP. X. THEOR.

If the first have to the second the same ratio which the third has to the fourth, and the fifth have to the second the same ratio which the sixth has to the fourth; the first and fifth together shall have to the second the same ratio which the third and sixth together have to the fourth.

Let A : B : : C : D, and also E : B : : F : D, then A+E : B : : C+F : D.

Because E : B : : F : D, by inversion B : E : : D : F, (2.) But by hypothesis A : B : : C : D; therefore *ex æquali*, (8.) A : E : : C : F, and by composition A+E : E : : C+F : F. Now again by hypothesis, E : B : : F : D, therefore *ex æquali*, (8.) A+E : B : : C+F : D.

PROP. XI. THEOR.

If four quantities be proportionals, as the sum of one antecedent and its consequent is to their difference, so is the sum of the other antecedent and consequent to their difference.

Let A : B : : C : D, then A+B : A—B : : C+D : C—D.
For by composition, A+B : B : : C+D : D (4.)
And by Div. and Inver. B : A—B : : D : C—D (5 and 2.)
Therefore *ex æquo* A+B : A—B : : C+D : C—D (8.)
Note. Proportionals formed in this manner, are said to be so by *mixing*.

PROP. XII. THEOR.

If there be any number of proportionals, as one antecedent is to its consequent, so is the sum of all the antecedents to the sum of all the consequents.

Let A : B : : C : D : : E : F, then A : B : : A+C+E : B+D+F.

For suppose that A contains two such parts, each = X, as B contains three; and that C contains two such parts, each =Y, as D contains three; and that E contains two such parts, each = Z, as F contains three; and so on, then

$$A = 2X,\ B = 3X,$$
$$C = 2Y,\ D = 3Y,$$
$$E = 2Z,\ F = 3Z.$$

Hence by addition,

$$A+C+E = 2X+2Y+2Z = 2(X+Y+Z),$$
$$B+D+F = 3X+3Y+3Z = 3(X+Y+Z).$$

Thus it appears, that A contains a third part of B twice, and that A + C + E contains a third part of B+D+F also twice; therefore A : B : : A+C+E : B+D+F.

PROP. XIII. PROB.

To find the numerical ratio of two straight lines AB, CD, supposing them to have a common measure. Fig. 85.

Take the lesser of the two lines on the greater as often as possible; for example twice, with a remainder EB.

Take the remainder BE on the line CD as often as possible; once, for example, with a remainder DF.

Take the second remainder DF on the first BE as often as possible; once, for example, with a remainder BG.

Take the third remainder BG on the second DF as often as possible, and continue this process until a remainder is found, which is contained an exact number of times in that going before it. Then the last remainder shall be the common measure of the proposed lines; and considering it as unity, we shall easily find the values of the preceding remainders, and at last those of the two proposed lines; that is, we shall know how often each contains the unit, so that if AB contain it *m* times, and CD contain it *n* times, then AB : CD : : *m* : *n*.

For example, if it is found that GB is contained exactly twice in FD, BG shall be the common measure of the two lines. Let BG=1, then FD=2; but EB=FD+GB, therefore EB=3; CD=EB+FD, therefore CD=5; lastly, AB=2 CD+EB, therefore AB=13: therefore the ratio of AB to CD is that of 13 to 5.

SCHOLIUM. This operation is evidently the same as that by which the common measure of two numbers is found. Its demonstration is given in ALGEBRA, Art. 72. and 73. If the operation terminate, and the lines have a common measure, they are said to be *commensurable*; but the lines may be such that the operation will never terminate, and as then the quantities have no common measure, they are said to be *incommensurable*. The side of a square AB, and its diagonal AC, are of this nature, (Fig. 86.) For if we take AD=AB, and draw DE perpendicular to AC, to meet CB in E, and join AE, the triangles ABE, ADE will be equal, (18. 1.) and BE=DE. But the angle DEC=DAB (1 Cor. 24. 1.) =DCB, (12. 1.) therefore DE=DC, (13. 1.) and hence BE=DC. Now to determine whether AB and AC have a common measure, we first take AB out of AC, and DC will remain; we next take DC out of CB, and get it once, with a remainder CE; but as CE is still greater than DC, we must again take CD out of CE, and then proceeding exactly as before, we must take the last remainder out of CD as often as we can, and so on. Now CE is evidently the diagonal of a square, of which DC is a side; therefore it appears, that in seeking the common measure, we must make the very same kind of construction in this second square that was made upon the first; and again, in pursuing the operation, we must make a like construction on a third square, and so on continually, so that the operation can never come to an end: therefore the quantities AC, AB can have no common measure. Fig. 86.

On the subject of incommensurable quantities, see also ALGEBRA, Sect. VI.

In the theory of proportion, we have, with a view to brevity and perspicuity, treated only of commensurable ratios; that is, such as can be accurately expressed by numbers. Although the ratio of incommensurable quantities cannot be so expressed, yet a ratio may be always assigned in numbers, which shall be as near to the true ratio as we please. For let A and B be any two

Proportion of Figures.

quantities whatever, and suppose that X is such a part of A, that $A=mX$; then, if n denote the number of times that X can be taken from B, and D the remainder, we have $B=nX+D$, and $B-D=nX$; and because $m:n::mX:nX$, therefore $m:n::A:B-D$. Now as D is less than X, by taking X sufficiently small, D may be less than any proposed quantity, and B—D may differ from B by less than any given quantity; therefore such values may be given to m and n, as shall make the ratio of m to n as near to the ratio of A to B as we please. Hence we may, with perfect confidence, apply whatever has been delivered in this Section concerning commensurable quantities to such as are incommensurable.

SECTION IV.

The Proportion of Figures.

Definitions.

Definitions. 1. *Equivalent* figures are such as have equal surfaces. Two figures may be equivalent, although dissimilar. For example, a circle may be equal to a square; a triangle to a rectangle, &c.

We shall apply the term *equal* to such figures only as would coincide entirely, if placed the one upon the other.

2. Two figures are *similar*, when the angles of the one are equal to the angles of the other, each to each, and the homologous sides proportional. By the homologous sides, we mean those that have the same position in the two figures, or which are adjacent to equal angles: the angles themselves may be called *homologous angles.*

Fig. 87. 3. In two circles, similar sectors, similar arcs, similar segments, are those which have equal angles at the centre. Thus, if the angle A=O, the arc BC is similar to the arc DE, and the sector ABC to the sector ODE (Fig. 87.)

Fig. 96. 4. The *altitude* of a triangle ABC, (Fig. 96,) is a perpendicular drawn from any one of its angles A upon the opposite side BC its base.

Fig. 94. The *altitude* of a parallelogram ABCE, (Fig. 94,) is the distance AD between any two of its parallel sides.

Fig. 95. The *altitude* of a trapezoid ABCD, is the distance EF between its parallel sides. (Fig. 95.)

5. The *area* and the *surface* of a figure, are terms of nearly the same import. The area, however, is more particularly the quantity of superficies, as expressed by some other superficies taken a certain number of times.

Prop. I. Theor.

Parallelograms which have equal bases and equal altitudes are equivalent.

Fig. 88. Let AB be the common base of the two parallelograms ABCD, ABEF; since they are supposed to have the same altitude, their sides DC, FE, opposite to their bases, will be in the same straight line parallel to AB. But by the nature of parallelograms AD=BC, and AF=BE; also DC=AB, and FE=AB, (26. 1.) and therefore DC=FE; and taking away DC and FE from the same straight line DE, there remains DF=CE: Hence the triangles DAF, CBE have the three sides of the one equal to the three sides of the other, each to each, therefore they are equal (11. 1.): Now if the former be taken away from the quadrilateral ABED, there will remain the parallelogram AFEB; and if the latter be taken from the same quadrilateral, the parallelogram ABCD will remain; therefore the parallelogram ABCD is equivalent to the parallelogram ABEF.

Cor. Every parallelogram ABCD is equal to a rectangle FBCE of the same base and altitude. (Fig. 89.) Fig. 10[illegible]

Prop. II. Theor.

Any triangle ABC is half of a parallelogram ABCD of the same base and altitude. Fig. 89

For the triangles ABC, ACD are equal, (26. 1.)

Cor. 1. Therefore a triangle ABC is half of a rectangle BCEF, which has the same base BC and the same altitude AO.

Cor. 2. Triangles which have equal bases and equal altitudes are equivalent.

Prop. III. Theor.

Two rectangles of the same altitude are to one another as their bases.

Let ABCD, AEFD be two rectangles, which have a common altitude AD; they are to one another as their bases AB, AE.

For suppose that the base AB contains seven such parts as the base AE contains four; then, if AB be divided into seven equal parts, AE will contain four of them. At each point of division draw a perpendicular to the base; these will form seven equal rectangles (1.); and as AB contains seven such parts as AE contains four, the rectangle AC will also contain seven such parts as the rectangle AF contains four; therefore AB has to AE the same ratio that the rectangle AC has to the rectangle AF. Fig. 9[illegible]

Prop. IV. Theor.

Any two rectangles are to one another as the products of the numbers which express their bases and altitudes.

Let ABCD, AEGF be two rectangles, and let some line taken as an unit be contained m times in AB the base of the one, and n times in AD its altitude; also p times in AE the base of the other, and q times in AF its altitude; the rectangle ABCD shall be to the rectangle AEGF as the product mn to the product pq. Fig. [illegible]

Let the rectangles be so placed, that their bases AB, AE may be in a straight line, then their other sides AD, AF shall also form a straight line (3. 1.) Complete the rectangle EADH, and because this rectangle has the same altitude as the rectangle ABCD when EA, AB are taken as their bases, and the same altitude as the rectangle AEGF when AD, AF are taken as their bases, we have

$$ABCD : ADHE :: AB : AE :: m : p \quad (3.)$$
$$\text{but } m : p :: mn : pn \quad (1.\ 3.)$$
$$\text{therefore } ABCD : AEHD :: mn : pn.$$

In like manner, it appears that

$$AEHD : AEGF :: AD : AF :: n : q :: pn : pq.$$

Therefore, *ex æquo,* $ABCD : AEGF :: mn : pq$.

Scholium. If ABCD, one of the rectangles, (Fig. 92.) be a square having the measuring unit for its side, this square may be taken as the measuring unit of surfaces; and because the linear unit AB is contained p times in EF, and q times in EH, by the proposition Fig. 92.

$$1 \times 1 : pq :: ABCD : EFGH;$$

hence the rectangle EFGH will contain the superficial unit ABCD as often as the numeral product pq contains unity, consequently the product pq will express the *area* of the rectangle, or will indicate how often it contains the unit of superficies. Thus, if EF contain the linear unit AB four times, and EH contain it three times, the area EFGH will be $3 \times 4 = 12$, that is, twelve times a square whose side is $AB = 1$.

In consequence of the surface of a rectangle EFGH being expressed by the product of its sides, the rectangle, or its area, may be denoted by the symbol $EF \times FG$; or thus, EF.FG, in conformity to the manner of expressing a product in arithmetic.

However, instead of expressing the area of a square made on a line AB thus, $AB \times AB$, it is thus expressed, AB^2.

Note. A rectangle is said to be *contained* by two of its sides about any one of its angles.

PROP. V. THEOR.

The area of a parallelogram is equal to the product of its base by its altitude.

Fig. 93. For the parallelogram ABCD is equivalent to the rectangle ABEF, which has the same base AB and the same altitude (1.); and this last is measured by $AB \times BE$, or $AB \times AF$; that is, by the product of the base of the parallelogram and its altitude (4.)

COR. Parallelograms of the same base are to one another as their altitudes; and parallelograms of the same altitude are to one another as their bases. For in the former case, put B for their common base, and A and A′ for their altitudes; then we have $B \times A : B \times A' :: A : A'$. And in the latter, put A for their common altitude, and B and B′ for their bases; then $B \times A : B' \times A :: B : B'$.

PROP. VI. THEOR.

The area of a triangle is equal to the product of its base by half its altitude.

Fig. 94. For the triangle ABC is half the parallelogram ABCE, which has the same base BC, and the same altitude AD (2.); but the area of the parallelogram is $BC \times AD$ (5.); therefore the area of the triangle is $\frac{1}{2}BC \times AD$, or $BC \times \frac{1}{2}AD$.

COR. Two triangles of the same base are to one another as their altitudes, and two triangles of the same altitude are to one another as their bases.

PROP. VII. THEOR.

Fig. 95. The area of a trapezoid ABCD is equal to the product of half the sum of its parallel sides AB, DC by its altitude EF.

Through I, the middle of the side BC, draw KL parallel to the opposite side DA, and produce DC until it meet KL. In the triangles IBL, ICK, the side $IB = IC$, the angle $B = C$ (2 Cor. 21. 1.), the angle $BIL = CIK$; therefore the triangles are equal (7. 1.), and the side $CK = BL$. Now, the parallelogram ALKD is the sum of the polygon ALICD and the triangle CIK, and the trapezoid ABCD is the sum of the same polygon and a triangle equal to BIL; therefore the trapezoid ABCD is equal to the parallelogram ALKD, and has for its measure $AL \times EF$. And because $AL = DK$ and $BL = CK$, therefore $AB + CD = AL + DK = 2AL$; and hence AL is half the sum of the parallel sides AB, CD: therefore the area of the trapezoid is equal to $\frac{1}{2}(AB + CD) \times EF$.

PROP. VIII. THEOR.

If a straight line AC be divided into any two parts AB, BC, the square made on the whole line AC is equal to the squares on its two parts AB, BC, together with twice the rectangle contained by these parts. Or the proposition may be briefly expressed thus; AC^2 or $(AB + BC)^2 = AB^2 + BC^2 + 2\,AB \times BC$. Fig. 97.

Construct the square ACDE; take $AF = AB$; draw FG parallel to AC, and BH parallel to AE.

The square ACDE is composed of four parts; the first ABIF is the square on AB, because $AF = AB$; the second IGDH is the square on BC; for since $AC = AE$, and $AB = AF$, the difference $AC - AB$ is equal to the difference $AE - AF$, that is, $BC = EF$; but because of the parallels, $BC = IG$, and $EF = HI$, therefore HIGD is the square on BC. These two parts being taken from the whole square, there remains the two rectangles BCGI, EFIH, which are each equal to $AB \times BC$; so that the truth of the proposition is evident.

PROP. IX. THEOR.

If a line AC be the difference of two lines AB, BC, the square of AC shall be equal to the excess of the squares of AB and BC above twice the rectangle contained by AB and BC; that is, Fig. 98.

$$AC^2 \text{ or } (AB - BC)^2 = AB^2 + BC^2 - 2\,AB \times BC.$$

Construct the square ABIF, take $AE = AC$, draw CG parallel to BI, HK parallel to AB, and complete the square FEKL.

The two rectangles CGIB, GLKD are each equal to $AB \times BC$. If these be taken from the figure ABILKEA, which is equal to $AB^2 + BC^2$, there will evidently remain the square ACDE, that is, the square of $AB - BC$.

PROP. X. THEOR.

The rectangle contained by the sum and the difference of two lines, is equal to the difference of the squares of these lines; that is, Fig. 99.

$$(AB + BC) \times (AB - BC) = AB^2 - BC^2.$$

Construct upon AB and AC the squares ABIF, ACDE, produce AB so that $BK = BC$, and complete the rectangle AKLE.

The base AK of the rectangle is the sum of the two lines AB, BC; the altitude AE is the difference of the same lines; therefore the rectangle $AKLE = (AB + BC) \times (AB - BC)$. But the same rectangle is made up of two parts $ABHE + BHLK$; and the part BHLK is equal to the rectangle EDGF; for $BH = DE$, and $BK = EF$; therefore $AKLE = ABHE + EDGF$. But these two parts form the excess of the square ABIF above the square DHIG, which is the square of BC; therefore $(AB + BC) \times (AB - BC) = AB^2 - BC^2$.

PROP. XI. THEOR.

In any right angled triangle, the square which is described on the side opposite to the right angle is equal

Proportion of Figures.

to the sum of the squares on the two sides containing the right angle.

Fig. 100. Let ABC be a right angled triangle, of which A is the right angle. Having formed squares on the three sides, draw AD perpendicular to the hypothenuse, producing it to E; draw also the lines AF, CH.

The angle ABF is made up of the angle ABC and a right angle CBF; the angle HBC is made up of the same angle ABC and a right angle ABH; therefore the angle ABF = HBC: but AB = BH, because they are sides of the square, and BF = BC for a like reason; therefore the triangles ABF, HBC are equal (6. 1.) Now the triangle ABF is half of the rectangle BDEF, or BE, because they have the same base BF and the same altitude (2.); and the triangle HBC is in like manner half of the square BL, for they have the same base BH, and the same altitude; for, because the angles BAC, BAL are right angles, the lines CA, AL form a continued straight line (3. 1.), which is parallel to BH; therefore the rectangle BE is equivalent to the square BL. In like manner, by joining AG and BI, it may be demonstrated that the rectangle CE is equivalent to the square CK; therefore the two rectangles BE, CE are together equal to the two squares BL, CK: but these rectangles make up the whole square on BC, the side opposite to the right angle, and BL, CK are the squares on BA, and AC, the sides containing the right angle; therefore the square on the side subtending the right angle is equal to the sum of the squares on the sides containing the right angle.

Prop. XII. Theor.

Fig. 101. In any triangle ABC, the square of AB, the side opposite to any one of its acute angles, is less than the sum of the squares of the sides AC, CB, which contain that angle; and if a perpendicular AD be drawn to either of these BC from the opposite angle, the difference shall be equal to twice the rectangle BC × CD, so that

$$AB^2 = AC^2 + CB^2 - 2\,BC \times CD.$$

There are two cases, according as the perpendicular falls within or without the triangle. In case first, BD = BC − CD; and in case second, BD = DC − BC. In either case, $BD^2 = BC^2 + CD^2 - 2\,BC \times CD$ (9.) To each of these equals add DA^2, and we have

$$BD^2 + DA^2 = BC^2 + CD^2 + DA^2 - 2\,BC \times CD;$$

but $BD^2 + DA^2 = BA^2$ (11.), and $CD^2 + DA^2 = CA^2$; therefore $BA^2 = BC^2 + CA^2 - 2\,BC \times CD$.

Prop. XIII. Theor.

Fig. 102. In any obtuse angled triangle ABC, the square of AB, the side opposite to the obtuse angle, is greater than the squares of AC, BC, the sides containing the obtuse angle; and if a perpendicular AD be drawn on either of these sides, the excess will be equal to 2 BC × CD; so that we have

$$AB^2 = AC^2 + CB^2 + 2\,BC \times CD.$$

For BD = BC + CD; therefore $BD^2 = BC^2 + CD^2 + 2\,BC \times CD$ (8.); to each of these equals add DA^2, and we have

$$BD^2 + DA^2 = BC^2 + CD^2 + DA^2 + 2\,BC \times CD.$$

But $BD^2 + DA^2 = BA^2$; and $CD^2 + DA^2 = CA^2$; therefore $BA^2 = BC^2 + CA^2 + 2\,BC \times CD$.

Prop. XIV. Theor.

Fig. 1 In any triangle ABC, if a straight line AE be drawn from its vertex to the middle of the base, the sum of the squares of the sides is equal to twice the square of that line, and twice the square of half the base.

Draw AD perpendicular to the base. Then

$$AB^2 = AE^2 + EB^2 + 2\,BE \times ED \quad (13.)$$

$$AC^2 = AE^2 + EC^2 - 2\,CE \times DE \quad (12.)$$

Hence, by adding, and observing that BE = CE, and therefore $BE^2 = CE^2$, and BE × ED = CE × ED, we get $AB^2 + AC^2 = 2\,AE^2 + 2\,BE^2$.

Prop. XV. Theor.

Fig. A straight line DE drawn parallel to the base of a triangle ABC, divides the sides AB, AC proportionally; or so that AD : DB :: AE : EC.

Join BE and DC; the two triangles BDE, CDE have the same base DE; they have also the same altitude, because BC is parallel to DE; therefore they are equivalent, (2.) Again, because the triangles ADE, BDE have manifestly the same altitude, they are to one another as their bases, that is ADE : BDE :: AD : BD. Also because the triangles ADE, CDE have the same altitude, they are to each other as their bases, that is ADE : CDE :: AE : CE; but we have seen that the triangle BDE = triangle CDE; therefore, because of the common ratio in the two proportions, it follows that AD : BD :: AE : CE.

Prop. XVI. Theor.

Fig. Conversely, if the sides AB, AC be cut proportionally by the line DE, so that AD : DB :: AE : EC, the line DE shall be parallel to the base BC.

For if DE be not parallel to BC, some other line DO will be parallel to BC: then, by the preceding theorem, AD : DB :: AO : OC, but by hypothesis, AD : DB :: AE : EC; therefore, AO : OC :: AE : EC; and by composition, AC : OC :: AC : EC; hence OC must be equal to EC, which is impossible, unless the point O fall at E; therefore no line besides DE can be parallel to BC.

Prop. XVII. Theor.

Fig. If a straight line BD be drawn from the vertex of a triangle, so as to make equal angles with its sides BA, BC, the distances of the point D, in which it cuts the base from A and C, the extremities of the base, shall have to each other the same ratio as the adjacent sides BA, BC of the triangle: that is AD : DC :: AB : BC.

From C, one extremity of the base, draw CE parallel to BD, meeting AB in E. The angle ABD = BEC and the angle CBD = BCE (2 and 3 Cor. 21. 1.), but by hypothesis the angle ABD = CBD, therefore the angle BEC = BCE; hence the side BC = side BE, (13.) Again, because ABD is a triangle, and CE is drawn parallel to one of its sides, AD : DC :: AB : BE; but it has been shewn that BE = BC; therefore AD : DC :: AB : BC.

Scholium. There may be two cases, in one the line

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BD meets the base between its extremities; and in the other, it meets the base produced.

Prop. XVIII. Theor.

Two equiangular triangles have their homologous sides proportionals, and the triangles are similar.

Fig. 106. Let ABC, DCE be two triangles which have their angles equal, each to each, viz. BAC=CDE, ABC=DCE, and ACB=DEC; the homologous sides, or the sides adjacent to the equal angles, shall be proportionals: that is, BC : CE : : AB : DC : : AC : DE.

Place the homologous sides BC, CE in the same direction, and because the angles B and E are together less than two right angles, the lines BA, ED shall meet if produced, (Schol. 21. 1.); let them meet in F. Then since BCE is a straight line, and the angle BCA=E; AC is parallel to FE (2 Cor. 20. 1.) In like manner, because the angle DCE = B; CD is parallel to FB; therefore ACDF is a parallelogram.

In the triangle BFE, the line AC is parallel to FE, wherefore BC : CE : : BA : AF (15.); or since AF = CD, BC : CE : : BA : CD. Again, in the same triangle BFE, CD is parallel to BF, therefore BC : CE : : FD : DE; that is, because FD = AC, BC : CE : : AC : DE. Since then it appears that the ratio of BC to CE is equal to the ratio of BA to CD, and also to the ratio of AC to DE, it follows that BA : CD : : AC : DE; therefore the homologous sides are proportionals; and because the triangles are equiangular, they are similar, (Def. 2.)

Scholium. It may be remarked that the homologous sides are opposite to the equal angles.

Prop. XIX. Theor.

Two triangles which have their homologous sides proportionals, are equiangular and similar.

Fig. 107. Suppose that BC : EF : : AB : DE : : AC : DF; the triangles ABC, DEF have their angles equal, viz. A=D, B=E, C=F.

At the point E, make the angle FEG = B, and at F, make the angle EFG = C, then G shall be equal to A (1 Cor. 24. 1.), and the triangles GEF, ABC shall be equiangular; therefore, by the preceding theorem, BC : EF : : AB : EG; but by hypothesis, BC : EF : : AB : DE; therefore EG = DE. In like manner we have BC : EF : : AC : FG; but by hypothesis, BC : EF : : AC : DF; therefore FG = DF. Thus it appears that the triangles DEF, GEF have their three sides equal, each to each; therefore they are equal (11.1.) But, by construction, the triangle GEF is equiangular to the triangle ABC; therefore also the triangles DEF, ABC, are equiangular and similar.

Prop. XX. Theor.

Two triangles which have an angle of the one equal to an angle of the other, and the sides about them proportionals, are similar.

Fig. 108. Let the angle A = D, and suppose that AB : DE : : AC : DF; the triangle ABC is similar to DEF.

Take AG = DE, and draw GH parallel to BC; the angle AGH shall be equal to ABC (3 Cor. 21.1.) and the triangle AGH equiangular to the triangle ABC; therefore AB : AG : : AC : AH; but by hypothesis, AB : DE : : AC : DF, and by construction, AG = DE, therefore AH = DF. The two triangles AGH, DEF have therefore an angle of the one equal to an angle of the other, and the sides containing these angles equal; therefore they are equal (6. 1.); but the triangle AGH is similar to ABC; therefore DEF is also similar to ABC.

Prop. XXI. Theor.

In a right angled triangle, if from the right angle A a perpendicular AD be drawn to the hypothenuse. Fig. 109.

1. The two triangles ABD, ADC are similar to the whole triangle ABC, and to each other.

2. Each side AB or AC is a mean proportional between the hypothenuse BC, and the adjacent segment BD or DC.

3. The perpendicular AD is a mean proportional between the two segments BD, DC.

First, The triangles BAD and BAC have the common angle B; and, besides, the right angle BDA is equal to the right angle BAC; therefore the third angle BAD of the one, is equal to the third angle C of the other (1 Cor. 24. 1.); therefore the two triangles are equiangular and similar. In like manner it may be demonstrated, that the triangle DAC is equiangular, and similar to the triangle BAC; therefore the three triangles are equiangular, and similar to one another.

Secondly, Since the triangle BAD is similar to BCA, their homologous sides are proportionals, that is, CB : BA : : BA : BD (18.) In like manner, because of the similar triangles CAD, CBA, we have BC : CA : : CA : CD; therefore each side is a mean proportional between the hypothenuse and its segment adjacent to that side.

Thirdly, Because of the similar triangles BDA, ADC, we have BD : DA : : DA : DC; so that the perpendicular is a mean proportional between the segments of the hypothenuse.

Prop. XXII. Theor.

If four straight lines be proportionals, the rectangle contained by the extremes is equal to the rectangle contained by the means; and conversely, if the rectangle contained by the extremes be equal to the rectangle contained by the means, the four straight lines are proportionals.

Let HA, HB, HC, HD be four straight lines, proportionals; the rectangle HA × HD = rectangle HB × HC. Fig. 110.

Let HA, HB be placed in a straight line, and HC, HD also in a straight line perpendicular to AB, and construct the rectangles P=HA × HD, Q=HC × HB, and R=HD × HB; then HA : HB : : P : R, and HC : HD : : Q : R, (3.) but by hypothesis, HA : HB : : HC : HD; therefore P : R : : Q : R, and hence P=Q, that is HA × HD=HB × HC.

Again, if P=Q, that is, if HA × HD=HB × HC, then HA : HB : : HC : HD; for the same construction being made, we have P : R : : Q : R; but P : R : : HA : HB; and Q : R : : HC : HD; therefore HA : HB : : HC : HD.

Cor. If three straight lines be proportionals, the rectangle contained by the extremes is equal to the square

Proportion of Figures.

of the mean; and if the rectangle contained by the extremes be equal to the square of the mean, the three straight lines are proportionals.

PROP. XXIII. THEOR.

Fig. 111.

If four straight lines be proportionals, and also other four, the rectangles contained by the corresponding terms shall be proportionals; that is, if A : B : : C : D, and E : F : : G : H; then supposing rectangles constructed, having these lines for their sides, as in the figure,

$A \times E : B \times F : : C \times G : D \times H.$

On the line B construct another rectangle which shall have E for its altitude; and on the line D construct a second rectangle that shall have G for its altitude. Then, by Prop. 3,

$A : B : : A \times E : B \times E$, and $C : D : : C \times G : D \times G$;

but A : B : : C : D, by hypothesis,

therefore $A \times E : B \times E : : C \times G : D \times G$;

Now, $B \times E : B \times F : : E : F$, and $D \times G : D \times H : : G : H$, and by hypothesis E : F : : G : H;

therefore $B \times E : B \times F : : D \times G : D \times H$;

but it was shewn that

$A \times E : B \times E : : C \times G : D \times G$

therefore, *ex æquo*, $A \times E : B \times F : : C \times G : D \times H$.

COR. Hence the squares of four proportional straight lines are also proportionals.

PROP. XXIV. THEOR.

Fig. 112.

Two triangles which have an angle of the one equal to an angle of the other, are to each other as the rectangle of the sides about the equal angles: That is, the triangle ABC is to the triangle ADE as $AB \times AC$ to $AD \times AE$.

Draw BE; the triangles ABE, ADE have a common vertex E, therefore ABE : ADE : : AB : AD (Cor. 6.); but $AB : AD : : AB \times AE : AD \times AE$ (3.) therefore,

trian. ABE : *trian.* ADE : : $AB \times AE : AD \times AE$.

In like manner it may be demonstrated, that

trian. ABC : *trian.* ABE : : $AB \times AC : AB \times AE$;

therefore (8. 3.)

trian. ABC : *trian.* ADE : : $AB \times AC : AD \times AE$.

COR. 1. Therefore the two triangles are equivalent, if $AB \times AC = AD \times AE$; or if AB : AD : : AE : AC (22.)

COR. 2. Two parallelograms which have an angle of the one equal to an angle of the other, will be to each other as the rectangles contained by the sides about these angles: For the parallelograms are the doubles of triangles which have an angle and two sides common with those of the parallelogram.

PROP. XXV. THEOR.

Similar triangles are to each other as the squares of their homologous sides.

Fig. 108.

Let the angle A=D, and the angle B=E, then,

AB : DE : : AC : DF (18.)

and AB : DE : : AB : DE,

for the terms of the two last ratios are identical, therefore,

$AB^2 : DE^2 : : AC \times AB : DF \times DE$ (23.)

But *trian.* BAC : *trian.* EDF : : $AC \times AB : DF \times DE$ (24.)

Therefore *trian.* ABC : *trian.* EDF : : $AB^2 : DE^2$.

PROP. XXVI. THEOR.

Similar polygons are composed of the same number of triangles, which are similar, each to each, and similarly situated.

In the polygon ABCDE, draw from an angle A the diagonals AC, AD, and in the other polygon FGHIK, draw in like manner from the angle F, which is homologous to A, the diagonals FH, FI. And since the polygons are similar, the angle B is equal to its homologous angle G, (Def. 2.) and besides, AB : BC : : FG : GH; therefore the triangles ABC, FGH are similar, (20.), and the angle BCA = GHF; these equal angles being taken from the equal angle BCD, GHI, the remainders ACD, FHI are equal; but since the triangles ABC, FGH are similar, we have AC : FH : : BC : GH, and because of the similitude of the polygons we have BC : GH : : CD : HI; therefore AC : FH : : CD : HI. Now it has been shewn that the angle ACD = FHI; therefore the triangles ACD, FHI are similar (20.) In like manner, it may be demonstrated, that the remaining triangles of the two polygons are similar; therefore the polygons are composed of the same number of similar triangles similarly situated. Fig. 113.

PROP. XXVII. THEOR.

The circumferences or perimeters of similar polygons are to one another as their homologous sides; and their areas are as the squares of their homologous sides.

1. For by the nature of similar figures, AB : FG : : BC : GH : : CD : HI, &c. Therefore, AB is to FG as AB + BC + CD, &c. the perimeter of the first figure to FG + GH + HI, &c. the perimeter of the second figure (12. 3.) Fig. 113.

2. And because the triangles ABC, FGH are similar, ABC : FGH : : $AC^2 : FH^2$ (25.), and in like manner, because the triangles ACD, FHI are similar, ACD : FHI : : $AC^2 : FH^2$; therefore, ABC : FGH : : ACD : FHI. In the same way it may be shewn that ACD : FHI : : ADE : FIK, and so on, if the polygons consist of more triangles. Hence, by Prop. 12. 3. the triangle ABC is to the triangle FGH as the sum of the triangles ABC, ACD, ADE, or the polygon ABCDE, to the sum of the triangles FGH, FHI, FIK, or the polygon FGHIK: But the triangle ABC is to the triangle FGH as AB^2 to FG^2 (25.); therefore the similar polygons are as the squares of their homologous sides.

COR. 1. If three similar figures have their homologous sides equal to the three sides of a right angled triangle; the figure made on the side opposite to the right angle shall be equal to the other two. For the figures are proportional to the squares on their homologous sides; and since the square on the side opposite to the right angle is equal to the squares on the other two sides, the figure on the former shall be equal to those on the latter.

COR. 2. Similar polygons have to each other the duplicate ratio of their homologous sides. For let L be a third proportional to the homologous sides AB, FG, then (Def. 11. 3.) AB has to L the duplicate ratio of AB to FG; but AB : L : : $AB^2 : AB \times L$ (3.); or, since $AB \times L = FG^2$ (Cor. 22.), AB : L : : $AB^2 : FG^2$: : ABCDE : FGHIK; therefore the figure

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ABCDE has to FGHIK the duplicate ratio of AB to FG.

Prop. XXVIII. Theor.

Fig. 114. The segments of two chords AB, CD, which cut each other within a circle, are reciprocally proportionals, that is, AO : DO : : CO : OB.

Join AC and BD: In the triangles AOC, BOD, the vertical angles at O are equal; also the angle A = D, and C = B (17. 2.); therefore the triangles are similar, and the homologous sides proportionals, that is, AO : OD : : CO : OB.

Cor. Hence the rectangle AO × OB is equal to the rectangle CO × OD (22.) That is, the rectangle contained by the segments of the one chord is equal to the rectangle contained by the segments of the other.

Prop. XXIX. Theor.

Fig. 115. If two chords BA, CD in a circle be produced to intersect each other without it; the distances of the extremities of the chords from their mutual intersection are reciprocally proportionals, that is, AO : DO : : CO : BO.

For, joining BD and AC, the triangles OAC, OBD have the angle O common, and besides, the angle B=C (17. 2.), therefore the triangles are similar, and the homologous sides proportional; that is, AO : OD : : CO : OB.

Cor. Hence the rectangle AO × OB is equal to the rectangle CO × OD (22.)

Prop. XXX. Theor.

Fig. 116. If from any point O in the prolongation of a chord CD, a tangent OA be drawn to the circumference, the tangent is a mean proportional between the distances of the intersection from the extremities of the chord. That is, CO : OA : : OA : OD.

For if DA and AC be joined, the triangles OAD and OAC have the angle at O common, besides the angle OAD=C (20. 2.); therefore the two triangles are similar, and hence CO : OA : : OA : OD.

Cor. Hence we have AO^2=CO × OD, (Cor. 22.)

Scholium. The three preceding propositions have a great affinity. In fact, they constitute an individual property of the circle; for when two of the intersections unite, the chord becomes a tangent.

Prop. XXXI. Theor.

Fig. 117. In the same circle, or in equal circles, any angles ACB, DEF at the centres are to each other as the arcs AB, DF of the circles, intercepted between the lines which contain the angles.

Let us suppose that the arc AB contains three such equal parts as DF contains five. Let A*p*, *p q*, *q* B be the equal parts in AB, and D *r*, *r s*, &c. the equal parts in DF; draw the lines C*p*, C*q*, E*r*, E*s*, &c.; the angles AC*p*, *p*C*q*, *q*CB, DE*r*, &c. are all equal (15.2.) therefore as the arc AB contains ⅕th of the arc DF three times, the angle ACB will evidently contain ⅕th of the angle DEF also three times; and, in general, whatever number of times the arc AB contains some part of the arc DF, the same number of times will the angle ACB contain a like part of the angle DEF.

Problems to Sect. IV.

PROBLEMS RELATIVE TO SECT. IV.

Problem I.

To divide a given straight line into any number of equal parts, or into parts proportional to given lines.

1. Let it be proposed to divide the line AB into five equal parts. Through the extremity A draw an indefinite straight line AG; and in this line, take five equal distances AC, CD, DE, EF, and FG, of any length. Join BG, and draw CI parallel to GB, then AI will be the fifth part of AB, and the distance AI being set off five times from A, the line AB will be divided into five equal parts at the points I, K, L, M, as required. For the sides AG, AB are cut proportionally in C and I, (15. 4.); and as AC is one-fifth of AG, AI will also be one-fifth of AB. Fig. 118.

Next let it be proposed to divide the line AB into parts proportional to the lines P, Q, R, (Fig. 119.) From the extremity A, draw the indefinite straight line AE, and take AC=P, CD=Q, DE=R. Join the extremities E and B, and draw CI, DK, parallel to EB; then the line AB shall be divided into parts AI, IK, KB proportional to the given lines P, Q, R. Fig. 119.

For because of the parallels AC:CD:: AI:IK(15.4.), and by composition, AD : DC : : AK : KI; again, DE : AD : : KB : KA; therefore, *ex æquo*, DE : DC : : KB:KI, and so on; since then it appears that AC:AI:: CD : IK : : DE : KB, the parts of the line AB have to each other the ratios of the lines AC, CD, DE, that is of P, Q, and R.

Prob. II.

To find a fourth proportional to three given lines A, B, C. Fig. 120.

Draw the two indefinite lines DE, DF, making any angle. On DE take DA = A, and DB = B; and on DF take DC = C; join AC, and through B draw BX parallel to AC; then shall DX be the fourth proportional required. For since BX is parallel to AC, DA : DB : : DC : DX (15. 4.); therefore DX is the fourth proportional required.

Cor. By this problem, a third proportional to two given lines may be found; for it will be the same as a fourth proportional to A, B and B.

Prob. III.

To find a mean proportional between two given lines A and B. Fig. 121.

On the indefinite line DF take DE=A, and EF=B; on DF as a diameter describe a semicircle DGF; at the point E draw EG perpendicular to the diameter, meeting the circumference in G; then shall EG be the mean proportional required. Join GD and GF; the triangle DGF is right angled at G, for G is an angle in a semicircle (19. 2.); therefore the perpendicular GE

Problems to Sect. IV.

on the hypothenuse is a proportional between DE and EF, (21.) that is between A and B.

PROB. IV.

Fig. 122. To divide a straight line AB into two parts, so that one of them shall be a mean proportional between the whole line and the other part.

At B, one extremity of the line, erect a perpendicular BC equal to half AB; on C as a centre, with CB as a radius, describe a circle; draw AC to meet the circumference in D, and take AF = AD; then the line AB shall be divided at the point F in the manner required, that is, AB : AF :: AF : FB.

For AB being perpendicular to the extremity of the radius BC, is a tangent to the circle (9. 2.); therefore if AC be produced until it meet the circumference again in E, we shall have AE : AB :: AB : AD; hence, by division, AE—AB : AB :: AB—AD : AD; but since BC $=\frac{1}{2}$ AB, therefore DE = AB, and consequently AE — AB = AD = AF; also, because AF = AD, we have AB — AD = FB; therefore AF : AB :: FB : AD, or AF, and by inversion, AB : AF :: AF : FB.

SCHOLIUM. A line divided in this manner is said to be cut in *extreme and mean ratio*; and it may be remarked, that AE is also divided into extreme and mean ratio at the point D, for since AB = DE, we have AE : DE :: DE : AD.

PROB. V.

Fig. 123. Through a given point A in a given angle BCD, to draw a straight line BD, so that the parts AB, AD contained between the point A and the two sides of the angle shall be equal.

Through the point A, draw AE parallel to CD; take EB = EC, and draw AB to meet CD in D, and the thing is done. For AE being parallel to CD, we have BE : EC :: BA : AD; but BE = EC, therefore BA = AD.

PROB. VI.

To make a square equivalent to a given parallelogram, or to a given triangle.

Fig. 124. 1. Let ABCD be the given parallelogram, AB its base, and DE its altitude. Between AB and DE find a mean proportional XY (Prob. 3.); the square made on XY shall be equivalent to the parallelogram ABCD. For since by construction, AB : XY :: XY : DE; therefore, (Cor. 22.) XY^2 = AB × DE = the parallelogram ABCD, (Cor. 1.)

Fig. 125. 2. Let ABC be the given triangle, BC its base, and AD its altitude. Take a mean proportional between BC and the half of AD; and let XY be that mean. The square made on XY shall be equivalent to the triangle ABC.

For since BC : XY :: XY : $\frac{1}{2}$ AD; therefore XY^2 = BC × $\frac{1}{2}$ AD = triangle ABC.

PROB. VII.

Fig. 126. Upon a given straight line AD, to make a rectangle DAEX equivalent to a given rectangle ABFC.

Find AX a fourth proportional to the three lines AD, AB, AC, (Prob. 2.); the rectangle contained by AD and AX will be that required.

For since AD : AB :: AC : AX, it follows that AD × AX = AB × AC (22.); therefore the rectangle ADEX is equivalent to the rectangle ABFC.

PROB. VIII.

Having given any rectilineal figure to make another equivalent to it, that shall have one side fewer.

Let ABCDE be the given figure. Draw a diagonal CE so as to cut off from it a triangle CDE; through D, the vertex of the triangle, draw DF parallel to its base CE, to meet AE, one of the adjacent sides of the figure (produced if necessary) in F; join CF, and the figure ABCF shall be equal to the figure ABCDE, and have one side fewer. For the triangle CFE is equivalent to CDE (6.), therefore, adding the common space ABCE, the figure ABCF is equal to the figure ABCDE. Fig. 127.

SCHOLIUM. By this problem, a triangle may be found that shall be equivalent to a rectilineal figure of any number of sides. Thus, the five-sided figure ABCDE having been reduced to the quadrilateral ABCF, if we join CA, and draw BG parallel to CA, to meet FA produced in G, and then join CG, the quadrilateral will be transformed into an equivalent triangle CGF, which will also be equal to the original figure ABCDE.

It has been already shewn that a square may be found equivalent to any triangle; therefore by this, and Prob. 6. any rectilineal figure whatever may be transformed into an equivalent square.

PROB. IX.

To make a square that shall be equal to the sum, or to the difference of two given squares.

Let A and B be the sides of the two given squares. Fig. 128.

1. To make a square equal to the sum of two squares, draw two indefinite lines ED, EF, containing a right angle; take DE=A and EG=B; join DG, and DG is evidently the side of the square required, (11.)

2. If a square is to be found equal to the difference of two squares; form a right angle FEH; take EG equal to the lesser of the two sides A, B, and on G as a centre, with a radius equal to the greater, describe an arc, to meet EH in H; then EH shall be the side of a square equal to the difference of the squares on GH and GE, or on A and B, as is evident from Prop. 11. Sect. 4.

SCHOLIUM. By this problem, a square may be made equal to any number of given squares.

PROB. X.

On a given straight line FG, homologous to AB, to describe a polygon similar to a given polygon ABCDE. Fig. 113

Draw the diagonals AC, AD: at the point F make the angle GFH equal to the angle BAC, and at G make the angle FGH equal to ABC; the lines FH, GH will meet in H, and form a triangle FGH similar to ABC. In like manner, on FH, which is homologous to AC, construct a triangle FHI, similar to ACD; and on FI, homologous to AD, construct a triangle FIK similar to ADE. The polygon FGHIK shall be similar to ABCDE. For hese two polygons are composed ular rons. of the same number of triangles, similar and similarly situated, (26.)

SECT. V.

Of Regular Polygons, and the Measure of the Circle.

ir po- , and ·asure circle. Definition. A polygon, which is at the same time equilateral and equiangular, is called a *regular polygon.*

Prop. I. Problem.

To inscribe a square in a given circle.

29. Draw two diameters AC, BD, at right angles to each other; join their extremities A, B, C, D; and the figure ABCD shall be the inscribed square. For the angles ABC, BCD, &c. are right angles, (19. 2.), and the chords AB, BC, &c. are equal.

Prop. II. Prob.

To inscribe a regular hexagon and an equilateral triangle in a given circle.

30. From any point B in the circumference, apply BA and BC each equal to the radius BO; draw the diameters AD, BE, CF, and join their adjoining extremities, and the figure ABCDEF, thus formed, will be the hexagon required.

For the triangles AOB, COB being equilateral, each of the angles AOB, BOC will be one third of two right angles (4. Cor. 24. 1.); therefore COD will also be one-third of two right angles (2. 1.); therefore the angles AOF, FOE, EOD, vertical to these, will be each one-third of two right angles, and the six angles at O will be equal; and hence the straight lines AB, BC, CD, DE, EF, FA will be all equal (15. 2.), and the hexagon will be equilateral. It will also be equiangular; for the angles FAB, ABC, &c. stand each on two-thirds of the whole circumference; therefore they are all equal (17. 2.) If straight lines be drawn joining A, C, E, the vertices of the alternate angles of the hexagon, there will be formed an equilateral triangle inscribed in the circle, as is sufficiently evident.

Scholium. In the same way as we have proved that every equilateral hexagon is equiangular, it may be proved that any equilateral polygon whatever in a circle is also equiangular.

Prop. III. Prob.

To describe a regular decagon in a circle, also a regular pentagon.

1. Divide the radius AO in extreme and mean ratio at the point M; take the chord AB equal to the greater segment OM, and AB shall be a side of the regular decagon, or figure of ten sides, which may be completely formed by placing straight lines, each equal to AB, round the circumference.

Join BM; and because, by construction, AO : OM : : OM : AM, and AB=OM, therefore AO : AB : : AB : AM; hence the triangles AOB, ABM, which have an angle OAB common to both, have the sides about that angle proportionals; therefore they are similar (20. 4.) And because the triangle AOB is isosceles, the triangle ABM is also isosceles, and AB=BM; but AB=MO, by construction; therefore BM=MO, and the triangle BMO is isosceles. Therefore the angle AMB, which is equal to the sum MOB + MBO (24. 1.), will be double MOB. But the angle AMB = MAB; therefore each of the angles OAB, OBA is double AOB; and the three angles of the triangle AOB will be five times the angle O. Thus the angle O will be one-fifth of two right angles (24. 1.), or one-tenth of four right angles, therefore the arc AB is one-tenth of the circumference; and the chord AB is the side of a regular decagon inscribed in a circle. Regular Polygons.

If every second angle of the decagon be joined by straight lines, there will be formed a regular pentagon ACEGI inscribed in the circle.

Cor. By this and the foregoing problems a regular quindecagon, or polygon of fifteen sides, may be inscribed in a circle. For let AL be the side of a hexagon; then the arc ABL will be $\frac{1}{6}$, or $\frac{5}{30}$ of the whole circumference, and the arc AB $\frac{1}{10}$, or $\frac{3}{30}$ of the circumference, therefore the difference of the two arcs will be $\frac{2}{30}$, or $\frac{1}{15}$ of the circumference, and LB the chord of the arc will be the side of a quindecagon.

Scholium. By bisecting the arc subtended by a side of any polygon, another of double the number of sides may be inscribed in a circle. Hence from a square, we may inscribe polygons of 8, 16, 32, &c. sides; and from a hexagon others of 12, 24, &c.

The square, the regular pentagon and hexagon, and such figures as can be formed from them in the manner we have described, were the only regular figures that th ancients could inscribe in a circle. A mathematician o our own times, Mr Gauss, has however shewn, that a regular polygon of 17 sides may be inscribed in a circle by drawing straight lines and circles only; and tha the same is true of all polygons of which the number of sides is a prime number of the form 2^n+1. This formula includes figures of 3, 5, 17, 257, 65537, &c. sides; but the demonstration, even in the case of 17 sides, has not yet been given on principles purely geometrical. See *Disquisitiones Arithmeticæ*, published at Brunswick, 1801; or a French translation, 1807.

Prop. IV. Prob.

Having given any regular polygon ABCD, &c. inscribed in a circle, to describe a regular polygon of the same number of sides about the circle.

At H, the middle of the arc AB, draw the tangent *a* H *b*; do the same at the middle of each of the other arcs BC, CD, &c. these tangents shall form by their intersections a regular circumscribed polygon *a b c d*, &c. similar to the inscribed polygon. Fig. 132.

Draw the radii OH, OI, and because OH is perpendicular to the tangent *a b*, (9. 2.) and also to the chord AB (schol. 6. 2.), the tangent is parallel to the chord (19. 1.) In like manner it may be shewn that all the other sides of the circumscribing figure are parallel to the sides of the inscribed figure. Draw a line from O to *b*; and because the right angled triangles O *b* H, O *b* I are equal (18.1), for they have a common hypothenuse O *b*, and the side OH=OI, therefore the angle HO *b*= IO*b*, and the line O *b* passes through the middle of the arc HI, that is, a line drawn from the centre to the intersection of any two sides of the circumscribing polygon passes through the intersection of the sides parallel to them of the inscribed polygon: And because the angles *cb*O and *a b* O are respectively equal to CBO and ABO (3 Cor. 21. 1.), the whole angle *c b a* = CBA; in like manner it may be proved, that *b a f* = BAF, &c. therefore the angles of the circumscribing polygon are equal to those of the inscribed polygon. Again, be-

Regular Polygons. cause of the similar triangles OBA, O b a, and OBC, O b c, we have AB : $a\,b$: : (BO : $b\,o$: :) BC : $b\,c$ (18. 4.) but AB = BC, therefore $a\,b = b\,c$: For a like reason $b\,c = c\,d$, &c. therefore the circumscribing polygon is regular and similar to the inscribed polygon.

Prop. V. Theor.

Regular polygons of the same number of sides inscribed in circles are similar, and are to one another as the squares of the radii of the circles.

Fig. 133. Let ABCDEF and $a\,b\,c\,d\,e\,f$ be equilateral hexagons inscribed in circles; these will also be equiangular, (schol. 2.) and consequently regular; and because all the angles of each polygon are together equal to eight right angles (25. 1.), the angle A is $\frac{1}{6}$ of eight right angles; and as the same is also true of a, therefore the angles A and a are equal. In like manner it appears that B = b, C = c, &c. and because the sides of each figure are all equal, we have FA : AB : : $f\,a$: $a\,b$, &c. therefore the polygons are similar (2 def. 4.)

Draw BO, CO, $b\,o$, $c\,o$, to the centres: The triangles BOC, $b\,o\,c$ are similar, for the angles at O and o are equal, each being $\frac{1}{6}$ of four right angles, and CO : OB : : $c\,o$: $o\,b$; therefore COB : $c\,o\,b$: : CO^2 : $c\,o^2$; but the triangles COB, $c\,o\,b$ are manifestly like parts of the whole polygons, therefore (1. 3.) the polygons are to each other as the squares of CO, $c\,o$, the radii of the circles.

Prop. VI. Theor.

A circle being given, two similar polygons may be found, the one described about the circle; and the other inscribed in it, which shall differ from one another by less than any given space.

Fig. 134. Let Q be the side of a square, equal to the given space; bisect AC, a fourth part of the circumference of the circle, and again bisect the half of this fourth, and proceed in this manner, always bisecting one of the arcs found by the former bisection, until an arc is found of which the chord AB is less than Q: As this arc will be an exact part of the circumference, if we place chords AB, BC, CD, &c. in it each equal to AB, the last will terminate at A, and there will be formed a regular polygon ABCDE &c. in the circle:

Next describe about the circle a regular polygon $a\,b\,c\,d\,e$, &c. of the same number of sides as the inscribed polygon, and having its sides parallel to those of the latter (4.) The difference of these two shall be less than the square of the line Q.

For, draw lines from a and b to O the centre, these will pass through A and B, as was shewn in the demonstration of Prop. 4. also a line drawn from O to K, the point in which $a\,b$ touches the circle, will bisect AB in I, and be perpendicular to it (6. 2.): complete the diameter AOE, and join EB. Put P for the circumscribing polygon, and p for the inscribed polygon; then, because the triangles $a\,o\,b$, AOB are manifestly like parts of P and p, we have P : p : : $a\,o\,b$: AOB; (1. 3.) but these triangles being similar, $a\,o\,b$: AOB : : $o\,a^2$: OA^2, or OK^2, (25. 4.); and again, because the triangles O aK, EAB are manifestly similar, we have O a^2 : OK^2 : : EA^2 : EB^2 (18. and 23. 4.); therefore P : p : : EA^2 : EB^2, and by conversion, P : P — p : : EA^2 : $EA^2 - EB^2$ or AB^2. Now, as a square described about a circle will manifestly include within it a polygon of 8, also of 16, and of 32 sides, &c. the polygon P will be less than the square of EA; therefore P — p, the difference of the circumscribing and inscribed polygons, will be less than the square of AB, that is, by construction, less than the given space Q. (cor. 3. 3.)

Cor. 1. Because the polygons differ from each other more than either differs from the circle, we may infer, that a polygon may be described about a circle, and also a polygon may be inscribed in a circle, either of which shall differ from the circle by less than any given space.

Cor. 2. A space that is less than any polygon whatever, described about a circle, and also greater than any polygon whatever, inscribed in the same circle, must be equal to that circle.

Axiom.

Fig. If HBI be any arc of a circle, and b H, b I tangents at its extremities, the sum of the tangents b H, b I is greater than the arc HBI.

Cor. The circumference of a circle is less than the perimeter of its circumscribing polygon.

Prop. VII. Theor.

The area of any circle is equal to a rectangle contained by half the perimeter, and the radius.

Fig. Let ABCD, &c. be a regular polygon inscribed in the circle, and $a\,b\,c\,d$ &c. a similar polygon, described about it, and having the sides ab, bc, &c. parallel to AB, BC, &c. draw OIK perpendicular to AB, ab; and OAa, OBb, through the points A, a, and B, b. Let P be the perimeter of the polygon $a\,b\,c\,d$ &c. p that of the polygon ABCD &c. and Q that of the circle.

The triangle a O b is equal to $\frac{1}{2}a\,b \times$ OK, (6. 4.) and multiplying these equals by n, the number of sides of the polygon, we have $n \times$ trian. a O $b = n \times \frac{1}{2}a\,b \times$ OK; but $n \times$ trian. a O b is manifestly the area of the polygon $a\,b\,c\,d$ &c. and $n \times \frac{1}{2}a\,b$, or $\frac{1}{2} \times n \times a\,b$ is equal to $\frac{1}{2}$ P; therefore the area of the polygon $a\,b\,c\,d$ &c. is $\frac{1}{2}$P $\times$ OK; and similarly, the area of the polygon ABCD &c. is $\frac{1}{2}\,p \times$ OI.

Because $\frac{1}{2}$Q $< \frac{1}{2}$ P, therefore $\frac{1}{2}$ Q $\times$ KO $< \frac{1}{2}$ P $\times$ KO, but $\frac{1}{2}$ P $\times$ KO is the area of the polygon $a\,b\,c\,d$ &c. therefore $\frac{1}{2}$ Q $\times$ KO is less than the area of the polygon $a\,b\,c\,d$ &c. Again, because $\frac{1}{2}$Q $> \frac{1}{2}p$, therefore $\frac{1}{2}$Q $\times$ OK $> \frac{1}{2}p \times$ OK; but OK $>$ OI, and $\frac{1}{2}p \times$ OK $> \frac{1}{2}\,p \times$ OI: much more then is $\frac{1}{2}$ Q $\times$ OK $> \frac{1}{2}p \times$ OI, but $\frac{1}{2}p \times$ OI is the area of the polygon ABCD, &c. therefore $\frac{1}{2}$ Q $\times$ OK is greater than the area of the polygon ABCD, &c. Thus it appears, that the rectangle contained by $\frac{1}{2}$ Q the perimeter of the circle, and OK its radius, is greater than any polygon inscribed in the circle, and less than any polygon described about the circle; therefore it must be exactly equal to the area of the circle, (Cor. 6.)

Prop. VIII. Theor.

The areas of circles are to each other as the squares of their radii.

F. 133. Let ABCDEF, and $a\,b\,c\,d\,e\,f$ be regular, and similar polygons inscribed in the circles; and as OB^2 : $o\,b^2$, so let the circle ABCDEF be to a fourth proportional Q; then because OB^2 : $o\,b^2$: : pol. ABCDEF : pol. $abcdef$, (5.) it follows, that ular gons.

pol. ABCDEF : pol. $abcdef$ :: cir. ABCDEF : Q.

Now the third term of this proportion is greater than the first, therefore the fourth is greater than the second; that is, Q is greater than any polygon inscribed in the circle $abcdef$.

Because the areas of similar polygons described about a circle are also to each other as the squares of the radii, it may be shewn in the same way, that the space Q is less than any polygon described about the circle $abcdef$; therefore Q must be exactly equal to the circle $abcdef$ (2 Cor. 6.) and the circle ABC &c. is to the circle abc &c. as OB^2 to ob^2.

Cor. 1. The perimeters of circles are to each other as their radii. Let P be half the circumference of the circle ABCDEF, and R its radius; also let p and r be half the circumference and the radius of the other circle; then the areas of the circles are equal to the rectangles $P\times R$ and $p\times r$, (7.); and it has been shewn, that $P\times R : p\times r :: R^2 : r^2$; therefore, by alternation, $P\times R : R^2 :: p\times r : r^2$; but $P\times R : R^2 :: P : R$, and $p\times r : r^2 :: p : r$; therefore $P : R :: p : r$; and by alternation, $P : p :: R : r$.

Cor. 2. A circle described with the hypothenuse of a right angled triangle as a radius, is equal to two circles described with the other two sides as radii, (Fig.

135. 135.) Let the sides of the triangle be a, b, and its hypothenuse h; and let the circles described with these lines as radii be A, B, and H; and because

$$A : H :: a^2 : h^2,$$
$$\text{and } B : H :: b^2 : h^2;$$

Therefore $A+B : H :: a^2+b^2 : h^2$ (10. 3.) but $a^2+b^2=h^2$; therefore $A+B=H$.

Prop. IX. Prob.

Having given the surfaces of a regular polygon inscribed in a circle, and of a similar polygon described about it, to find the surfaces of the inscribed and circumscribed polygons of double the number of sides.

136. Let AB be the side of the inscribed polygon, EF parallel to AB, that of the similar circumscribed polygon, and C the centre of the circle. If the chord AM, and the tangents AP, BQ be drawn, the chord AM shall be the side of an inscribed polygon of double the number of sides, and PQ=2 PM, the side of a similar circumscribed polygon. This being supposed, as the same construction may be made in all the different angles equal to ACM, and as the triangles contained in ACM have to each other the ratios of the whole polygons, it will be sufficient to consider these only.

Let A be the surface of the inscribed polygon, of which AB is a side, B the surface of the similar circumscribed polygon, a the surface of the polygon, of which AM is a side, and b the surface of the circumscribed polygon. A and B are supposed known, and it is required to determine a and b.

1. The triangles ACD, ACM, are to each other as their bases CD, CM, (Cor. 6. 4.) besides they are to each other as the polygons A and a, of which they are like parts; therefore $A : a :: CD : CM$. The triangles CAM, CME, are to each other as their bases CA, CE, and also as the polygons a and B; therefore $a : B :: CA : CE$. But because of the similar triangles CDA, CME, we have $CD : CM :: CA : CE$, (18. 4.) therefore $A : a :: a : B$; so that the polygon a, one of those we seek, is a mean proportional between the two known polygons A and B; and if these are expressed by numbers, a will be found by taking the square root of their product; that is, $a=\sqrt{A\times B}$.*

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2. Because of the common altitude CM, the triangle CPM is to the triangle CPE as PM to PE; but because the angle ECM is bisected by CP, $PM : PE :: CM : CE$ (17. 4.) $:: CD : CA :: A : a$, therefore $CPM : CPE :: A : a$, and by inversion and composition, $CPM+CPE$, or $CME : CPM :: A+a : A$, and taking the doubles of the consequents, $CME : 2\,CPM :: A+a : 2A$; now CME and 2 CPM, or CMPA, are like parts of the polygons B and b, therefore $A+a : 2A :: B : b$; hence b is known, because it is a fourth proportional to the three known quantities $A+a$, 2 A and B, and $b=\dfrac{2A\times B}{A+a}$.

Therefore, by means of the polygons A and B, it is easy to find the polygons a and b, which have double the number of sides.

Prop. X. Prob.

To find nearly the ratio of the diameter of a circle to its circumference.

The most obvious method, although not the best, is to express the diameter by a number, and compute the areas of two polygons of the same number of sides, one inscribed in the circle, and the other described about it. The area of the circle itself will be some quantity between these two. If the number of sides be considerable, either, or any quantity between them, will be nearly equal to the area of the circle. And since the area is equal to the rectangle contained by the radius and half the circumference, if the approximate value of the area be divided by the radius, twice the quotient will be an approximate value of the circumference.

Let us suppose the radius to be unity, then the diameter will be 2, and the side of a square described about the circle, will be expressed by the number 4; and as the inscribed square A, is evidently half the circumscribed square, the area of the inscribed square will be 2. Employing now the formulæ found in last proposition, viz.

$$a=\sqrt{A\times B},\quad b=\frac{2A\times B}{A\times a},$$

and making A=2, and B=4, we find a, the area of a regular polygon of eight sides inscribed in the circle, $=\sqrt{2\times 4}=\sqrt{8}=2.8284271$, and b the circumscribed polygon $=3.3137085$.

Putting now A=2.8284271, and B=3.3137085, we may hence find a and b the inscribed and circumscribed figures of 16 sides, and so on as in this Table.

Number of Sides.	Inscr. Polygon.	Circum. Pol.
4	2.0000000	4.0000000
8	2.8284271	3.3137085
16	3.0614674	3.1825979
32	3.1214451	3.1517249
64	3.1365485	3.1441184
128	3.1403311	3.1422236
256	3.1412772	3.1417504
512	3.1415138	3.1416321
1024	3.1415729	3.1416025
2048	3.1415877	3.1415951
4096	3.1415914	3.1415933
8192	3.1415923	3.1415928
16384	3.1415925	3.1415927
32768	3.1415926	3.1415926

* The radical sign $\sqrt{}$ placed over the symbol that expresses any quantity, indicates that the square root of the expression which it affects is to be taken. See Algebra, Art. 137.

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Hence it appears that the inscribed and circumscribing polygons of 32768 sides agree in the first seven decimal places of the numeral expressions for their value; therefore the numeral expression for the circle itself, which is between these, will be correct in all these figures; so that the radius of a circle being one, its area is 3.1415926 nearly, and this divided by the radius gives 3.14159926 for half the circumference nearly, the radius being one; hence the diameter is to the circumference nearly as 1 to 3.1415926 nearly.

Scholium. By this method, the ratio of the diameter to the circumference may be found to any approximate degree of accuracy. Archimedes, by means of inscribed and circumscribed polygons of 96 sides, shewed that the diameter is to the circumference nearly as 7 to 22; and Metius found, by polygons of a greater number of sides, that the diameter is to the circumference as 113 to 355. The manner of deducing these from the ratio found in the proposition, is explained in Algebra, art. 364.*

Prop. XI. Prob.

To find a straight line nearly equal to any given arc of a circle.

Fig. 137. Let AB be any arc of a circle, of which C is the centre. Draw the radii CA, CB, and draw AH perpendicular to AC, and CD perpendicular to CB, meeting HA in D. Bisect the angle ACB by the straight line CH; again bisect the angle ACH by the line CI, and bisect the angle ACI by the line CK, and bisect the angle ACK by the line CL, and proceed in this manner with any number of bisections; the greater the number, the more accurate will be the result.

Let H, I, K, L, &c. be the points in which the bisecting lines meet the line DA. In AD produced, take DP$=\frac{1}{2}$ of AH, PQ$=\frac{1}{4}$ of AI, QR$=\frac{1}{8}$ of AK, RS$=\frac{1}{16}$ of AL, and so on, if there were more lines intercepted between A and the bisecting lines, but if AL be the last, then take ST$=\frac{1}{3}$ of RS. Draw a straight line now from C to T, and draw Cb perpendicular to CT, meeting AH in b, and the straight line Ab shall be nearly equal to the arc AB of the circle.

This construction is derived from an elegant formula which we have investigated in the conclusion of the Arithmetic of Sines, also in Conic Sections, (Sect. VII.) It is this, putting a for any arc,

$$\frac{1}{a} = \text{cot. } a + \tfrac{1}{2}\text{ tan. } \tfrac{1}{2}a + \tfrac{1}{4}\text{ tan. } \tfrac{1}{4}a + \tfrac{1}{8}\text{ tan. } \tfrac{1}{8}a + \text{\&c.}$$

Now, from the construction and the definition of the trigonometrical lines about a circle, it is manifest that AD is the cotangent of AB or a, and that AH $=$ tan. $\frac{1}{2}a$, AI $=$ tan. $\frac{1}{4}a$, &c. and therefore that DP$=\frac{1}{2}$ tan $\frac{1}{2}a$, PQ$=\frac{1}{4}$ tan $\frac{1}{4}a$, &c. and therefore that AS $=$ cot. $a+\frac{1}{2}$ tan. $\frac{1}{2}a+\frac{1}{4}$ tan. $\frac{1}{4}a+\frac{1}{8}$ tan. $\frac{1}{8}a+\frac{1}{16}$ tan. $\frac{1}{16}a$; the addition of ST $=\frac{1}{3}$ RS is an approximate value of the sum of the remaining terms of the series; and as TCb is a right-angled triangle, of which C is the right angle, $CA^2 = AT \times Ab$ (21. 4.) and

$$\frac{CA^2}{Ab} = AT, \text{ that is } \frac{1}{Ab} = \text{cot. } a + \tfrac{1}{2}\text{ tan. } \tfrac{1}{2}a + \text{\&c.}$$

Hence it is evident that A$b =$ arc a.

Scholium. If we suppose the arc AB a quadrant, then AD $= 0$, and by calculation, (see Arithmetic of Sines, Art. 33), supposing CA$=1$, it will be found that DP $=$ 5000000 PQ $=$ .1035534, QR $=$ .0248640, RS $=$ .0061557, ST $=$ .0020519; hence DT or AT $=$ .6366250; and since AT : AC $=$ 1 :: AC : Ab, we find Ab or AB$=$1.570784, the approximate value of the quadrant. The more correct value is 1.570796, &c. by which it appears that the error is little more than the $\frac{1}{100000}$ part of the radius.

Part II. THE GEOMETRY OF SOLIDS.

Of Planes and solid Angles.

SECT. I.

Of Planes and Solid Angles.

Definitions.

Definitions. 1. A straight line is *perpendicular* or at right angles to a plane, when it makes right angles with every straight line, meeting it in that plane. On the other hand, the plane is perpendicular to the line.

2. A straight line is *parallel* to a plane when they do not meet, to whatever distance both are produced. The plane is also parallel to the line.

3. Two planes are *parallel* to each other, when they do not meet although produced.

4. Admitting what will be afterward demonstrated, (in Prop. 3.) that the common sections of two planes is a straight line, the *angle* or the *inclination* of two planes is the angle contained by two straight lines, drawn from the same point of their common section at right angles to it; the one in the one plane, and the other in the other. This angle may be either acute, right, or obtuse.

5. If this angle is a right angle, the planes are perpendicular.

6. A solid angle is that which is made by the meeting of more than two plane angles, which are not in the same plane, in one point.

Prop. I. Theor.

A straight line cannot be partly on a plane, and partly above it.

For, according to the definition of a plane, when a straight line has two common points with a plane, it is entirely on that plane.

Prop. II. Theor.

Two straight lines, which cut each other in a plane determine its position; that is, a plane which passes through two straight lines, that cut each other, can have only one position.

Let AB, AC be two straight lines which cut each other in A; suppose a plane to pass through AB, and to turn on that line, until it pass through C; then the

* The ratio of 113 and 355 is easily remembered, by observing that the figures of the numbers are 1, 1, 3, 3, 5, 5, viz. the first three odd numbers each repeated.

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points A and C lying on the plane, the whole line AC will be in the plane; therefore the position of the plane is determined by the single condition of its containing the two straight lines AB, AC.

Cor. 1. Any triangle ABC, or three points A, B, C, not in a straight line, determine the position of a plane.

Fig. 141. Cor. 2. Therefore also any two parallels AP, ED (Fig. 141.) determine the position of a plane, for if a straight line AD meet them, the plane of the two lines AP, AD is that of the parallels AP, ED.

Prop. III. Theor.

If two planes cut each other, their common section is a straight line.

Fig. 139. Draw a straight line joining any two points E and F in the common section of two planes AB, CD, this line will be wholly in the plane AB (by the definition of a plane), and also wholly in the plane CD; therefore it is in both planes at once, and consequently is their common section.

Prop. IV. Theor.

Fig. 140. If a straight line AP is perpendicular to two straight lines PB, PC at the point of their intersection P, it is perpendicular to the plane in which these lines are.

Through P draw any straight line PQ in the plane of the lines PB, PC; through Q, any point in that line, draw a straight line to meet PB, PC, so that BQ=QC, (Prob. 5. Sect. 4. Part I.) Join AC, AQ, AB; and because ABC is a triangle, of which the base BC is bisected at Q, therefore

$$AB^2+AC^2=2BQ^2+2AQ^2, \text{ (14. 4. Part. I.)}$$

In like manner, in the triangle PBC, we have

$$PB^2+PC^2=2BQ^2+2PQ^2;$$

therefore, taking equals from equals, we have

$$AB^2-PB^2+AC^2-PC^2=2AQ^2-2PQ^2.$$

But because the triangles APB, APC are right angled at P, $AB^2-PB^2=AP^2$; and $AC^2-PC^2=AP^2$ (11. 4.); therefore

$$AP^2+AP^2=2AQ^2-2PQ^2,$$

that is, $2AP^2=2AQ^2-2PQ^2$, and $AP^2=AQ^2-PQ^2$, and $AQ^2=AP^2+PQ$, hence in the triangle APQ, the angle at P must be a right angle, (11, 12, and 13. of 4. Part I.), and AP is perpendicular to any line whatever on the plane of the lines PB, PC, therefore it is perpendicular to the plane itself, (Def. 1.)

Cor. 1. The shortest line that can be drawn to a plane from A any point above it, is the perpendicular AP.

Cor. 2. Only one perpendicular PA can be drawn to a given plane, from a given point P in that plane: For if two perpendiculars could be drawn, a plane might pass along them, and meet the given plane in PQ; and thus two lines would be perpendicular to PQ, which is impossible.

Cor. 3. It is also impossible to draw more than one straight line perpendicular to a plane, from a point without it. For if there could be two perpendiculars AP, AQ, the triangle APQ would have two right angles, which is impossible.

Prop. V. Theor.

If a straight line AP is perpendicular to a plane MN, every straight line DE, parallel to AP, is perpendicular to the same plane.

Fig. 141. Let a plane pass along the parallels AP, ED, so as to meet the plane MN in the line PD. In this plane draw a line BDC through D, perpendicular to PD, take equal distances DB, DC, and join AB, AC, AD. And because in the triangles DBP, DCP, DB = DC, and DP is common to both, and the angle PDB=PDC, therefore PB = PC (6. 1. Part I.) Again, in the triangles APB, APC, AP is common to both, and it has been shewn that PB = PC, besides the angles APB, APC are right angles, because AP is perpendicular to the plane MN, therefore AB=AC, so that the triangle ABC is isosceles; hence BD is perpendicular to AD (12. 1. Part I.); but BD is also perpendicular to PD, by construction therefore BD is perpendicular to the plane of the triangle APD (4.), and consequently to DE, which is in that plane; since then EDB is a right angle, and also EDP is a right angle (1 Cor. 21. Part I.), the line DE is perpendicular to the two lines DP, DB; it is therefore perpendicular to the plane MN.

Cor. 1. Conversely, if the two straight lines AP, DE are perpendicular to the same plane MN, they are parallel: For if they are not, let a line be drawn through D parallel to AP, this line will be perpendicular to the plane MN; therefore through the same point D, two perpendiculars can be drawn to the same plane, which is impossible, (2 Cor. 4.)

Cor. 2. Two straight lines A and B parallel to a third C, though not in the same plane, are parallel to one another; for suppose a plane perpendicular to the line C, the lines A and B, which are parallel to C, will be perpendicular to this plane; therefore by the preceding corollary, they will be parallel to one another.

Prop. VI. Theor.

Fig. 142. Two planes MN, PQ perpendicular to the same straight line AB, are parallel to each other.

For if they could meet, let O be one of their common points; join OA, OB; then, because AB is perpendicular to the two planes, the angles OAB, OBA are right angles (Def. 1.); therefore OA, OB are two perpendiculars from the same point on the same straight line, which is impossible; therefore the planes cannot meet, that is, they are parallel.

Prop. VII. Theor.

Fig. 143. The intersections EF, GH of two parallel planes MN, PQ, with a third plane FG, are parallel.

For if the lines EF, GH situated in the same plane, be not parallel, they would meet if produced; therefore, the planes in which they are would also meet, and consequently would not be parallel.

Prop. VIII. Theor.

Fig. 142. A straight line AB perpendicular to a plane MN, is also perpendicular to any plane PQ parallel to MN.

From B draw any straight line BC in the plane PQ, and let a plane passing through BC and AB meet the plane MN in AD, then AD will be parallel to BC, Of Planes and solid Angles.

(7.) Now AB is perpendicular to AD one of two parallel lines AD, BC, therefore it is perpendicular to BC the other line, (21. 1. Part I.); and since BC is any line drawn from B in the plane PQ, it follows that AB is perpendicular to the plane PQ, (Def. 1.)

Prop. IX. Theor.

Fig. 143. Parallel straight lines EG, FH intercepted between two parallel planes MN, PQ are equal.

Let a plane EGHF pass through the parallel lines, so as to meet the parallel planes in the lines EF, GH; these are parallel to each other (7.), as well as EG, FH; therefore EFHG is a parallelogram, and hence EG = FH.

Cor. Parallel planes are every where at the same distance from each other; for if EG and FH are perpendicular to the two planes, they are parallel (1 Cor. 5.), and therefore are equal.

Prop. X. Theor.

Fig. 144. If two straight lines CA, EA meeting one another, be parallel to two others DB, FB that meet one another, though not in the same plane with the first two; the first two and the other two shall contain equal angles; and the plane passing through the first two, shall be parallel to the plane passing through the other two.

Take AC = BD, AE = BF, and join CE, DF, AB, CD, EF. Since AC is equal and parallel to BD, the figure ABDC is a parallelogram, (28. 1. Part I.); therefore CD is equal and parallel to AB. For a like reason, EF is equal and parallel to AB; therefore also CD is equal and parallel to EF. The figure CEFD is therefore a parallelogram, and thus the side CE is equal and parallel to DF; therefore the triangles CAE, DBF are equal (11. 1. Part I.) and the angle CAE=DBF.

In the next place, the plane ACE is parallel to the plane BDF; for if the plane passing through A parallel to BDF could meet the two lines DC, FE in any other points than C and E, for example in G and H, then the three lines AB, DG, FH would be equal (9.), and thus DG would be equal to DC, and FH to FE, which is absurd; therefore the plane AEC is parallel to BFD.

Prop. XI. Theor.

Fig. 144. If three straight lines AB, CD, EF not situated in the same plane, are equal and parallel, the triangles ACE, BDF formed by joining the extremities of these lines are equal, and their planes parallel.

For since AB is equal and parallel to CD, the figure ABDC is a parallelogram, therefore the side AC is equal and parallel to BD; in like manner, it may be shewn that the sides AE, BF are equal and parallel, as also CE, DF; therefore the two triangles CAE, BDF are equal; it may be demonstrated, as in the last proposition, that their planes are parallel.

Prop. XII. Theor.

If two straight lines be cut by parallel planes, they shall be cut in the same ratio.

Fig. 145. Let the straight line AB meet the parallel planes MN, PQ, RS in A, E, B; and let the line CD meet the same planes in C, F, and D; then shall AE : EB :: CF : FD.

Draw AD to meet the plane PQ in G, and join AC, EG, GF, BD; the intersections EG, BD of the parallel planes PQ, RS with the plane ABD are parallel (7.), therefore AE : EB :: AG : GD, (15. 4. Part I.) In like manner, the intersections AC, GF are parallel, therefore AG : GD :: CF : FD; hence, because of the common ratio AG : GD, we have AE : ED :: CF : FD.

Prop. XIII. Theor.

Fig. 146. If a straight line AP be perpendicular to a plane MN, every plane APB, which passes along AP, shall be perpendicular to the plane MN.

Let BC be the intersection of the planes AB, MN. In the plane MN draw DE perpendicular to BP; then, because AP is perpendicular to every line drawn from P in the plane MN, the angles APD and APB are right angles; but the angle APD formed by the two perpendiculars PA, PD is the angle of the planes AB, MN (Def. 4.), therefore the two planes are perpendicular to one another, (Def. 5.)

Scholium. When three straight lines, such as PA, PB, PD are perpendicular to each other, each line is perpendicular to the plane of the other two, and the three planes are perpendicular to one another.

Prop. XIV. Theor.

Fig. 14 If a plane AB be perpendicular to a plane MN, and in the plane AB a straight line PA be drawn perpendicular to their common intersection PB, the line PA shall be perpendicular to the plane MN.

In the plane MN, draw PD perpendicular to PB; then because the planes are perpendicular to each other, the angle APD is a right angle; therefore AP is perpendicular to the lines PB, PD; consequently it is perpendicular to their plane.

Cor. If the plane AB be perpendicular to the plane MN, and through P, any point in their common intersection, a perpendicular be drawn to the plane MN, this perpendicular shall be in the plane AB. For if it is not, a line AP might be drawn in the plane AB perpendicular to PB, the common intersection of the planes, which at the same time would be perpendicular to the plane MN; thus, from the same point P, there would be two perpendiculars to a plane MN, which is impossible, (2 Cor. 4.)

Prop. XV. Theor.

Fig. 1 If two planes AB, AD be perpendicular to a third MN; their common intersection AP is perpendicular to the third plane.

For a perpendicular to the plane MN at P, the point in which it meets the two planes AB, AD must be in both these at the same time, therefore it is their common intersection AP.

Prop. XVI. Theor.

If a solid angle be formed by three plane angles, the sum of any two of them is greater than the third.

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Fig. 147. It is sufficiently evident, that the sum of the greatest of the three, and either of the other two, is greater than the remaining angle, and it is only necessary to prove that the sum of the angles AVC, BVC, neither of which is the greatest, exceeds the greatest angle AVB.

In the plane AVB, make the angle BVD=BVC; take any two points A, B, in the lines VA, VB, and draw ADB; take VC=VD, and join AC, BC. And because BV is common to the triangles, VBD, VBC, and VC=VD, and the angle BVD=BVC, therefore BD=BC; now AB, or AD+BD, is less than AC+BC, therefore taking away the common side DB, there remains AD < AC. The two triangles AVC, AVD, have AV common, VC=VD and the base AC > AD, therefore (converse of 10. 1. Part I.) the angle AVC > AVD, and AVC+CVB > AVD+DVB, that is > AVB.

Prop. XVII. Theor.

The sum of all the plane angles which form any solid angle is less than four right angles.

Fig. 148. Let the solid angle V be cut by any plane ABCDE; from a point O taken in this plane, draw to all its angles the lines OA, OB, OC, OD, OE. The sum of the angles of the triangles AVB, BVC, &c. formed about the vertex V, is equivalent to the sum of the angles of a like number of triangles AOB, BOC, &c. formed about the point O; but at the point B, the angles OBA, OBC taken together, make the angle ABC less than the sum of the angles VBA, VBC (16.); in like manner at the point C, we have OCB+OCD < VCB+VCD, and so on with all the angles of the polygon ABCDE. Hence it follows, that in the triangles of which the vertex is O, the sum of the angles at the bases is less than the sum of the angles at the bases of the triangles, which have their vertex at V; therefore, by compensation, the sum of the angles about the point O, is greater than the sum of the angles about the point V; but the sum of the angles about O is equal to four right angles; therefore the sum of the plane angles which form the solid angle about the point V, is less than four right angles.

Scholium. This demonstration supposes, that the solid angle is convex, or that the solid angle lies all on one side of the plane of any one of its faces; if it were otherwise, the sum of the plane angles would not be limited.

Prop. XVIII. Theor.

If two solid angles be composed of three plane angles which are equal, each to each, the planes in which these angles are, have the same inclination to one another.

Figs. 149, 150. Let the angle CAD=*c a d*, the angle CAB=*c a b*, and the angle BAD=*b a d*; the two planes CAB, DAB shall have to each other the same inclination as the planes *c a b*, *d a b*.

Take B any point in AB, and in the planes BAC, BAD, draw BC and BD perpendiculars to AB, and join CD; then the angle CBD is the inclination of the planes BAC, BAD, (Def. 4.) Again, take *a b*=AB, and in the planes *b a c*, *b a d* draw *b c* and *b d* perpendiculars to *a b*, and join *c d*; then the angle *c b d* is the inclination of the planes *b a c*, *b a d*.

The triangles BAC, *b a c*, have the angle BAC=*b a c*, the angle CBA=*c b a*, also the side AB=*a b*; therefore the triangles are equal, (7. 1. Part I.) and BC=*b c*, also AC=*a c*. In the same way it may be proved, that the triangles BAD, *b a d* are equal, and therefore that BD=*bd*, also AD=*a d*. The triangles CAD, *c a d*, have therefore CA=*c a*, AD=*a d*, and the angle CAD=*c a d*; hence CD=*c d*. Now the triangles CBD, *c b d* having CB=*c b*, DB=*d b*, and the base CD=*c d*, the angle CBD will be equal to the angle *c b d*; that is, the inclination of the plane BAC to the plane BAD, is equal to the inclination of the plane *b a c* to the plane *b a d*. In the same way it may be proved, that the other planes are equally inclined to one another.

Scholium. If the three plane angles which contain the solid angles, besides being equal each to each, are also *disposed in the same order as in* Fig. 149, the solid angles will coincide when applied the one to the other, and they will be equal. But if the plane angles are *disposed in a contrary order*, as in Fig. 150, the solid angles will not coincide, although the theorem is alike true in both cases. However, in the latter case as well as in the former, the solid angles must be accounted equal, seeing that they are equal in every thing that determines their magnitude. This kind of equality, which does not admit of superposition, and on that account is not absolute, may be distinguished from the other, by calling it *equality by reason of symmetry*; and two solid angles, which are contained by three plane angles, having the same magnitude in each, but placed in a contrary order, may be called *symmetrical angles*. What is here said, will apply to solid angles contained by any number of plane angles.

SECTION II.

Of Solids bounded by Planes.

Definitions.

Definitions. 1. A *solid* is that which has length, breadth, and thickness.

2. A *prism* is a solid contained by plane figures, of which two that are opposite are equal, similar, and parallel to one another, and the others are parallelograms.

Fig. 151. To construct this solid, let ABCDE be any rectilineal figure, (Fig. 151.) In a plane parallel to ABC draw the lines FG, GH, HI, &c. parallel to the sides AB, BC, CD, &c. thus there will be formed a figure FGHIK, similar to ABCDE. Now let the vertices of the corresponding angles be joined by the lines AF, BG, CH, &c. the faces ABGF, BCHG, &c. will evidently be parallelograms, and the solid thus formed will be a prism.

3. The equal and parallel plane figures ABCDE, FGHIK, are called the *bases* of the prism. The other planes, or parallelograms, taken together, constitute the *lateral* or *convex* surface of the prism.

4. The *altitude* of a prism is the distance between its bases; and its *length* is a line equal to any one of its lateral edges, as AF, or BG, &c.

5. A prism is *right*, when the lateral edges AF, BG, &c. are perpendicular to the planes of its bases; then each of them is equal to the altitude of the prism; in every other case the prism is oblique.

6. A prism is *triangular*, *quadrangular*, *pentagonal*, &c. according as the base is a triangle, a quadrilateral, a pentagon, &c.

7. A prism which has a parallelogram for its base, has all its faces parallelograms, and is called a *parallelopiped*, (Fig. 152.) A parallelopiped is *rectangular*, when all its faces are rectangles. Fig. 152.

8. When the faces of a rectangular parallelopiped are squares, it is called a *cube*.

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Fig. 148. 9. A *pyramid* is a solid formed by several triangular planes, which meet in a point V, (Fig. 148.) and terminate in the same plane rectilineal figure ABCDE.

The plane figure ABCDE is called the *base* of the pyramid; the point V is its *vertex*; and the triangles AVB, BVC, &c. taken together, form the *convex* or *lateral* surface of the pyramid.

10. The *altitude* of a pyramid, is the perpendicular drawn from its vertex to the plane of its base, produced if necessary.

11. A pyramid is *triangular*, *quadrangular*, &c. according as its base is a triangle, a quadrilateral, &c.

12. A pyramid is *regular*, when its base is a regular figure, and the perpendicular from its vertex passes through the centre of its base; that is, through the centre of a circle that may be described about its base.

13. Two solids are *similar*, when they are contained by the same number of similar planes, similarly situated, and having like inclinations to one another.

Prop. I. Theorem.

Two prisms are equal, when three planes, which contain a solid angle of the one, are equal to three planes which contain a solid angle of the other, each to each, and are similarly situated.

Fig. 151. Let the base ABCDE be equal to the base *a b c d e*; the parallelogram ABGF equal to the parallelogram *a b g f*, and the parallelogram BCHG equal to the parallelogram *b c h g*; then shall the prism ABCDE-FGHIK be equal to the prism *a b c d e-f g h i k*.

For if the base ABCDE be placed upon its equal *a b c d e*, they will entirely coincide; and because the three plane angles which form the solid angle B are equal to the three plane angles which form the solid angle *b*, each to each, namely, ABC=*a b c*, ABG=*a b g*, and GBC=*g b c*; and besides, these angles are similarly situated; the solid angles B and *b* shall be equal (18. 1.), and consequently the side BG will fall on *b g*. Also, because of the equal parallelograms ABGF, *a b g f*, the side GF will fall on its equal *g f*, and, similarly, GH on *g h*: Therefore the upper base FGHIK will coincide entirely with its equal *f g h i k*, and the two solids will coincide entirely, and be equal to one another.

Cor. Two right prisms which have equal bases and equal altitudes are equal to one another.

If the equal angles of the lower bases follow each other in the same order, then the three planes which contain each solid angle of the one prism will be respectively equal to three planes which contain a corresponding solid angle of the other, and will be similarly situated; and when the one solid angle is applied to the other, these planes will coincide, and the prisms will exactly coincide. If the equal angles of the lower bases follow each other in a contrary order, then, by inverting one of the prisms, so that its upper may become its lower base, the angles of the two bases will then be placed in the same order, so that in either case the prisms coincide, and are equal.

Prop. II. Theor.

In every parallelopiped, the opposite planes are equal and parallel.

Fig. 152. From the definition of this solid, the bases ABCD, EFGH are equal parallelograms; and their sides are parallel: it remains therefore to demonstrate that the same is true for two opposite lateral faces, such as AEHD, BFGC. Because the figure ABCD is a parallelogram, AD is equal and parallel to BC; and for a like reason AE is equal and parallel to BF; therefore the angle DAE is equal to the angle CBF (10. 1.) and the plane DAE is parallel to the plane CBF; therefore also the parallelogram DAEH is equal to the parallelogram CBFG. In like manner, it may be demonstrated that the opposite parallelograms ABFE, DCGH are equal and parallel.

Cor. Any two opposite faces of a parallelopiped may be taken for its bases.

Prop. III. Lemma.

In every prism ABCDE-FGHIK, the sections NOPQR, STVXY made by parallel planes are equal polygons. Fig. 153.

For the sides NO, ST are parallel, (7.1.) because the two parallel planes are cut by a third plane ABGF; these same sides NO, ST are comprehended between the parallels NS, OT, which are sides of the prism; therefore NO=ST; for a like reason the sides OP, PQ, QR, &c. of the section NOPQR are respectively equal to the sides TV, VX, XY, &c. of the section STVXY: Besides, these equal sides being at the same time parallel, it follows that the angles NOP, OPQ, &c. of the first section are respectively equal to the angles STV, TVX, &c. of the second section. Therefore the two sections NOPQR, STVXY are equal polygons.

Cor. Every section of an upright prism by a plane parallel to the base is equal to that base.

Prop. IV. Theor.

If a parallelopiped AG, be cut by a plane passing through BD, FH, the diagonals of two of the opposite planes, it will be cut into two equivalent prisms, BAD-EFH, BCD-FGH. Fig. 154.

Through B and F, the extremities of one of the sides, draw the planes B *a d c*, F *e h g* perpendicular to BF to meet the three other sides of the solid in *a*, *d*, *c*, and in *e*, *h*, *g*; these sections are equal (3.), because the planes are perpendicular to FB, and therefore parallel. They are also parallelograms (7. 1.), because the opposite sides of the same section, *a* B, *d c* are the intersections of two parallel planes ABFE, DCGH, by the same plane.

For a like reason, the figure B *a e* F is a parallelogram, as also the other lateral faces BF *g c*, *c d h g*, *a d h e*, of the solid B *a d c*-F *e h g*; therefore this solid is a prism (Def. 2.), and it is a right prism, because BF is perpendicular to the plane of its base.

This being premised, and it being observed that the right prism B *h* is divided into two right triangular prisms *a* B *d-e* F *h*, *c* B *d-g* F *h*, we shall now demonstrate that the oblique triangular prism ABD-EFH is equal to the right triangular prism *a* B *d*-*e* F *h*: In fact, these two prisms have a common part ABD-*e* F *h*, therefore it is only necessary to prove that the remainders, viz. the solids B *a* AD *d*, F *e* EH *h*, are equivalent to each other.

Because BAEF, B *a e* F, are parallelograms, we have AE=BF=*a e*, therefore A *a*=E *e*: In like manner, it may be proved that D *d*=H *h*: Conceive now that F *e h*, the base of the solid F *e* EH *h*, is placed on *a* B *d*, the base of the solid B *a* AD *d*; then the point *e* falling on *a*, and *h* on *d*; the lines e E, *h* H will coincide with their equals, *a* A, *d* D, because they are perpendiculars to the same plane: Therefore the two solids in question will coincide entirely, the one with the other, and hence it follows that the oblique prism BAD-FEH is equivalent to the right prism B *a d*-F *e h*.

In the same manner it may be demonstrated, that the oblique prism BCD-FGH is equal to the right prism B *c d*-F *g h*; but the two right prisms are equal (Cor. 1.), since they have the same altitude, and their bases are equal, they being halves of the same parallelogram, therefore the two triangular prisms BAD-FEH, BCD-FGH which are equivalent to these are equivalent to each other.

Cor. Every triangular prism ABD-EFH is half a parallelopiped AG, having the same solid angle A, with the same edges AB, AD, AE.

Scholium. Although the triangular prisms into which the oblique parallelopiped is divided are contained by equal planes, and have their solid angles equal, yet they cannot be made to coincide. The reason is, that the plane angles about the corresponding solid angles in the two prisms are not placed in the same order. These solid angles are therefore *symmetrical*, and cannot be brought to coincide. (18. 1.) Two prisms, or two solids of any kind so constituted, are called *symmetrical solids*. An exact notion of their relation to each other may be acquired by considering that any object and its image reflected from a mirror are *symmetrical* figures. They resemble each other exactly, but every part is placed in a reverse order; thus the reflected image of a right hand is a left hand.

In symmetrical solids, every circumstance upon which the magnitude of either depends, is the very same in both, hence their *equivalence* might even be assumed as an axiom in solid geometry.

Prop. V. Theor.

155. If two parallelopipeds, AG, AL, have a common base ABCD, and their upper bases EFGH, IKLM in the same plane, and between the same parallels EK, HL; these two parallelopipeds are equivalent to each other.

There may be three cases, according as EI is greater or less than EF, or equal to it, but the demonstration is the same for them all. In the first place, the triangular prism AEI-DHM is equal to the triangular prism BFK-CGL; for since AE is parallel to BF, and EH to FG, the angle AEI = BFK, and HEI = GFK, and HEA=GFB; of these six angles, the three first form the solid angle E, and the three others form the solid angle F; therefore, since the plane angles are equal, each to each, and similarly situated, the solid angles E and F are equal: and if the prism AEI-DHM be placed on the prism BFK-CGL, so that the base AEI may be on the base BFK, these being manifestly equal, they will coincide; and since the solid angle at E is equal to the solid angle at F, the side EH will fall on its equal FG, and coincide with it; thus the planes which form the solid angles E and F will coincide, and the prisms will be equal (1.): Now if from the whole solid contained between the trapezoids AEKB, DHLC, there be taken the prism AEI-DHM, there will remain the parallelopiped AIL, and if from the same solid there be taken the prism BFK-CGL, there will remain the parallelopiped AEG; therefore the two parallelopipeds AIL, AEG are equivalent to one another.

3

Prop. VI. Theor.

Two parallelopipeds of the same base and the same altitude are equivalent to one another.

Let ABCD be the common base of the two parallelopipeds AG, AL; since they have the same altitude, their upper bases EFGH, IKLM will be in the same plane; also the sides EF, AB are equal and parallel, and the same is also true of IK and AB; therefore EF is equal and parallel to IK; for a like reason GF is equal and parallel to LK. Let the sides EF and HG be produced, as also the sides LK and IM, so as to form by their intersection the parallelogram NOPQ; it is evident that this parallelogram is equal to each of the bases EFGH, IKLM. Now if we suppose that there is a third parallelopiped, which, with the same lower base as the other two, has for its upper base NOPQ; this third parallelopiped will be equivalent to the parallelopiped AG, (5.) and for a like reason it will be equivalent to the parallelopiped AL; therefore the two parallelopipeds AG, AL, which have the same base, and the same altitude, are quivalent to one another. Fig. 156.

Prop. VII. Theor.

Every parallelopiped is equivalent to a rectangular parallelopiped which has the same altitude and an equivalent base.

Let AG be the proposed parallelopiped; from the points A, B, C, D, draw AI, BK, CL, DM, perpendicular to the plane ABCD, and terminating in the plane of the upper base, and join IK, KL, LM, MI; thus there will be formed a par llelopiped AL equivalent to the parallelopiped AG, and of which the lateral faces AK, DL are rectangles. If the base ABCD is also a rectangle, AL will be a rectangular parallelopiped equivalent to the proposed parallelopiped AG; but if it is not, (Fig. 157.) draw AO and BN perpendicular to CD, and OQ and NP perpendiculars to the upper base, thus there will be formed a solid ABNO-IKPQ, which will be a rectangular parallelopiped. For, by construction, the base ABNO, and its opposite IKPQ are rectangles, as also the lateral faces, because the edges AI, OQ are perpendicular to the plane of the base; therefore the solid AP is a rectangular parallelopiped. But the two parallelopipeds AP, AL may be considered as having the same base ABKI, and the same altitude AO; therefore they are equivalent; wherefore the parallelopiped AG, which was first transformed to the equivalent solid AL (Fig. 156.) is now reduced to the equivalent rectangular parallelopiped AP (Fig. 157.) which has the same height AI, and a base AONB equivalent to the base ABCD. Fig. 156. Fig. 157. Fig. 156. Fig. 157.

Prop. VIII. Theor.

Two rectangular parallelopipeds AG, AL, which have the same base ABCD, are to one another as their altitudes AE, AI. Fig. 158.

Let us suppose that AE contains some part of AI a certain number of times exactly, for example, let it contain the third part of AI five times, and let these equal parts be A *p*, *p q*, *q* I, I *r*, *r* F: Let planes be supposed to pass through *p*, *q*, *r* parallel to the common base; these will divide the solid AG into five parallelopipeds,

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which will be equal, because they have equal bases (6.) and equal altitudes, and the solid AL will contain three of these parallelopipeds: thus the parallelopiped AG will contain a part of the parallelopiped AL exactly as often as the altitude AE of the former contains a like part of the altitude AI of the latter, therefore the solids AG, AL have to each other the same ratio as their altitudes AE, AI.

When the altitudes are incommensurable, it may still be inferred that the ratio of the solids is the same as that of their altitudes, for the reasons assigned in the conclusion of Sect. III. Part I.

Prop. IX. Theor.

Fig. 159. Two rectangular parallelopipeds AG, AK, which have the same altitude, are to one another as their bases.

Suppose the solids placed side by side, as in the Figure: Produce the plane ONKL, until it meet the plane DCGH in the line PQ; thus there will be formed a third parallelopiped AQ, which may be compared with the other two. The two solids AG, AQ, having the same base AEHD, are to each other as their altitudes AB, AO (8.) In like manner the two solids AQ, AK, having the same base AOLE, are to one another as their altitudes AD, AM: But the rectangles AC, AP, having the same breadth, are also to each other as AB to AO, (3. 4. Part 1.) and similarly, the rectangles AP, AN are to each other as AD to AM; therefore

sol. AG : *sol.* AQ : : *base* AC : *base* AP,
sol. AQ : *sol.* AK : : *base* AP : *base* AN;

therefore, *ex æquo*,

sol. AG : *sol.* AK : : *base* AC : *base* AN.

Prop. X. Theor.

Any two rectangular parallelopipeds are to each other as the products of numbers proportional to their bases and altitudes; or as the products of the numbers which express their three dimensions.

Fig. 159. Let the two rectangular parallelopipeds AG, AZ be so placed, that their surfaces may have a common angle BAE; and let their bounding planes be produced, so as to form a third parallelopiped AK, having the same altitude as the solid AG. By the last proposition,

sol. AG : *sol.* AK : : *base* AC : *base* AN;

and by Prop. 8,

sol. AK : *sol.* AZ : : AE : AX.

Now, if we consider the bases AC, AN as measured by numbers, and also their altitudes AE, AX, we shall have by Prop. 1. Sect. 3. Part 1,

base AC : *base* AN : : AE × *base* AC : AE × *base* AN,
and AE : AX : : AE × *base* AN : AX × *base* AN;
therefore,
sol. AG : *sol.* AK : : AE × *base* AC : AE × *base* AN,
sol. AK : *sol.* AZ : : AE × *base* AN : AX × *base* AN.

From these two proportions, we have, *ex æquo*,

sol. AG : *sol.* AZ : : AE × *base* AC : AX × *base* AN.

By substituting in this proportion instead of the bases AC, AN, their numerical values AD × AB and AM × AO, we have also

sol. AG : *sol.* AZ : : AD × AB × AE : AM × AO × AX.

Scholium. Hence it appears that the product of the numbers which express the base of a rectangular parallelopiped, and its altitude, or the product of the numbers which express its three dimensions, may be taken as its *numerical measure*: For, if the length of the solid be equal to five times a certain line, which is considered as an unit, its breadth three times that unit, and its height seven times the same unit; then the parallelopiped will be to a cube, whose side or edge is that unit, as 5 × 3 × 7 to 1 × 1 × 1, that is as 5 × 3 × 7 to 1: Hence the parallelopiped will be equivalent to 5 × 3 × 7 = 105 times a cube whose side is unity.

The magnitude of a solid, its bulk, or its extension, constitutes what is called its *solidity* or its *content*. Thus we say that the solidity or content of a rectangular parallelopiped, is equal to the product of its base by its altitude; or to the product of its three dimensions.

Prop. XI. Theor.

The solidity of a parallelopiped, and, in general, the solidity of any prism, is equal to the product of its base by its altitude.

1. For any parallelopiped whatever is equivalent to a rectangular parallelopiped of the same altitude, and an equivalent base (7.); and the solidity of this last has been proved to be equal to the product of its base by its altitude; therefore the solidity of the other is also the product of its base by its altitude.

2. Every triangular prism is half a parallelopiped, which has the same altitude, and a base twice that of the prism; but the solidity of this last is equal to the product of its base by its altitude; therefore the solidity of the prism is the product of its base (half that of the parallelopiped) by its altitude.

3. Any prism whatever may be divided into as many triangular prisms of the same altitude, as there can be triangles in the polygon which forms its base: now the solidity of each prism is the product of its base by its altitude, which is common to them all; therefore the sum of their solidities is equal to the sum of their bases multiplied by the common altitude; that is, the solidity of the whole prism is equal to the product of its base by its altitude.

Cor. Two prisms, which have the same base, are to each other as their altitudes; and two prisms, which have the same altitude, are to each other as their bases. Let B and A be the base and altitude of a prism P, and b and a the base and altitude of another prism p; then since $P=B\times A$, and $p=b\times a$, we have $P:p::B\times A:b\times a$, therefore if $A=a$, then $P:p::B:b$; and if $B=b$, then $P:p::A:a$.

Note. The cube of a line AB is sometimes expressed thus, AB × AB × AB, but more commonly thus, $(AB)^3$, or thus, AB^3.

Prob. XII. Theor.

Fig. Similar prisms are to one another as the cube of their homologous sides.

Let P and p be two prisms, of which BC, bc are the homologous sides; the prism P is to the prism p as the cube of BC to the cube of bc. From A and a, homologous angles of the two prisms, draw AH, ah perpendicular to their bases, BCD, bcd. Join BH, take $Ba=ba$, and in the plane BHA draw ah perpendicular to BH; then ah shall be perpendicular to the plane CBD (13. and 14. 1.) and equal to ah, the altitude of the other prism; for if the solid angles B and b were applied the one to the other, the planes which contain them, and consequently the perpendiculars $a\,h$, $a\,h$, would coincide (Schol. 18. 1.)

Now, because of the similar triangles ABH, $a\,b\,h$, and the similar figures AC, $a\,c$, we have

$$AH : ah :: AB : ab :: BC : bc;$$

and because of the similar bases,

$$base\ BCD : base\ b\,c\,d :: BC^2 : b\,c^2 \text{ (25. 4. Part 1.)}$$

From these two proportions, by considering all the quantities as represented by numbers, we get, (by Prop. 1. Sect. 3. Part 1.)

$$AH \times base\ BCD : a\,h \times base\ BCD :: BC^3 : b\,c \times BC^2,$$
$$a\,h \times base\ BCD : a\,h \times base\ b\,c\,d :: b\,c \times BC^2 : b\,c^3;$$

therefore, *ex æquali*,

$$AH \times base\ BCD : a\,h \times base\ b\,c\,d :: BC^3 : b\,c^3.$$

But $AH \times base$ BCD expresses the solidity of the prism P; and $a\,h \times base\ b\,c\,d$ expresses the solidity of the other prism p, therefore,

$$prism\ P : prism\ p :: BC^3 : b\,c^3.$$

Cor. Similar prisms are to one another in the triplicate ratio of their homologous sides. For let Y and Z be two lines, such, that $BC : b\,c :: b\,c : Y$, and $b\,c : Y :: Y : Z$; then the ratio of BC to Z is triplicate of the ratio of BC to $b\,c$ (12. Def. Sect. 3. Part 1.) But since $BC : b\,c :: b\,c : Y$, therefore $BC^2 : b\,c^2 :: b\,c^2 : Y^2$, (23. 4. Part 1.) and, multiplying the antecedents by BC, and the consequents by $b\,c$, $BC^3 : b\,c^3 :: BC \times b\,c^2 : b\,c \times Y^2 :: BC \times b\,c : Y^2$; but $Y^2 = b\,c \times Z$ (22. 4. Part. 1.); therefore $BC^3 : b\,c^3 :: BC \times b\,c : b\,c \times Z :: BC : Z$. But $BC^3 : b\,c^3 :: prism\ P : prism\ p$, therefore the prisms have to each other the ratio of BC to Z, that is, the triplicate ratio of BC to $b\,c$.

Prop. XIII. Theor.

If a triangular pyramid A-BCD be cut by a plane parallel to its base, the section FGH is similar to the base.

161. For because the parallel planes BCD, FGH are cut by a third plane ABC, the sections FG, BC are parallel (7. 1.) In like manner it appears that FH is parallel to BD; therefore the angle HFG is equal to the angle DBC (10. 1.) And because the triangle ABC is similar to the triangle AFG, and the triangle ABD is similar to the triangle AFH, we have

$$BC : BA :: FG : FA,$$
$$\text{and } BA : BD :: FA : FH.$$

Therefore, *ex æquali*, BC : BD :: FG : FH; now the angle DBC has been shewn to be equal to the angle HFG; therefore the triangles DBC, HFG are equiangular (20. 4. Part 1.)

Prop. XIV. Theor.

161. If two triangular pyramids A-BCD, a-$b\,c\,d$, which have equivalent bases, and equal altitudes, be cut by planes that are parallel to the bases, and at equal distances from them; the sections FGH, $f\,g\,h$ will be equal.

Draw AKE, $a\,k\,e$ perpendicular to the bases BCD, $b\,c\,d$, meeting the cutting planes in K and k; then, because of the parallel planes, we have $AE : AK :: AB : AF$, and $a\,e : a\,k :: a\,b : a\,f$ (12. 1.); but, by hypothesis, $AE = a\,e$, and $AK = a\,k$; therefore, $AB : AF :: a\,b : a\,f$; again, because of similar triangles, $AB : AF :: BC : FG$, and $a\,b : a\,f :: b\,c : f\,g$; therefore, $BC : FG :: b\,c : f\,g$; and hence $BC^2 : FG^2 :: b\,c^2 : f\,g^2$ (23. 4. Part 1.) but because of the similar triangles BDC, FHG, $BC^2 : FG^2 :: trian.\ BDC : trian.\ FHG$, and in like manner $b\,c^2 : f\,g^2 :: trian.\ b\,c\,d : trian.\ f\,g\,h$ (25. 4. Part. 1.) therefore

$$trian.\ BCD : trian.\ FGH :: trian.\ b\,c\,d : trian.\ f\,g\,h.$$

Now $trian.\ BCD = trian.\ b\,c\,d$ (by hypothesis) therefore the triangle FHG is equal to the triangle $f\,h\,g$.

Scholium. It is easy to see, that what is proved in this and the preceding Proposition is also true of polygonal pyramids.

Prop. XV. Theor.

A series of prisms of the same altitude may be inscribed in a pyramid, and another series may be circumscribed about it, which shall exceed the other by less than any given solid.

Let A-BCD be a pyramid, and let AC, one of its lateral edges, be divided into some number of equal parts, at the points F, G, H; through these, let planes pass parallel to the base BCD, making with the sides of the pyramid the sections QPF, SRG, UTH; which will be similar to one another and to the base (13.) From B, in the plane of the triangle ABC, draw BK parallel to CF, meeting FP produced in K; in like manner, from D draw DL parallel to CF, meeting FQ produced in L; join KL, and the solid CBD-FKL will evidently be a prism. By the same construction, let the prisms PM, RO, TV be described: Also let the straight line IP, which is in the plane of the triangle ABC, be produced till it meet BC in h, and let MQ be produced till it meet DC in g; join $h\,g$, then C $h\,g$-FPQ will be a prism, and be equal to the prism PM. In the same manner is described the prism m S equal to the prism RO, and the prism q U equal to the prism TV. Therefore the sum of all the inscribed prisms h Q, m S, and q U is equal to the sum of the prisms PM, RO, and TV; that is, to the sum of all the circumscribed prisms, except the prism BL; wherefore BL is the excess of the prisms circumscribed about the pyramid above the prisms inscribed within it. Fig. 162.

Let us now suppose that Z denotes some given solid equal to a prism, which has the same base CBD as the pyramid, and its altitude equal to a perpendicular from E (a point in AC) upon the base. Then, however near E may be to C, it will evidently be possible to divide AC into such a number of equal parts, that one of them, CF, shall be less than CE; and this being the case, the prism BL will evidently be less than the prism whose base is the triangle CBD, and altitude a perpendicular from E on the base BCD; that is, less than the given solid Z: Therefore the excess of the circumscribed above the inscribed prisms may be less than the solid Z.

Cor. Since the difference between the circumscribed and inscribed prisms may be less than any given magnitude, and the pyramid is greater than the latter, and less than the former, it follows that a series of prisms may be circumscribed about the pyramid, and also a series of prisms may be inscribed in it, which shall differ from the pyramid itself by less than any given solid.

Prop. XVI. Theor.

Pyramids that have equal bases and altitudes, are equal to one another.

Let A-BCD, a-$b\,c\,d$ be two pyramids that have equal bases BCD, $b\,c\,d$, and equal altitudes; viz. the perpendiculars drawn from the vertices A and a upon Fig. 163.

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the planes BCD, *bcd*, the pyramid A-BCD is equal to the pyramid *a-b c d*.

For if they are not equal, let Z represent the solid which is equal to the excess of one of them, *a-b c d*, above the other A-BCD; and let a series of prisms CE, FG, HK, LM, of the same altitude be circumscribed about the pyramid A-BCD, so as to exceed it by a solid less than Z, which is always possible (15.); also let a series of prisms *c e*, *f g*, *h k*, *l m*, equal in number to the other, and of the same altitude, be circumscribed about the pyramid *a-b c d*. And because the pyramids have equal altitudes, and the number of prisms described about each is the same, the altitudes of the prisms will be all equal, and the bases of the corresponding prisms in the two pyramids, as EF, *e f*, will be sections of the pyramids at equal distances from their bases, therefore they are equal (14.), and the prisms themselves are equal (1.), and the sum of all the prisms described about the one pyramid is equal to the sum of all the prisms described about the other pyramid. To abridge, put P and *p* to denote the pyramids A-BCD, and *a-b c d* respectively, and Q and *q* to express the sums of the prisms described about them. Then, because by hypothesis $Z = p - P$, and by construction $Z > Q - P$, therefore $p - P > Q - P$, hence *p* must be greater than Q; but Q is equal to *q*, therefore *p* must be greater than *q*, that is the pyramid *p* is greater than *q*, the sum of the prisms described about it, which is impossible; therefore the pyramids P, *p* are not unequal, that is they are equal.

Prop. XVII. Theor.

Every prism having a triangular base, may be divided into three pyramids that have triangular bases, and that are equal to one another.

Fig. 164. Let ABC, DEF be the opposite bases of a triangular prism; join AE, EC, CD; and because AE is the diagonal of a parallelogram, the triangles ABE, ADE are equal; therefore the pyramids C-ABE and C-ADE, which have a common vertex C, and the triangles ABE, ADE for their bases, will be equal (16.) When these are taken from the whole prism, there remains the pyramid C-DEF, which is equal to the pyramid C-ABE, or E-ABC, for they have equal bases DEF, ABC, and the same altitude, viz. the altitude of the prism ABC-DEF. Therefore the three pyramids C-ABE, C-ADE, and C-DEF, are equal.

Cor. 1. From this it appears, that every pyramid is the third part of a prism, which has the same base and the same altitude with it. For if the base of the prism be any other figure than a triangle, it may be divided into prisms having triangular bases.

Cor. 2. Pyramids of equal altitudes are to one another as their bases; because the prisms upon the same bases, and of the same altitude, are to one another as their bases.

Prop. XVIII. Theor.

Similar pyramids are to one another as the cubes of their homologous sides.

Fig. 161. If two pyramids be similar, it is evident from Def. 13. that the lesser may be placed in the greater, so that they shall have a common solid angle A; and then their bases BCD, FGH will be parallel; for since the homologous faces are similar, the angle AFG = ABC, and the angle AGH = ACD, and so on; therefore the plane FGH is parallel to the plane BCD: Hence, again, it will follow, that a straight line AKE perpendicular to the base of the one, will also be perpendicular to the base of the other, and AE, AK, the altitudes of the two pyramids, will have to each other the ratio of AB to AF, or of BC to FG, &c. Now, let P represent a right prism, having the same base BCD as the pyramid A-BCD, and the same altitude AE, and similarly let *p* represent another right prism, having the same base FGH as the pyramid A-FGH, and the same altitude AK: Then these prisms will manifestly be contained by the same number of similar planes, similarly situated, and having a like inclination to each other, therefore they will be similar (Def. 13.) and consequently P is to *p* as the cube of BC to the cube of FG (12.), but the pyramids A-BCD, A-FGH are like parts of the prisms (1 Cor. 17.); therefore the pyramids are also to one another as the cubes of their homologous sides BC, FG.

Of the three round Solids.

SECT. III.

Of the Three Round Solids.

Definitions.

Definitions.

1. A *cylinder* is a solid figure, generated by the revolution of a right-angled parallelogram, which revolves about one of its sides, that side remaining fixed, (Fig. 165.)

2. The *axis* of a cylinder is the straight line about which the parallelogram revolves.

3. The *bases* of a cylinder are the circles described by the two revolving opposite sides of the rectangle.

4. A *cone* is a solid figure generated by the revolution of a right-angled triangle about one of the sides containing the right angle, which remains fixed.

5. The *axis* of the cone is the straight line about which the triangle revolves.

6. The *base* of the cone is the straight line generated by that side containing the right angle which revolves.

7. A *sphere* is the solid figure generated by the revolution of a semicircle about a diameter, which remains fixed.

8. The *axis* of a sphere is the straight line about which the semicircle revolves.

9. The *centre* of the sphere is the same with that of the semicircle.

10. *Similar cones* and *cylinders* are those which have the diameters of their bases and their axes proportionals.

Prop. I. Theorem.

If from any point E in the circumference of AEB, the base of a cylinder, a straight line EF be drawn perpendicular to the plane of the base, it will be wholly in the cylindric superfices.

Let AGHD be the generating rectangle, and GH the axis. Because in every position of the revolving rectangle, the angle AGH is a right angle, GH is perpendicular to the plane of the base AEB; therefore, AD, the line which generates the cylindric superfices, is in every position perpendicular to the plane of the base (5. 1.), and consequently, when the revolving radius GA comes to the position GE, AD will coincide with EF; therefore EF is in the cylindric superfices.

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Prop. II. Theor.

A cylinder and a parallelopiped having equal bases and altitudes, are equal to one another.

Fig. 166. If the cylinder ABCD and parallelopiped EF, which have equal bases, (viz. the circle AGB and parallelogram EH), and the same altitude, be not equal, let us suppose that they are unequal, and first let the cylinder be less than the parallelopiped. From EF, let a parallelopiped EQ, equal to the cylinder, be cut off by a plane PQ parallel to NF. Let a polygon AGKBLM be inscribed in the circle AGB so as to differ from it by a less space than the parallelogram PH (6. 5. Part I.) and let the parallelogram RO be equal to the polygon AGKBLM; the point R will manifestly fall between P and N. Now, if an upright prism, having the same altitude as the cylinder, be formed on the polygon AGKBLM as a base, and a solid ES be cut off from the parallelopiped EF by a plane RS parallel to NF; the prism and solid ES will be equal (11. 2.) But the prism being entirely contained within the cylinder, is less than it; therefore the prism is also less than the solid EQ; and consequently the solid ES is equal to a solid which is less than EQ; now this is impossible; therefore the cylinder is not less than the parallelopiped EF. In the same way it may be shewn not to be greater, therefore the cylinder and parallelopiped having equal bases and altitudes, are equal or equivalent to one another.

Prop. III. Theor.

If a cone and cylinder have the same base and altitude, the cone is the third part of the cylinder.

Fig. 167. If a cone A-BCD be not the third part of a cylinder BFKG, having the same base and altitude, it will be the third part of a cylinder LMNO, having the same altitude as the other, but a base either less or greater; and first, let the base LIM be less than the base BCD; then, because the circle LIM is less than the circle BCD, a polygon BECFD may be described in the latter, which shall differ from it by less than its excess above the circle LIM (6. 5. Part I.); wherefore this polygon will be greater than the circle LIM. Let an upright prism and pyramid be constituted on the polygon BECFD as a base, and having the same altitude as the cylinders; and because the cone A-BCD is the third part of the cylinder LMNO, and this cylinder is less than the prism BCD-GHK, because it has a less base and the same altitude, therefore the cone A-BCD is less than the third part of the prism BCD-GHK; but the pyramid A-BECFD is the third part of the prism (17. 2.); therefore the cone A-BCD is less than the pyramid A-BCD: Now this is impossible, because the pyramid being contained entirely within the cone, the cone must be greater than the pyramid. Therefore the cone A-BCD is not less than the third part of the cylinder BFKG. In the same manner, by circumscribing a polygon about the base of the cylinder, it may be shewn that the cone is not greater than the third part of the cylinder; therefore it is equal to the third part of the cylinder.

Prop. IV. Lemma.

Fig. 168. Let ABDC be a plane figure, bounded by a straight line CD, a line of any kind AB, which is terminated by perpendiculars at the extremities of CD, and by these perpendiculars AC, BD. Let AB*ba* be a solid generated by the revolution of this figure about CD as an axis; a series of cylinders may be described about the solid, and another series may be inscribed in it, having all the same altitude, and such that the sum of the circumscribed cylinders shall exceed the sum of the inscribed cylinders by less than any given solid S.

Let the solid S be a cylinder, having B*b* for the diameter of its base, and DP for its height. Suppose the fixed axis CD to be divided into a number of equal parts DK, KG, GE, EC, each less than DP. In the plane of the figure ABDC, draw perpendiculars EF, GH, KL to meet the line AB in F, H, L. Construct the inscribed rectangles AE, FG, HK, LD, also the circumscribed rectangles CF, EH, GL, KB. By the rotation of the plane figure about the axis CD, these rectangles will evidently generate a series of cylinders inscribed in the solid, and another series described about it. Let the circumscribed cylinders, reckoned from the bottom of the solid to the top, be denoted by V, X, Y, Z, and the inscribed cylinders by v, x, y, z, then the sums of the circumscribed and inscribed cylinders will be

$$V + X + Y + Z,$$

and $$v + x + y + z.$$

Now by the nature of the figure, each circumscribed cylinder is equal to the inscribed cylinder next below it; therefore $X = v$, $Y = x$, and $Z = y$, and hence the excess of the sum of all the circumscribed above the inscribed cylinders will be the same as the excess of the greatest circumscribed above the least inscribed cylinder: that is, it will be equal to $V - z$, and consequently will be less than V; but the lowest circumscribed cylinder V is less than the solid S, because it has the same base, (viz. the circle having for its diameter B *b*), and a less altitude KD, by construction; therefore the excess of the series of circumscribed above the series of inscribed cylinders is less than the given solid S.

Cor. The difference between the solid AB*ba* and either of the two series of cylinders will be less than the greatest circumscribed cylinder: For the solid AB*b a* is greater than the one series of cylinders and less than the other, therefore it will differ from either series by a quantity less than the difference between the two.

Prop. V. Theor.

If a cone and hemisphere have equal bases and altitudes, and if a series of cylinders be described about the cone, and another series be inscribed in the hemisphere, and the cylinders have all the same altitude, the sum of the two series will be equal to a cylinder having the same base and altitude as the hemisphere.

Let AFB be a semicircle, and CFDA, CFEB, squares described on the radius CF, and let CE be the diagonal of one of the squares BF: Let CF be divided into any number of equal parts CG, GK, KM, MF; and let perpendiculars be drawn through the points of division, meeting the diagonal CE, in the points O, P, Q; the quadrantal arc BF in the points H, L, N; and the side of the square in the points R, S, T: Construct the rectangles CO, GP, KQ, ME, which will circumscribe the triangle CFE; construct also the rectangles CH, GL, KN, which will be inscribed in the quadrant CFB. Suppose now the plane of the square to revolve about its side CF as an axis; the triangle CFE will then generate a cone, which will have DE for the diameter of its base, and C for its vertex; the quadrant CFB will generate a hemisphere, having for its base a circle of which AB is a diameter; and the square CBEF will generate a cylinder, having the same base and altitude as the hemisphere: Also, the rectangles described about

Fig. 169.

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the triangle CFE will manifestly generate a series of cylinders circumscribing the cone; the rectangles inscribed in the quadrant will generate a series of cylinders inscribed in the hemisphere; and the rectangles CR, GS, KT, ME will generate a series of cylinders which will compose a cylinder having the same base and altitude as the hemisphere.

The triangles CFE, CGO are manifestly similar, and CF=FE; therefore CG=GO: In like manner, it may be proved that CK=KP and that CM=MQ.

Join CH, and because CGH is a right angled triangle, a circle described with CH as a radius will be equal to two circles described with CG and GH as radii (2 Cor. 8. 5. Part I.) but CG=GO, and CH=GR, therefore a circle described with GR as a radius will be equal to two circles described with GO and GH as radii; hence again it follows, that the cylinder generated by the rectangle CR will be equal to both the cylinders generated by the rectangles CO and CH, for they have all the same altitude, and the base of the first is equal to the sum of the bases of the other two. It may be demonstrated in the same manner that the cylinder generated by the rectangle GS is equal to the sum of the cylinders, generated by the rectangles GP and GL, and the same of all the rest; therefore the sum of the cylinders, generated by the rectangles CR, GS, KT, ME is equal to the two series of cylinders, one generated by the rectangles CO, GP, KQ, ME, and the other generated by the rectangles CH, GL, KN; that is, a cylinder having the same base and altitude as the hemisphere, is equal to the sum of the two series of cylinders, one described about the cone, and the other described in the hemisphere.

Prop. VI. Theor.

Every sphere is two thirds of the circumscribing cylinder.

Fig. 169.

Let a figure be constructed exactly as in last proposition; and to abridge, let C denote the cone, c the series of cylinders described about it, H the hemisphere, h the cylinders described in it, and K the cylinder having the same base and altitude as the hemisphere, or cone: Moreover, put d for the difference between the cone and its circumscribed cylinders, and d' for the difference between the hemisphere and its inscribed cylinders; then we have

$$C + d = c, \text{ and } H = h + d',$$

and adding equals to equals,

$$C + H + d = c + h + d'.$$

But $c + h = K$ (5.); therefore, $C + H + d = K + d'$, and $C + H + d - d' = K$, also $C + H = K + d' - d$. Hence it appears that the difference between C+H and K is equal to the difference between d and d'. Now d is less than the cylinder generated by the rotation of the rectangle ME (Cor. to prop. 4.), and d' is less than the cylinder generated by the rectangle CR, which is equal to ME, therefore the difference between d and d' must be less than the same rectangle; hence the difference between C+H and K is less than the cylinder generated by the revolution of the rectangle ME, or is less than a cylinder having the same base as the cone, and the line FM for its altitude. From this we may infer, that C+H is exactly equal to K; for if there can be any difference, let it be a cylinder having the same base as the cone, and its altitude equal to FV; then FM must be greater then FV; but the number of parts into which FC is divided may be so great that FM may be less than FV; therefore C+H cannot be unequal to K; and since C+H=K, and $C = \frac{1}{3}K$ (3.), therefore $H = \frac{2}{3}K$; that is, the hemisphere is two-thirds of its circumscribing cylinder; and taking the doubles of these; the whole sphere is two-thirds of its circumscribing cylinder.

An Index to shew the Propositions in the foregoing Treatise, which correspond to the principal Theorems in the first six, and the eleventh and twelfth Books of Euclid's Elements.

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Appendix.

APPENDIX

TO THE ELEMENTS OF GEOMETRY.

SECT. I.

Of the Maxima and Minima of Geometrical Quantities.

Definitions.

Maxima and minima geometrical quantities. 1. A quantity is said to be a *maximum*, when it is the greatest; and a *minimum*, when it is the least of all quantities of the same kind.

Thus the diameter of a circle is a *maximum* among all the chords that can be drawn in a circle; and the perpendicular is a *minimum* among all lines that can be drawn from a given point to terminate in a straight line.

2. Figures are called *isoperimetrical*, when they have equal perimeters.

Prop. I. Theor.

Of all triangles having the same base and the same perimeter, the *maximum* triangle is that in which the two indeterminate sides are equal.

Fig. 170. Let ACB, AMB, be two triangles on the same base AB, and such that AC+CB=AM+MB; then if AC=CB, and AM, be greater or less than MB, the triangle ACB is greater than AMB.

Draw CE perpendicular to AB, and MD perpendicular to CE; join AD, BD, and in AD produced take DF=DB, and join MF. Then AE=BE (Geometry, Schol. to 12 of Sect. I. Part I.) and AD=BD (6. 1.) and the angle FDM=DAE (3 Cor. 21. 1.)=DBE (12. 1.)=BDM; hence the triangles FDM, BDM are equal, (6. 1.) and MF=MB, and AM+MF=AM+MB=AC+CB=2AC; but AM+MF is greater than AF, or 2AD; therefore 2AC>2AD, and AC>AD; and hence EC>ED (16. 1.) Now EC and ED are the altitudes of the triangles ACB and AMB respectively; therefore the triangle ACB is greater than the triangle AMB, (Cor. 6. 4).

Prop. II. Theor.

Of all isoperimetrical polygons of the same number of sides, that which is a *maximum* has its sides equal.

Fig. 171. For let ABCDEF be the maximum polygon, if the side BC be not equal to CD on the base BD, make an isosceles triangle BOD, which shall be isoperimetrical to BCD; then the triangle BOD is greater than BCD (I.), and consequently the polygon ABODEF is greater than the polygon ABCDEF; therefore this last is not the greatest of all polygons having the same number of sides and the same perimeter, which is contrary to what we have supposed; hence BC must be equal to CD; and in like manner it may be demonstrated, that any two adjoining sides are equal.

Prop. III. Theor.

Of all triangles constructed with two given sides which contain any angle, that is the greatest, of which the given sides contain a right angle.

Fig. 172. Let BAC, BAD, be two triangles, which have the side AB common, and AC=AD. If BAC be a right angle, the triangle BAC shall be greater than BAD, or BAD′: for the triangles BAC, BAD, are to one another as their altitudes AC, DE, because they have the same base; but DE is less than AD, or its equal AC; therefore the triangle BAD is less than BAC.

Prop. IV. Theor.

If all the sides of a polygon be given, except one, the polygon will be a *maximum* when all its angles are on half the circumference of a circle of which the unknown side is the diameter.

Fig. 173. Let ABCDEF be the greatest polygon that can be formed by the given lines AB, BC, CD, DE, EF, and the indetermined line AF. Draw AD, FD to the vertex of any one of its angles. If the angle ADF be not a right angle, supposing two parts of the polygon, ABCDA and FEDF, to remain the same, the triangle ADF, and consequently the whole polygon, might be increased by making ADF a right angle (3.); but the polygon being by hypothesis a *maximum*, it cannot be increased, therefore the angle ADF must be already a right angle. The same is also true of the angles ACF, ABF, AEF; therefore all the angles of the polygon are in the circumference of a semicircle of which AF is the diameter.

Scholium. This proposition gives rise to a question, whether it be possible to form different polygons which shall each be inscribed in a semicircle, and have all their sides, except that which is the diameter, equal to given lines? Before deciding this question it may be observed, that if one and the same chord AB (Fig. 174.) subtends arcs described with different radii AC, AD, the angle which the chord subtends at the centre of the greater circle shall be less than the angle it subtends at the centre of the less circle: For the angle ADO = ACD + DAC; therefore ADO>ACO, and doubling each ADB>ACB. Fig. 174.

Prop. V. Theor.

Fig. 173. There is only one way of forming a polygon ABCDEF which shall be inscribed in a semicircle, and have all its sides, except the diameter AF, equal to given lines.

For supposing a circle to be found that satisfies the question, if a greater circle would also satisfy it, the chords AB, BC, CD, &c. would subtend lesser angles at the centre of this than at the centre of the other circle; and the sum of these angles would be less in the one than in the other circle; but by the nature of the figure, in each the sum should be the same, viz. two right angles, therefore the polygon cannot be inscribed in two different semicircles.

Scholium. The order of the given sides AB, BC, CD, &c. may be changed, and still the diameter of the circle shall be the same, as well as the area of the polygon; for whatever be the order of the arcs AB, BC, CD, &c. it is sufficient that their sum be a semicircumference. The different polygons will also have equal areas, because by drawing lines to the centre, the triangles which constitute any one polygon will be respectively equal to those which constitute any other, as is evident.

Appendix.

PROP. VI. THEOR.

Of all polygons formed with given sides, the *maximum* is that which can be inscribed in a circle.

Fig. 175. Let ABCDEFG be the polygon inscribed in a circle, and *a b c d e f g* that which cannot be so inscribed. Draw the diameter EM; join AM, MB, and on *a b* = AB make a triangle *a m b* so that *a m*=AM, and *m b*=MB, and join *e m*. Then by Prop. 4. the polygon EFGAM is greater than *c f g a m*, unless this last can be inscribed in a circle of which *e m* is the diameter, because in this case the two polygons would be equal (Prop. 5.) For the same reason the polygon EDCBM is greater than *e d c b m*, excepting the case of the latter admitting of being inscribed in a semicircle, so as to make them equal. Therefore the whole polygon EFGAMBCDE is greater than the whole polygon *e f g a m b c d e*, unless they are entirely equal, which cannot happen, because the one is supposed to admit of being inscribed in a circle, but not the other; therefore the inscribed polygon is the greater of the two, and taking away the equal triangles AMB, *a m b*, there remains the polygon ABCDEFG, inscribed in a circle, greater than the other polygon *a b c d e f g*, which does not admit of such inscription.

SCHOLIUM. It may be demonstrated, as in Prop. V. that there can be only one circle, and consequently only one *maximum* polygon that satisfies the question; and this polygon will have the same surface, in whatever order the sides follow each other.

PROP. VII. THEOR.

The regular polygon is the greatest of all the isoperimetrical polygons, having the same number of sides.

For by Theorem 2, the *maximum* polygon has all its sides equal; and by the last Theorem, it may be inscribed in a circle. Now no other than a regular polygon has these two properties.

PROP. VIII. LEMMA.

Fig. 176. If two circles ADH, ABK, touch each other internally at A, and a straight line CD be drawn from the centre of the inner circle, to cut the circumferences in B and D, the arc AD of the outer circle shall be greater than the arc AB of the inner circle.

In the circumference of the inner circle, take the arc BE=BA; join CE, and through E and D, with a radius equal to the radius of the outer circle, describe an arc ED; then the trilateral figures ACD, ECD, will manifestly be exactly alike, and the arcs EB, ED will touch each other at E. And because the concave line ADE, (formed by the arcs AD, ED,) and the arc ABE, have their concavities turned the same way, by an axiom in geometry, the former is greater than the latter; therefore taking their halves, the arc AD is greater than the arc AB.

PROP. IX. THEOR.

Of two isoperimetrical regular polygons, that which has the greater number of sides is the greater.

Fig. 177. Let AB, DE be half the exterior sides of the two polygons, C their common centre; also CA and CAD those radii of circles inscribed in the polygons, which are perpendicular to their sides. Draw CB, CE, and let CE meet AB in M. Draw BH parallel to CE. On C as a centre, describe the arc AF, meeting CE in G; and on H as a centre, describe the arc AK, meeting CF in I.

Because the polygons have equal perimeters, the lengths of their sides will be reciprocally as their number; and because all the angles at the centre of each polygon make four right angles, the angles which the sides subtend at the centre, will also be reciprocally as their number: hence we have DE : AB : : arc AG : arc AF.

The triangles CAM, HAB, are manifestly similar, also the sectors CAG, HAK, hence

AB : AM : : arc AK : arc AG,

and since DE : AB : : arc AG : arc AF,

therefore, *ex. æq.* DE : AM : : arc AK : arc AF;

but DE : AM : : CD : CA;

therefore arc AK : arc AF : : CD : CA.

Now the arc AK is greater than the arc AI, which again is greater than the arc AF, (preceding Prop.) therefore CD is greater than CA; that is, the radius of the circle inscribed in the polygon having the lesser angle, or greater number of sides, is greater than the radius of the other polygon; but the polygons being isoperimetrical, and the area of each equal to half the rectangle of the perimeter, and the radius of the inscribed circle, the areas will be proportional to these radii; therefore the polygon that has the greatest number of sides, has the greatest area.

PROP. X. THEOR.

The circle is greater than any isoperimetrical polygon.

It has been proved, that if a regular and irregular polygon have equal perimeters, the former has the greater area; therefore it only remains to compare the circle with a regular polygon of the same perimeter. Fig. 178.

Let AI be half the side of the polygon, C the centre. In the isoperimetrical circle, let the angle DOE= ACI, and consequently the arc DE= the side AI: the polygon P is to the circle C as the triangle ACI is to the sector ODE; now the area of the triangle is $\frac{1}{2}$AI × IC, and the area of the sector is $\frac{1}{2}$ DE × EO; therefore P : C : : $\frac{1}{2}$ AI × IC : $\frac{1}{2}$ DE × EO : : IC : EO. Draw the tangent EG to meet OD in G. The triangles ACI, GOE being similar, IC : EO : : AI : GE; therefore, P : C : : AI, or arc DE : GE : : $\frac{1}{2}$ DE × EO : $\frac{1}{2}$ GE × EO; but $\frac{1}{2}$DE × EO=sector DOE; and $\frac{1}{2}$ GE × EO= triangle GOE, therefore P : C : : sector DOE : triangle GOE; now the triangle GOE is greater than the sector DOE; therefore the circle C is greater than the isoperimetrical polygon P.

COR. A circle contains within a given perimeter the greatest possible area.

PROP. XI. THEOR.

Of all polygons, having the same number of sides, and a given area, a regular polygon is that which has its perimeter a *minimum*.

Let A be the given area of a polygon, and v its perimeter; let a similar polygon have its perimeter equal to a given line b, and let its area be X. Because similar figures are as the squares of their perimeters, we have A : X : : v^2 : b^2; hence A × b^2=X × v^2, and v^2= Fig. 179.

Appendix. $\frac{A \times b^2}{X}$; hence it is evident that the greater the value of X, the less will be the value of v; but the perimeter b being given, the area X is the greatest possible when the polygon is regular, (7.), therefore the perimeter of a regular polygon, having a given area, will be less than the perimeter of an irregular polygon of the same number of sides, and the same area.

PROP. XII. THEOR.

Of regular polygons having the same area; that which has the greatest number of sides has the least perimeter.

Fig. 180. Let v and x be the perimeters of two regular polygons, having the same area A; also let Y and Z be the areas of two polygons, similar to them which have the same permeter b: then, because of the similar polygons, we have

$$v^2 : b^2 :: A : Y,$$
$$b^2 : x^2 :: Z : A,$$

hence, *ex æq.* $v^2 : x^2 :: Z : Y$.

Now, if of the two polygons Y and Z, Y be that which has the greater number of sides, then Y will be greater than Z (9.), and consequently $Z \angle Y$; therefore v^2 will be less than x^2, and v less than x; that is, the perimeter of the polygon having the greater number of sides, is less than the perimeter of the other polygon.

PROP. XIII. THEOR.

The perimeter of a circle is less than that of any polygon having an equal area.

This proposition may be proved exactly in the same manner as the last; or else by considering that a circle is the limit of all the regular polygons that can possibly be described about it; and that while the area of the circle may differ from the area of the polygon by less than any assignable quantity, its perimeter will be less than that of the polygon.

COR. A circle contains a given area with the least possible perimeter.

SECT. II.

THE CONSTRUCTION OF GEOMETRICAL PROBLEMS, BY DESCRIBING CIRCLES ONLY.

Construction of geometrical problems by circles only. A geometrical problem is considered as resolved, when it is shewn to be identical with some other known problem, or to be a combination of several, the mode of resolving each of which is known. The decomposition of a problem into others more simple, leads to the question, which problems are the most simple? so as not to admit of farther decomposition.

The ancient geometers assumed, as the most elementary, these three:

1. To draw a straight line from any one point to any other point.
2. To produce a terminated straight line to any length in a straight line.
3. To describe a circle from any centre at any distance from that centre.

They did not propose to resolve these, but took for granted that their resolution was known, and as obvious as the truth of the axioms.

However narrow a foundation these three self-evident problems, or *postulates* as they are called, may appear to afford, when compared with the vast fabric of geometry, attempts have been made to render it still narrower. Tartalea proposed to Cardan, to construct all the problems in Euclid by one and the same opening of the compasses, admitting, however, the use of a rule; and Benedictus composed a work on this problem. Schooten, instead of the postulate, "that a circle may be described from any centre at any distance from that centre," substituted this, "that from a given point in an indefinite straight line, a straight line may be cut off equal to a given terminated straight line;" by this change, he shewed elegantly how all the problems in elementary geometry might be constructed, without employing the circle farther than to cut off from a line a part of a given length, and thus in appearance the problems were constructed by straight lines only. See Schooten, *Exercit. Math.* lib. ii.

Mascheroni. Died 1801. At a later period, an Italian mathematician, Mascheroni, imposed on himself the task of resolving all plane problems whatever, by the circle alone; his success was complete, and the result of his labours is given in his *Geometrie du Compas*, the Geometry of the Compasses. It must be observed, that it is only in the construction of the problem that the straight line is dispensed with; for, in the demonstration, straight lines must be supposed drawn, and their properties introduced, in order to apply the common elements of geometry.

It is an anecdote not altogether without interest in the history of geometry, that the celebrated Bonaparte, late Emperor of the French, studied the geometry of the compasses under Mascheroni; he even condescended to propose to the French mathematicians one of its problems, namely, to divide the circumference of a circle into four equal parts, without employing straight lines.

We shall now give some specimens of this mode of constructing problems. And it is to be observed, that the propositions referred to in the article GEOMETRY, are all in the first Part.

PROP. I. PROB.

To determine a distance in the direction of a straight line passing through two given points A, B that shall be any multiple of the given distance A B.

First, To double the distance AB. On B as a centre, with BA as a radius, describe a portion ACDE of a circle, not less than its half. On A as a centre, with the same distance, describe an arc, to cut the circle in C. In like manner determine the points D and E in the circumference, so that the distances from C to D, and from D to E, may be equal to the distance from A to C, or from A to B. Then, because the chords of the arcs AC, CD, DE are each equal to the radius AB; the arc ACDE will complete a semicircle (2. 5.), and the points A, E will be the extremities of a diameter; therefore the points A, B, E will lie in a straight line, and the distance AE will be double AB. Fig. 181.

2d, To find the triple of the distance AB. Take BF the double of BE, and AF shall be the triple of AB; and proceeding in this way, any multiple whatever of AB may be found.

PROP. II. PROB.

To divide a given distance AB into any proposed number of equal parts. Fig. 182.

Appendix.

Let us suppose that the distance AB is to be divided into three equal parts. Take the distance AC equal to three times the distance AB, (by Prop. 1.), and in general, whatever be the number of equal parts into which AB is to be divided, take AC equal to the same number of times AB; in other respects, the construction is the same in all cases. On C as a centre, with CA as a radius, describe an arc PAp; and on A as a centre, with AB as a radius, describe another arc PBp, meeting the former in P and p. In the circle pBP, beginning from the point p, place three chords pm, mn, nQ, each equal to the radius AB. On P as a centre, with a radius equal to AB or AP, describe the arc AV, and on A as a centre, with a radius equal to the chord of PQ, describe another arc, meeting the former in V; then V shall be in a straight line joining A and B; and the distance AV shall be one third of the distance AB.

Join AP, CP, AQ, PQ, AV, PV. The triangles CAP, PAQ are manifestly isosceles; and because the arcs pm, mn, nQ are each one-sixth of the circumfe- (2. 5.) the arc pBQ is half the circumference; hence it is the measure of the three angles of the triangle CAP, (31. 4. and 24. 1.) that is of the angle C, and twice the angle CAP; but the arc PBp is the measure of twice the angle PAB, because arc BP = arc Bp; therefore the remaining arc PQ is the measure of the angle C. Now the same arc is also the measure of the angle PAQ; therefore the angle C is equal to the angle PAQ; and since PC : CA :: PA : AQ, the triangles PCA, PAQ are similar (20. 4.); hence the angle APQ is equal to the angle PAC; but the angle APQ = PAV, because by construction AP is common to the triangles APQ, PAV, and PQ = AV, and AQ = PV; therefore the angle PAC is equal to the angle PAV, and consequently V is in the straight line AC. And because CA : AP :: AP : AV, that is, CA : AB :: AB : AV, therefore whatever part AB is of AC, the very same part will AV be of AB.

The remaining points of division X, &c. may be found by making AX = 2 AV, &c. as taught in Prop. 1.

Scholium. The point V might also have been found by determining the points P and p as in the above construction, and then describing arcs on P and p as centres to pass through the point A, these would have intersected each other again in the point V. This construction, however, is not so good as the other, as a practical method, because the arcs cut each other obliquely.

Prop. III. Prob.

Having given two points in a straight line, to determine the direction of a perpendicular to it, which shall pass through one of the points.

Fig. 183. Let the given points be A, B. On these points, with any radius greater than half AB, describe arcs to intersect each other in C. On C, as a centre, describe a circle to pass through A and B, and determine the semicircle ABP, as in the former problems, by cutting off successively three arcs Am, mn, nP, with a radius in the compasses equal to that of the circle; then P will be a point in the perpendicular PB. For the angle APB, which is in a semicircle, is a right angle.

Prop. IV. Prob.

Having given two points in a straight line, to determine the direction of a perpendicular drawn from a point without it, and also the point in which the perpendicular meets the line.

Let A, B be the given points in the line AB, and P the point without it. On A and B, as centres, describe arcs to pass through P, and meet each other at p, a point on the other side of AB. Because each of the points A and B is equally distant from P and p, the line AB is perpendicular to the line which passes through P and p, (17. 1). It also bisects Pp at C; therefore C, the intersection of the line AB, and the perpendicular, may be found by Prop. 2. Fig. 18

Prop. V. Prob.

Having given two points A and B in a straight line, and a point P without it, to determine the position of a line that passes through P, and is parallel to AB. Fig. 19

On P as a centre, with a radius equal to AB, describe an arc of a circle; and on B as a centre, with a radius equal to PA, describe another arc, cutting the former in Q; a line passing through P and Q will be parallel to AB. For if AP, BP, BQ, be joined, the triangles PAB, BQP, will be, in all respects, equal; therefore the angles, QPB, PBA, are equal, and PQ is parallel to AB.

Prop. VI. Prob.

To find the side of a square, that shall be equal to the difference of two given squares.

Let AB and AC be the sides of the given squares. In the line AB produced, take Ba = BA, (Prop. I.), and on A and a, as centres, with a radius equal to AC, describe arcs cutting each other in D. The distance from B to D will be the side of the square required. Fig. 1

Because ADa is an isosceles triangle, a straight line drawn from D, the vertex of the triangle, to B, the middle of the base, will be perpendicular to the base, (12.1); therefore $AD^2 = AB^2 + BD^2$, and $BD^2 = AD^2 - AB^2$.

Prop. VII. Prob.

To bisect a given arc of a circle.

Let AB be the given arc, and C the centre of the circle. On B as a centre, with a radius equal to CA, describe an arc of a circle; and on C as a centre, with a radius equal to BA, describe another arc, cutting the former in D. Find m the side of a square, that shall be equal to the difference of the squares of the lines DA, DC, (Prop. 6.) On D, as a centre, with a radius equal to m, describe an arc, to meet the arc AB in V; then V shall be the middle of the arc AB. Fig. 1

Draw AE perpendicular to CD, and CF perpendicular to AB. Because by construction AB = CD, and AC = BD, the figure ABDC is a parallelogram; therefore also AFCE is a rectangle, and CE = AF, but AF = $\frac{1}{2}$ AB (6.2.); therefore CE = $\frac{1}{2}$ AB = $\frac{1}{2}$ CD, and 2 CE = CD. In the triangle ACD, we have $AD^2 = AC^2 + CD^2 + 2\,EC \times CD$ (13. 4.) $= AC^2 + 2\,CD^2$, therefore $AD^2 - CD^2 = AC^2 + CD^2$; but by construction $AD^2 - CD^2 = DV^2$; therefore $DV^2 = AC^2 + CD^2$; and, if a straight line be drawn from V to C, $DV^2 = VC^2 + CD^2$; hence DCV is a right-angled triangle (11. 4.)

Appendix. and CV is perpendicular to CD, and consequently is perpendicular to the chord AB; therefore CV bisects the arc AVB in V.

PROP. VIII. PROB.

Fig. 188. To find the sum or difference of two given distances AB, CD.

On B, one extremity of either of the given distances as a centre, with a radius equal to the other given distance CD, describe a circle. On A, the other extremity, with any radius, describe an arc to cut the circumference in *m* and *n*. Bisect the arcs of the circle between *m* and *n* in E and F, (last Prop.) then AE is the sum of the distances AB, CD, and AF their difference.

For if A *m*, B *m*, E *m*, A *n*, B *n*, E *n* be joined, the triangles on each side of AB will be equal; hence, as the prolongation of AB, and the line drawn from B to E will bisect the angle *m* B *n*, the points A, B, E will be in a straight line. In like manner it appears that the points A, B, F are in a straight line; consequently AE = AB + BE = AB + CD, and AF = AB — BE = AB — CD.

SCHOLIUM. By this problem, a line may be produced to any given distance. Also from the greater of two lines a part may be cut off equal to the less.

PROP. IX. PROB.

To find the centre of a given circle.

Fig. 189. Let ADB be the circle. Take any point B in the circumference, and on B as a centre, with any radius less than the diameter of the given circle, and greater than the fourth of that diameter, describe a circle ADC, cutting the other circle in D. Determine C, the opposite extremity of the diameter AC, as in the former problems. On BC construct the isosceles triangle BEC, having its sides BE, CE each equal to CD. On E as a centre, with EB or EC as a radius, describe an arc, cutting the circle ADC in F; then the distance from A to F shall be the radius of the circle ADB; and arcs described on any two points in its circumference as centres, with AF as a radius, will evidently intersect each other in its centre.

Suppose O the centre of the circle. Draw OA, OB, and the other lines as in the figure. Because the chord AB = chord BD, the arc AB is equal to the arc BD, and the angle BAD = angle BDA; now the angle BAD, or CAD, is half the angle CBD, (16. 2), and the angle BDA is half the angle BOA; therefore the angles CBD, BOA are equal, and since CB = BD and BO = OA, the triangles CBD, BOA are similar; and CD : CB :: BA : BO; that is, CE : CB : : AB : BO.

Again, because the isosceles triangles EBC, EBF are manifestly in all respects equal, the angle CBF is double the angle CBE; but in the isosceles triangle ABF, of which a side AB is produced, the exterior angle CBF is equal to the two angles BAF, BFA, that is, to 2 BAF, therefore the angle CBE = angle BAF, and BCE=BFA. Hence the isosceles triangles EBC, BFA are similar; and CE : CB :: AB : AF. But it was shewn that CE : CB : : AB : BO; therefore AF = BO, that is, AF is the radius of the given circle ABD.

PROP. X. PROB.

Fig. 190, 191. To determine the intersections of a line which passes through two given points A,B, and a circle given by position.

CASE 1. (Fig. 190.) When the line passes through C the centre of the circle. From C, set off CF and C*f*, in opposite directions, each equal to the radius of the circle, so that F and *f* may be in the line AB (by Prop. 8.); and the points F, *f* will manifestly be the intersection of the straight line and circle. Appendix. Fig. 190.

CASE 2. (Fig. 191.) When the line AB does not pass through the centre C. Draw CD perpendicular to AB (Prop. 4.), and produce it, so that DE = DC, (Prop. 1.). On C and E as centres, with the radius of the circle in the compasses, describe arcs to intersect each other in F and *f*; and these points will be the intersection of the straight line and the circle. For the points F and *f* are in the line which bisects CE at right angles (17. 1.); therefore they are in the line AB; and the same points F, *f* are manifestly in the circumference of the circle; therefore they are the intersections of the straight line and circle. Fig. 191.

PROP. XI. PROB.

To find a third proportional to two given lines P, Q. Fig. 192.

On any point C as a centre, with a radius equal to P, the first of the three proportionals, describe an arc ADB. In this arc place the chord AD equal to Q, the second term. On D as a centre, with DA as a radius, describe a circle ABE, and find E, the opposite end of the diameter passing through A, as in the former problems. The distance from B to E shall be the third proportional sought.

For, the isosceles triangles CAD, CBD being equal, the angle ADB is double the angle ADC; but in the isosceles triangle DBE, the outward angle ADB is the sum of the angles DEB, DBE, and therefore is double the angle DEB. Hence the angles ADC, DBE are equal, and consequently the other angles of the triangles CAD, DBE are equal, and the triangles are similar. Therefore CA : AD : : DB : BE, that is P : Q :: Q : BE.

This construction can only apply, when the first term is greater than half the second; when it is not, it may be doubled or quadrupled, &c. by Prop. 1. until a multiple of it be found that exceeds the half of Q, and then a like multiple of a third proportional to this multiple of P, and the line Q will evidently be a third proportional to P and Q.

PROP. XII. PROB.

To find a fourth proportional to three given lines P, Q, R. Fig. 193.

On any point C as a centre, with radii equal to P and R, the first and third terms of the proportionals, describe concentric circles AB, DE. In the first of these, place the chord AB equal to the second term Q. Take any point D in the circumference of the other circle, and from B place between the two circumferences a line BE equal to AD. Then the distance between D and E shall be the fourth proportional sought.

For, by construction, the three sides of the triangle ACD are equal to the three sides of the triangle BCE, each to each. Hence the angle ACD is equal to the angle BCE, and adding the common angle BCD, the angle ACB is equal to the angle DCE; therefore the isosceles triangles ACB, DCE are similar, and CA : AB : : CD : DE; that is, P : Q : : R : DE.

If the third term is more than double of the first, this construction will not immediately apply; but it may be modified, as in last proposition, by taking a multiple of the first, and then, the line required will be a like mul-

Appendix. tiple of a fourth proportional to the multiple so taken of the first, and the second, and third terms.

PROP. XIII. PROB.

Fig. 194. To find a mean proportional between two given lines AB, CD.

Place BE = CD in a line with AB (Prop. 8.) Bisect AE in F (Prop. 2.). Make BG = BF (Prop. 1.) On F and G as centres, with a radius equal to FB, describe arcs intersecting in H; and the distance from B to H will be the fourth proportional required.

It is manifest from the construction, that FBH is a right angle, and that H is in the circumference of a circle of which AE is the diameter; therefore AB : BH :: BH : BE or CD. (Prob. 3. Sect. 4. Part 1.)

PROP. XIV. THEOR.

Having given two points in each of two straight lines, to find the intersection of the lines.

We shall give an analytical solution to this problem. Indeed the whole theory might, with great advantage, be given under the analytical form.

Fig. 195. Let A, B be given points in the line AB, and C, D given points in the line CD. Suppose the intersection of the lines to be found, and that it is the point V. Draw V a on the other side of VC, so that the angles CVa, CVA may be equal; take V a=VA, and Vb=VB, and draw lines from A to a, and from B to b. Then every point in CV will be equally distant from A and a, also from B and b (12, and 17 of Sect 1. Part I.); hence the distance a C = distance AC; and the distance a D = distance AD; but AC and AD are known, because the points A, C, D are given; therefore the distances aC, a D, are also known, and consequently the point a is known. In like manner it appears that the distances b C, b D are equal to the known distances BC, BD; thus the point b is known.

Draw BG parallel to V a, to meet A a in G. The figure BGab is evidently a parallelogram; therefore BG = a b, and a G = B b; now a b, and B b are lines of a given length, because the points a, b, B are known; therefore BG, a G are given distances; and consequently the point G is known.

The triangles AGB, A a V are evidently similar; hence AG : AB :: A a : AV; thus, AV = aV is a fourth proportional to three given lines; therefore it may be found by Prop. 12. And because V is at known distances from given points A, a, the position of the point V is determined.

CONSTRUCTION. On C and D as centres, with radii equal to CA and DA, describe arcs to meet on the other side of the line at a; also on the same centres, with radii equal to CB, DB describe arcs to meet in b. On B as a centre, with a radius equal to a b, describe an arc, and on a as a centre, with a radius equal to B b describe another arc, to cut the former in G. Lastly, on A and a as centres, with a radius equal to a fourth proportional to the distances AG, AB, A a, (found by Prop. 12.) describe arcs to intersect in the point V, which will be the intersection of the lines AB, CD, as is evident from the analysis of the problem.

PROP. XV. PROB.

To divide the circumference of a circle into four, and also into eight equal parts.

This problem might be resolved by the problem for the bisection of an arc, but more elegantly by a construction suited to the particular case. The analysis may be as follows.

Fig. 19 Let ADB be a semicircle, AD one fourth, and AE one eighth of the circumference. Draw the radii CD, CE, and draw EF, a tangent to the circle, meeting CD in F. Because CE bisects the arc AD, it is perpendicular to the chord AD; now CE is also perpendicular to EF; therefore EF is parallel to AD; hence the angles ADC, EFC are equal; now the angles ACD, CEF are also equal, therefore the triangles ACD, CEF are similar; and since AC = CE, therefore AD = CF. Join AF; and in the right angled triangle ACF, we have $AF^2 = AC^2 + CF^2$, but $CF^2 = AD^2 = AC^2 + CD^2 = 2\ AC^2$; therefore $AF^2 = 3\ AC^2$: Now $AB^2 = 4\ AC^2$, therefore $AF^2 = AB^2 - AC^2$. Place in the circle a chord BG equal to the radius, and join AG; then, because $AG^2 = AB^2 - AC^2$, it follows that $AF^2 = AG^2$ and AF = AG. Hence this construction.

Determine the semicircle AGB as usual, and on A and B as centres, with a radius equal to AG, the chord of two thirds of the semicircumference, describe arcs to intersect each other in F. Place in the circle a chord AD equal to the distance from C to F, and D will be the middle of the arc ADB.

Again, on F as a centre, with a radius equal to AC, describe an arc to cut the circle in E, and E will be the middle of the quadrant AD. (ξ)

GEOMETRY, DESCRIPTIVE, the name given to a branch of geometry, which has of late years been much cultivated by the French mathematicians, and in particular by Monge, who may be regarded as its inventor. Its object is to represent on a plane, which has but two dimensions, any object which has three, and which admits of a strict definition. Descriptive geometry admits of a twofold application. First, it is employed by artists, to communicate to each other a knowledge of different objects. Thus it furnishes the means of constructing geographical and topographical charts; also plans of buildings and machines, architectural designs, sun-dials, theatrical decorations, &c. In this point of view, it is the best method that can be employed to describe the forms and the relative positions of objects. In the next place, it serves as an instrument of research, by which we may discover every thing relative to the form, and the position of the various parts of objects which admit of a rigorous definition. It is by the principles of descriptive geometry, that stone-cutters, carpenters, ship-builders, and other artists, find the dimensions of the different parts of the works which they execute, in as far as these dimensions result from the complete definition of the object.

Descriptive geometry formed an essential branch of the education of the French youth in the school of public works established at the beginning of the revolution; and it appears from the journal of the Polytechnic school, that the scholars were, during a certain period of the course, employed six hours every day in tracing the numerous objects which were the subject of their studies. The lessons given in the Normal School form a treatise on the subject by Monge, entitled *Geometrie Descriptive*, printed in 1799. There is also a treatise by Lacroix, entitled *Essais de geometrie sur les plans et les surfaces courbes* (*ou Elemens de geometrie descriptive*). We have already treated this subject under the head of CONSTRUCTIVE CARPENTRY. See CARPENTRY, Part II. (ξ)

Georgia in America.

GEORGIA, one of the United States of America, is situated between 31° and 35° North Lat. and between 5° and 16° West Long.; extending in length about 600 miles, and in breadth 250; and bounded on the east by the Atlantic ocean, on the south by the East and West Floridas, towards the west by the river Mississippi, and on the north and north-east by South Carolina, by the Tennessee State, or by lands ceded to the United States by South Carolina. The face of the country is various. That portion of its eastern division which lies in one direction between the rivers Savannah and St Mary's, in the other between the mountains and the ocean, a tract of territory which, from north to south, is upwards of 120 miles, and from east to west not less than 40 or 50, is entirely level, without a hill or stone. Farther to the westward, the lands begin to be more or less uneven; from ridges that rise gradually one above another, swelling progressively into hills, and thence finally terminating in mountains. The vast chain of the Alleghany or Appalachian mountains, which commences at Katts Kill, near Hudson's river, in the state of New York, terminates here about 60 miles south of the northern boundary, while; from the point where it ends, there spreads a widely extended plain, of the richest soil, in a latitude and climate favourably adapted to the culture even of most of the East India productions, or of those of the south of Europe. The winters in this country are mild and pleasant; snow is seldom or never seen, nor does it often happen that frosts prove injurious to the vegetation. In the flat country the air is rather confined, and being often contaminated by putrid vapours from the rice swamps, is comparatively less healthful than among the hills; and spring water is scarce. From June to September, the mercury in Fahrenheit's thermometer fluctuates here between 76° and 90°, and in winter between 40° and 60°. The most prevalent winds are the south-west and the eastern, and in winter the north-west. The east wind is warmest in winter, and coolest in summer.

Rivers.

Georgia is abundantly watered by numerous rivers, as well as smaller streams, which intersect it in every direction. The Savannah forms a part of the bounding line by which this state is separated from South Carolina. It is formed principally of two branches, the Tugulo and Keowee, which have their origin in the mountains. It is navigable for large vessels up to the town of the same name, and for boats of 100 feet keel as far as Augusta. There is a fall just above this place, beyond which it is farther passible for boats to the mouth of the Tugulo. Tybeebar, at the entrance of the river, in latitude 31° 57′, has at half tide a depth of 16 feet water. The Alalamaka and Ogeechee rivers have their course nearly parallel to the Savannah.

Besides these, with the several waters tributary to them, there are the Turtle River, Little Sitilla, Great Sitilla, Crooked River, and St Mary's, which last forms a part of the southern boundary of the United States, and is navigable for vessels of considerable burden for 90 miles. On the west, it is washed by the Mississippi, which separates it from Louisiana. Of rivers which fall into the Gulf of Mexico, there are the Pearl, the Pascagoula, the Alibama, the Tombegbee or Mobile, the Escambia, the Chatahouchee, with the Apalachicola, and the Flint rivers. The northern part of the state is watered by the Tennessee, Bend, and the Chuccamaga. All these rivers abound with various sorts of fish, among which are rock, mullet, whiting, shad, trout, drum, bap, cat-fish, brim, and sturgeon; and the bays and lakes afford oysters and other shell-fish. The chief lake or marsh in the state is Ekanfanoka, which is 300 miles in circumference.

Islands and coast.

The whole of the sea coast of Georgia is bordered with islands, through the medium of which there is constituted a sort of inland navigation, extending with but few interruptions from the river Savannah to St Mary's. The principal of these islands are Skedaway, Wassaw, Ossabaw, St Catharine's, Sassels, Frederica, Jekyl, Cumberland, and Amelia.

Soil and agriculture.

The soil of Georgia, and the degrees of its fertility, vary according to situation, and the differences that have taken place as to the manner or the extent of its improvement. The islands just mentioned are, in their natural state, covered with a plentiful growth of pine, oak, hiccory, live oak, and some red cedar. The soil is grey, formed by a mixture of sand and black mould. A considerable part of it, that particularly on which are chiefly found the oak, hiccory, and live oak, is very fertile, and yields on cultivation good crops of indigo, corn, cotton, and potatoes. The soil of the main land adjoining to the marshes and creeks, is nearly of the same quality with that of the islands. The portion of it which borders on the creeks and rivers, forms the chief exception, being the ground which furnishes the valuable rice swamps. These begin immediately upon the termination of the salts, and lie most of them on rivers, which, as far as the tide flows, are called tide lands, or on creeks and particular branches of water, flowing in some deeper or lower parts of the lands, which are called inland swamps, and extend back in the country from 15 to 25 miles, beyond which, for the most part, little rice is planted. Those lands immediately adjoining to the rivers are nearly level, continuing so in a breadth from two to three or four miles, for the space, in a direct line from the sea, of not less than 100 miles. In this distance, wherever a piece of high land extends to the bank of the river on one side, there may almost invariably be expected, on the other, a low or swampy ground of proportionable width. The intermediate lands, which are covered chiefly with pine, and a sort of wild grass and small reeds, afford a large range of feeding ground, both summer and winter. The oak and hiccory ranges that are interspersed, and which are of superior quality, yield, when cultivated, good crops of corn, indigo, or other valuable produce. At a distance from the sea, the soil changes from grey to red; in some places it is gravelly but fertile; and farther back into the country its tint is gradually deepened, till it becomes what is called the mulatto soil, consisting of a black mould and red earth. This sort of land is generally strong, and affords abundant crops of wheat, tobacco, corn, &c. It is succeeded in its turn by a soil that is nearly black, and very rich, and on which there grow large quantities of black walnut and mulberry. This sort of succession in the different soils which occur in the state, is throughout pretty regular and uniform. They stretch in the same order, in lines nearly parallel with the sea coast, not only across this state, but all along northwards, as far even as to Hudson's river.

Productions.

The staple commodity of Georgia is its rice. It yields also small quantities of indigo, cotton, and silk, besides Indian corn, potatoes, oranges, figs, pomegranates, with other useful grains or fruits. The forests afford an abundant supply of fine timber, consisting chiefly of oak, hiccory, mulberry, pine, and cedar.

Manufactures.

The manufactures of Georgia have not hitherto been very considerable. The people in the lower part of the

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state have not been accustomed to prepare even their own clothing, or that worn by their negroes. For almost every article, as well of their wearing apparel as of the tools used by them in their husbandry, they have been indebted to their merchants, who imported them from Great Britain or the northern states. But in the upper parts of the country, the inhabitants themselves manufacture the chief part of their clothing from cotton and from flax. The principal manufactures are those of indigo, silk, and sago. The latter is a kind of sediment or starch, that is obtained by properly macerating and washing potatoes. The large crops of this kind that grow on the dry plains of the country, besides affording wholesome nourishment, have been made to yield, by distillation, a spirituous liquor of a tolerable quality, though inferior to that which is made from rye. The chief articles of export from this state are rice, tobacco, indigo, sago, lumber of various kinds, naval stores, leather, deer-skins, snake-root, myrtle, and bees-wax, corn, live stock, &c. The value in sterling money of the whole amount of those exports in the year 1755, was £15,744; in 1760, £20,852; in 1765, £73,426; and in 1772, £121,677. In 1791, the value of articles in like manner exported, was, in dollars, 491,472; in 1792, 458,973; in 1793, 501,383; in 1794, 676,154; in 1796, 950,658; and in 1801, 1,854,951. The tonnage employed in this state was, in the year 1755, 1899; in 1760, 1457; in 1765, 7685; in 1772, 11,246; and in 1790, 28,540 tons. The number of American seamen, during the last of those years, was 11,235. In return for her exports, Georgia receives West India goods, teas, wines, clothing, and dry goods of all kinds; from the northern states, cheese, fish, potatoes, apples, cyder, and shoes. The imports and exports are principally to and from Savannah, which has a fine harbour, and is the chief emporium of the state.

Commerce.

Political division.

Before the revolution, Georgia, like the rest of the southern states, was divided into parishes; but since that period, the division has been into counties. According to this distribution, Georgia, under two districts, viz. the Upper and the Lower, comprehends 24 counties, of which 15 are included in the former division and nine in the latter. The counties of the upper district are Montgomery, Washington, Hancock, Green, Franklin, Oglethorpe, Elbert, Wilkes, Lincoln, Warren, Jefferson, Jackson, Bullock, Columbia, and Richmond; those of the lower district are Camden, Glynn, Liberty, Chatham, Bryan, M'Intosh, Effingham, Scriven, and Burke. The principal towns are Augusta, formerly the seat of government, Savannah, the former capital of the state, both on the river Savannah, Sunbury, Brunswick, Frederica, Washington, and Louisville, which last is now the metropolis of the state, and the place in which are deposited its records. The situation of these towns is generally advantageous; most of them standing on the banks of considerable rivers, and some of them, as Savannah, Brunswick, Frederica, and Sunbury, having safe and commodious harbours.

Counties.

Towns.

Population.

In the grand convention at Philadelphia in 1787, the inhabitants of Georgia were reckoned to amount in all to 90,000. By the census of 1790, it did not exceed 82,548 persons, of whom 29,264 were slaves. Subsequent to that period, however, there has been a very considerable augmentation. The disposition and character of the inhabitants, collected as they were led by interest, necessity, or inclination, from different parts of the world, are very much diversified. They have been charged with indolence, which is attributed partly to the relaxing heat of the climate, and partly to the want of the necessary motives to the excitement of industry. They are more advantageously distinguished by their open and friendly hospitality, particularly towards strangers. Their diversions are dancing, gaming, horse-racing, cock-fighting, and chiefly hunting. To this latter amusement the nature of the country is sufficiently favourable, the woods abounding with deer, racoons, rabbits, wild turkies, and other game, at the same time that they are commonly so thin and free from obstruction, as to throw no impediment in the way of the chace.

Civil constitution.

The civil constitution of Georgia, which was adopted and ratified by a convention of delegates from the people on the 6th of May 1789, is formed upon a plan similar to the federal constitution of the United States. According to it, all legislative power is vested in two distinct bodies, both of which are chosen by the people at large, and which are styled the General Assembly. These are the senate and the house of representatives; of the former of which the members are chosen for the term of three years, those of the latter annually. The senate consists of one member from each county, and the house of representatives of 34 members. The executive power is vested in a governor, who holds his office for the space of two years. It is decreed, that freedom of the press, and trial by jury, shall remain inviolate in the state, and that the benefits of the writ of habeas corpus shall be open to every one who may choose, or may have occasion to avail himself of these. The free exercise of their religion is at the same time guaranteed to all persons without exception, none moreover being obliged to contribute to the support of any religious profession but his own. A superior court is twice in each year to be held in the several counties, where all causes are to be tried civil and criminal, other than such as may be subject to the federal court, or as may by law be referred to inferior jurisdictions. The judges of the supreme court, and the attorney general, hold their commissions for three years, and have their stated salaries, which are fixed and secured to them by law. For the more convenient administration of justice, the whole state is divided into two districts, which are called the upper and the lower circuits. The number of judges appointed to sit in the superior court are two only, to each of whom it belongs also to try causes in the several circuits. Besides the superior court, there is an inferior one, viz. a court of common pleas, establishsd in each county, that sits twice in a year, with five judges, who are appointed by the legislature. The county courts have a jurisdiction in criminal causes, which are finally determined in the superior court. There are moreover the sheriff's court, and courts which are held by the justices of the peace in every part of the state.

Religious sects.

The religious sects of Georgia, are Baptists, Methodists, Presbyterians, Episcopalians, Roman Catholics, Quakers, and Jews. The two first are the most numerous, and inhabit principally the upper part of the state. The Episcopalians and Presbyterians are nearly equal in number. The Catholics and Jews have each of them one church. There are likewise some German Lutherans, and a society of Congregationalists.

Literature.

The literature of this state may be considered to be still in its infancy, though the measures adopted for its improvement have been such as to afford the most flattering prospects of ultimate success. The charter, containing the system of education to be followed out in it, passed in the year 1785. A college, with ample and liberal endowments, has been instituted at Louis-

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ville, a high and healthy part of the country near to the centre of the state, and provision made for the institution of an academy in every county, all which seminaries, in subordination to the principal, are to be supported from the same funds, and considered as the parts and members of one great establishment for the instruction of youth.

Diseases.

In the low country of Georgia, in the vicinity of the rice swamps, bilious complaints and fevers have been observed to be pretty general, especially during the months of July, August, and September, which for that reason are called the sickly months. Pleurisies, peripneumonies, and other inflammatory disorders, occasioned by sudden and violent colds, are prevalent, and not unfrequently fatal during the winter and spring. In the county of Wilkes, within a mile and a half of the town of Washington, there is a medicinal spring, which is said to be a sovereign remedy for the scurvy, scrofulous disorders, consumptions, gouts, and various other diseases. There is likewise at the distance from the sea of about 90 miles, on the way towards the mountains, a very remarkable bank of oyster shells. This runs in a direction nearly parallel with the seacoast, in three distinct ridges contiguous to each other, which together occupy a space of seven miles in breadth. These commence at the river Savannah, and have been traced to the northern branches of the Altamaha, furnishing, wherever they pass, an inexhaustible source of wealth and convenience to the neighbouring inhabitants, in the lime which they derive from them for building, for the making of indigo, or for other useful purposes.

Indian tribes.

The original population of the Georgian state consists chiefly of Muskogee or Creek Indians, Seminolas, Chactaws, Chicasaws, and Cherokees. The Muskogees have their residence principally in its middle parts, being the most numerous of the Indian tribes within the limits of the Indian states. Their numbers have been estimated to be little short of 20,000, of which a third is said to consist of fighting men. The country in which they are settled is hilly but not mountainous, the soil fruitful in a high degree, and well watered, their principal towns being situated in the Latitude of about 32°, and in from 86° to 87° W. Longitude. The Seminolas inhabit a level flat country on the Apalachicola and Flint rivers, possessed of similar advantages. The other tribes which have been mentioned, are found chiefly in the western parts of this state, much of which is still in their possession. Of these, the Chactaws, or flat heads, occupy a very fine and extensive tract of hilly country, with large and fertile plains, between the Alibama and Mississippi rivers. The Chicasaws are settled on the head branches of the Tombegbee and Yazoo rivers in the northwest corner of the state, where they have an extensive plain country, tolerably well watered from springs, and of a pretty good soil. The population of the former of these nations has been estimated at from 12,000 to 15,000 souls; and they have upwards of 40 towns and villages. The number of persons in the latter nation has been reckoned to be about 2000. They have seven towns, of which the central one is in Lat. 34° 23′, and in Long. about 90° 10′ W.

History.

It was in the year 1732, that the measure was meditated in England, of settling a colony between the rivers Savannah and Altamaha, with a view as well to the accommodation of poor people in Great Britain and Ireland, as for affording further security to Carolina It was proposed for this purpose to raise a fund, which should be expended in the conveyance of indigent emigrants to that part of America, free of expence. The plan was countenanced by humane and opulent men, through whose contributions and exertions it was quickly carried into effect. On application to his Majesty George II. letters patent were obtained June 9th, 1732. In November of the same year accordingly, 116 settlers were embarked for Georgia, under the conduct of General Oglethorpe, one of the trustees, and an active promoter of the measure; and soon after their arrival, in the beginning of the year 1733, the spot on which Savannah now stands was marked out as the most proper for the foundation of the settlement. Here, therefore, they proceeded to erect a small fort, with a number of huts for their accommodation and defence. A treaty of amity was concluded between them and their neighbours the Creek Indians, and various regulations were framed for their future government. In the formation of these, the general principle assumed was, that each inhabitant was to be considered as at once a planter and a soldier, who was of course to hold his portion of land as a military fief, and to appear in arms when the occasion required it for the public defence. That large tracts of ground might not accordingly, in the course of time, come to be occupied by the same person, nor the inconveniences be felt which in other colonies had been found to arise from great possessions, it was thought proper to limit the allowance of land for each family to 50 acres, which allotment, or any part of it, they were not to be permitted to mortgage nor to dispose of by will to their female issue. It was provided, that no man should depart from the province without a licence. Such parts of the lands granted by the trustees as should not be cleared, fenced round with a warm fence, or pales six feet high, within eighteen years from the date of the grant, were to revert to the trustees for the benefit of the colony. It was forbidden to use negroes, to import rum, or to trade with the Indians, unless in the case of a special licence being previously obtained for that purpose.

Georgia in America. History. A. D. 1732.

In consequence of the sentiments that came to be entertained at home, respecting the probable anticipated future importance of the settlement in Georgia, parliamentary aid had at different times been granted to promote the objects of the corporation. Additional settlers also were obtained, and these, for the most part, of a character and habits better adapted to the situation than those who had been at first introduced into it. The new comers were chiefly persons inured to labour and fatigue, from the Highlands of Scotland and from Germany, not like those who had preceded them, the idle and useless overflowings of cities and large towns. The accession of this valuable population was such, that within the space of three years, Georgia had received above 400 British subjects, and about 170 foreigners. Adventurers from Scotland, Germany, and Switzerland, still continued to follow their countrymen, contributing to sustain the hopes which the trustees had formed as to the permanence and prosperity of the colony. Several towns were built; and in 1739, more than 600 people were employed in trading with the Indians for furs and skins. It was eventually however found, that the system of government which had been formed for this colony, how pure soever might be the intentions of those by whom it was prepared, and how wise soever in their estimation, its provisions were in effect highly injudicious, and altogether incompatible with its prosperity. The alterations which it was judged necessary to introduce into it, though beneficial so far as they went, were not yet sufficient to render it even tolerably supportable; and the wars in which the province was involved with the Spaniards and Indians, and

A. D. 1739.

Georgia in America. the frequent insurrections among the people themselves, added still farther to the general confusion and wretchedness.

History. In 1741, it was notified to the English government,
A. D. 1741. that of the number of persons that had migrated to Georgia, scarcely a sixth part remained; and those who still continued, were so much discouraged, that they seemed to be desirous of fixing themselves in more favourable situations. The distressed and languishing state of the province was, by repeated complaints, represented to the trustees, who, weary of their irksome
A. D. 1752. and thankless charge, at length, in the year 1752, surrendered their charter to the king, and the province became a royal government. Notwithstanding the expence which had been incurred on account of it, the vestiges of cultivation were at this period scarcely perceptible in its forests; and the whole of the annual exports did not exceed £10,000 sterling. It still continued for several years more to struggle under many difficulties, arising from the want of credit with friends, and the frequent molestations of enemies. The benefits
A. D. 1763. of the peace of Paris, which took place in 1763, were, however, very sensibly felt here: the exports of that year
A. D. 1773. were but about £27,000; those of 1773 were little short of £122,000, while the population and agriculture of the state were proportionably increased. Georgia suffered a good deal during the war with Britain; and even after that was concluded, its progress in improvement yet lay under some checks and interruptions, from the disputes and hostilities in which it was involved with the Creek Indians; but a treaty of peace and friend-
A. D. 1790. ship having, in 1790, been entered into with that nation, it has since been rapidly advancing in all public prosperity. In consequence of an act of the legislature passed in 1795, twenty millions of acres of the Georgia western territory were sold to certain companies, and the purchase money, amounting to 500,000 dollars, was paid into the state treasury. This land was afterwards sold at an advanced price by the original purchasers, to various persons, principally of the middle and eastern states. This transaction produced a great degree of discontent: the ferment, however, afterwards subsided, without any thing having taken place which should shake the confidence of the purchasers as to their security, and the goodness of their title to the lands which they had thus acquired. See Morse's *American Geography.* (K)

GEORGIA, a country of Asia, situated between the Caspian and the Black Seas. Under this name were formerly comprehended also the states of Mingrelia and
Boundaries. Immertia; but it is now exclusively applied to the country made up of the four provinces of Cartuel, Kaket, Kisik, and the Georgian provinces of Armenia. Within these limits are contained the ancient Iberia, with a part of Armenia and Albania. On the north it is bounded by Mount Caucasus; on the north-west by a desert which separates it from Immertia; on the west and south by the Karagatich mountains and Mossian hills, which divide it from the Turkish and Persian provinces of Akiska and Erivan; and on the east by Daghestan and Shirvan. The face of the country is mountainous, diversified with extensive plains, and watered by innumerable rivers. The vallies are exceedingly fertile: cotton, and the finest European fruit-trees, grow here spontaneously; and rice, wheat, millet, hemp, and flax, are raised almost without culture. The hills are covered with forests of pine, oak, ash, beech, chesnuts, walnuts, and elms entwined with vines, which grow perfectly wild, and produce vast quantities of grapes. The rivers abound with the most delicious fish; poultry and game are frequent in the woods, and the pastures feed a great number of cattle. The air of this province is dry, very warm in summer, and very cold in winter. The fine weather commences in the month of May, and continues till November. Upon the whole, this may perhaps be truly characterised as one of the most beautiful and highly favoured regions in the world. Even the natives appear to approach nearer to perfection than those of other countries. The men are tall and elegantly formed, while the grace and beauty of the women are celebrated over all the east. — Georgia in Asia.

Of the four provinces which have been mentioned as constituting the state of Georgia, that of Cartuel, or, as it is sometimes called, Kartel, is on the east divided from Kaket by the Araqui; to the west it borders on Immertia; to the south on Akiska and Armenia; and northward it extends as far as the highest ridges of the Caucasus. It occupies both the banks of the Kur, and is known by the names of Semo or Higher Kartel, and Zemo or Lower Kartel. This is the province of the Georgian state which corresponds to the greater part of the ancient Iberia. The fine cities and handsome public buildings with which anciently that province was decorated, no longer remain. In consequence of the repeated revolutions to which it has been subjected since that period, and particularly through the destructive inroads of the Lesghaes, the face of the country has been completely changed, and its population almost exterminated. The few inhabitants who remain, are, as in ancient times, to be found in the southern and middle mountains of eastern Caucasus. They have their houses almost on the very tops of the hills, and live chiefly by agriculture. — Province of Cartuel.

The province of Kaket begins at the end of the plain 30 miles north-east of Teflis, near one of the front ranges of Mount Caucasus, and is bounded on the south by the adjoining province of Kisik. To the south of this latter province is the river Kur, and on the north and east it is encircled by the Alasan, which separates it from Shirvan and Daghestan. These provinces having formerly become subject to the King of Armenia, were given in fief to the noble Jewish tribe of Bargarut, from whom, it is said, are descended the Wallees of Georgia, Immertia, and the illustrious house of Bagration in Russia. Kaket was the only province which withstood the invasions of the Tartars and Lesghaes; hence it is covered with the ruins of villages, fortresses, and towns. The population, notwithstanding, is considerable. Together with the adjacent province of Kisik, it is stated to have contained, in the time of Reineggs, who visited and has given an account of these countries, to the amount of 18,000 families. The numbers have since, it is said, considerably increased, especially since the provinces fell under the dominion of Russia, the government of which has been at pains to repair the injuries sustained from the incursions of the neighbouring predatory tribes, and to collect the people from their scattered habitations. The province of Kaket is greatly in want of water, and the villages are often at such a distance from the springs, that the natives are under the necessity of alleviating their thirst by fruits or wine. This, however, does not affect the fertility of the country, as, unlike several of the other parts of this state, the gardens and fields here require no irrigation. — Of Kaket.

The Georgian province of Armenia has the hills of Karagatich to the west, the Mossian or Sissian hills to the south, and towards the north-east it is watered by — Of Armenia.

the river Kur. This is the best peopled and most flourishing of the provinces of this state, and it contains several towns. It has been long celebrated for its mines of gold, silver, lead, iron, and copper, as well as for its quarries of marble and jasper, the principal of which are those of Quoesch and Tamblutt.

The most noted of the Georgian rivers are the Kur, formerly known by the name of the Cyrus, which has its origin near Akiska. The Araqui, which rises near to the gates of Caucasus, flows to the south, and after dividing the southern range of Mount Caucasus into two equal parts, falls into the Kur at the town of Tagetta; the Kisia or Nachalir, which originates in the mountains of Karagatich; the river Alosan, the same which Strabo mentions under the name of Auxan; it traverses the province of Kaket, and forms part of the boundary between the states of Georgia and Shirvan.

The capital of Georgia is Teflis. This city lies in latitude 42° 45′ N. being at the distance from St Petersburgh of 2627 versts. It is situated on the N. W. side of the great plain at Karajoes, at the foot of a hill, and occupies both banks of the Kur, over which there is a bridge. It is called Thelestokar, (warm town,) from the warm baths in its neighbourhood, and was founded, according to an old inscription in the citadel, by a certain prince Surang in the year 1063. Before it was taken by Aga Mahomed Khan in 1797, it contained 4000 houses, and 22,000 inhabitants. The greater part of the houses are still standing, and are neatly built; but the population has suffered a reduction of not less than 7000 souls. While Georgia was an independent state, Teflis was for many years the residence of its prince Heraclius. It is at present that of the Russian governor and commander in chief, who has at all times a large force stationed in the city. These troops are quartered in the houses of the inhabitants, a circumstance which is far from being agreeable to them, and may lead to the most unpleasant consequences, as having the same ideas with regard to their women as are most generally prevalent among the eastern nations; they are naturally inimical, in an extreme degree, to any arrangement which may have the effect of exposing them to the view and to the familiarity of strangers. This is the only place in Georgia which is worthy of the name of city. There are, however, several other towns and villages, some of which, if of little importance in themselves, have acquired an interest as being the chief military positions occupied by the Russians in the course of their recent rapid encroachments towards the frontiers of Persia. In the province of Kaket, and about 16 miles to the N. E. of Teflis, is Mandropi, an opulent and well inhabited town. Kudala, Melani, and Magara, in the same province, though once flourishing cities, are now reduced to the state of wretched villages. Gori is a small town near the source of the Kur. Suram is situated on the western frontier of Kartel towards Kariska, and stands on the river Surmela, being defended by a strong hill fort. In a plain near the junction of the Kur and the Arakui are the remains of the city of Tsgetta, which has a most advantageous position on the frontiers of Armenia, Albania, and Iberia. It is supposed to have been founded by the Greeks or Romans, and to have been the place chosen by Pompey for keeping in check the restless spirit of the Albanians after that people had become subject to Rome. According to the Georgian histories and traditions, it was also the most ancient city in the kingdom at the time that it was converted to Christianity. Anamer, seated likewise on the banks of the Arakui, contains nothing remarkable but an old stone church, and a convent in ruins. Akdall stands on the river Tebete, a city once famed for its beautiful buildings, and where are still to be seen the splendid remains of the palace of Prince Allodius. Old and New Kremm are well situated towns, of which, however, the population is now greatly diminished. The fortress of Tellow is impregnable to an enemy unprovided with artillery. Bembeek is a small town, capital of a district of the same name, situated in the southern part of the state. About 70 miles farther to the westward is Gaucha. Both of these, from their contiguity to the Persian province of Erivan, are principal military stations of the Russians in Georgia.

The provinces into which the Georgian state is divided formerly constituted different principalities, which were governed by their own princes, in subordination to the Persian empire. Amidst the shocks that were afterwards sustained by that power, these took the opportunity of rendering themselves independent; and the authority which had been for a time lodged in separate hands, was ultimately engrossed by Prince Heraclius alone of the Kakhettian dynasty. This prince or czar, who is celebrated for his bravery and other great qualities, as well as for the important part which he acted during the disturbances that agitated Persia after the death of Tamas Kuli-Khan, submitted, in the year 1783, to the Russian empire, thus voluntarily sacrificing, for the sake of protection, that independence which his exploits seemed to have secured. Notwithstanding, however, his close alliance with this power, he was forced, in 1787, to renounce his connection with it, and to acknowledge himself tributary to the Porte. More recently the Russian interest has again prevailed, and the sons of Prince Heraclius, having been deprived of their inheritance, the whole of this delightful province became subject to the dominion of the Russian emperor. In February 1801 it was, by a public ukase, united to his dominions. On the accession of Alexander, the same year, the annexation was confirmed, and next year (1802) formally announced to the Georgians. The provinces of Kartel and Kaket have, since that period, been divided into five districts, viz. Ghori, Thelawi, Duschethi, Lori, and Ssignachi. The presidencies in the courts of judicature are intrusted to native Georgians, and civil causes decided according to the laws of the country. In 1803 Prince Zizianow took the command of the Russian forces in Georgia, and soon after reduced the Sesgians of Belucan and Dschari. It was in this year that the widow of King Georgi, the last of the Georgian sovereigns, stabbed the Russian major-general Lasarew, when imparting to her the emperor's command to repair to Russia. In 1804 Gandscha was taken by storm, and Solomon, King of Imerethi, placed himself and his dominions under the protection of Russia. About the same time, a small force was detached to occupy Mingrelia, which had submitted in 1803.

An expedition was undertaken against the Persian province of Armenia, and Prince Zizianow, after some important successes, formed the blockade of Erivan. The Persians, however, being suddenly and strongly reinforced, compelled him to abandon the enterprise, and to confine his future operations to the frontiers of Georgia. He chastised the Ossetes, and added Neichi and Schuschi to the imperial dominions.

The annual revenue of the province is 800,000 rubles, which is partly expended in the salaries of civil officers. The surplus has been hitherto generously con-

Georgia in Asia.

signed to the relief of the most necessitous of the inhabitants.

Inhabitants.

The Georgians, or, as they are sometimes called, the Grusinians, have avoided all commixture with the Tartars, and have ever distinguished themselves as the most numerous and powerful body of the mountaineers of Caucasus. Their manners and customs resemble in some degree those of their neighbours the Persians. They are brave but ignorant, and indolent in the extreme, scarcely earning themselves a subsistence, even in their very rich and productive country. They are chiefly in repute as soldiers, in which respect they are, perhaps, not surpassed by any other of the Asiatic nations. They excel particularly in the use of the bow. The only virtue of the men, however, is said to be courage, while the women, so much praised for their beauty, love to adorn themselves with paint, and are not in high estimation for their modesty. Both men and women are said to be addicted to intoxication, and to indulge freely in the use of strong liquors.

It is a principle established by the laws of war recognised in Turkey, that any revolted province should be given up to pillage, and the inhabitants reduced to a state of slavery. In consequence of this custom, which has been generally prevalent throughout Asia, the market of Constantinople has been supplied with slaves from Georgia and Circassia. Those supplies have likewise been, in great part, furnished through the Leaghai Tartars, who, situated between the Caspian and Black Seas, and in the vicinity of both those states, are continually at war with them. They carry over to the eastern coast of the Black Sea, the slaves whom they take in the course of their incursions, and sell them to the Turkish merchants, who come thither at stated times with a view to the traffic. The inhabitants of this same coast, likewise, seize on their countrymen in the neigbouring villages, and sell them. Children also have sometimes been sold by their parents, and wives by their husbands.

Trade.

Georgia has but little trade. A part of the wine which is made in the country is sold into Armenia and Persia, especially to Ispahan, for the king's table; and silk forms a considerable article of commerce with Erzeroom, though the inhabitants are unacquainted with the best method of winding it.

The nobility, which are here numerous, and possess an unlimited power of life and death over their vassals, treat them with the utmost harshness, levying a tax on the farmer to the amount of at least half the produce. This system, in addition to the sanguinary irruptions from the neighbouring states or tribes, has naturally had the effect of checking the prosperity of the country, and wasting its population. The number of its inhabitants is said not to amount to more now than about 320,000 souls.

Religion.

The religion of Georgia, when anciently it formed one distinct and independant kingdom, was Christianity: with this Mahometanism has, since the year 1639, been blended, the king of Persia having at that time conquered the country, and divided it into provinces, obliging the people to embrace the Mahometan faith. From the time that they have been under the protection of Russia, they have again, however, avowed themselves Christians, following in part the rites of the Armenian, but chiefly those of the Greek church. They are represented, indeed, as not being very tenacious as to those matters. The rest of the population consists of Jews, Tartars, and Russians, each tribe having its peculiar dialect. See Kinneir's *Geographical Memoir of the Persian Empire*; Klaproth's *Travels*; and Tooke's *View of the Russian Empire*, vol. I. (K)

Georgia Island.

GEORGIA, (New or South,) an island in the south Atlantic Ocean, discovered by La Roche in 1675; seen by Mr Guyot, in the ship Leon, in 1756; and explored with much attention, in 1775, by Captain Cook, who named it Georgia in honour of his majesty. This island is situated between 53° 57′ and 54° 57′ south latitude, and between 35° 34′ and 38° 13′ west longitude. It extends south-east by east, and north-west by west, being in that direction 31 leagues long, while its greatest breadth is about ten leagues. In the approach to this island by the last mentioned navigator, there was first discovered in south latitude 54°, and west longitude 38° 23′, a high rock of no great extent, to which was given the name of Willis's Isle. In the vicinity of this, there were some other rocky islets; and to the eastward about two miles, nearer to the main, was perceived a separate island, which, from the great numbers of birds that were seen upon it, received the name of Bird Isle. This, which was not so high, was of greater extent than Willis's Isle. The passage between these two islands having been cleared, and after a progress along the coast, first for about nine miles in the direction of east by north, and then for eleven miles more on an east and east-southerly direction, Cape Buller was gained, and at the distance of four or five miles from it, a bay to which was then given the name of Possession Bay, situated in 54° 5′ south latitude, and 37° 18′ west longitude. The land in which this bay lies was at first judged to be part of a great continent, but upon coasting round the whole country, it was found to be an island about 70 leagues in circumference. The first projecting point which had been fallen in with, in making this circuit, was one in the immediate vicinity of Bird Island, to which had been given the name of Cape North. Also between Cape Buller and Possession Bay there intervenes the Bay of Isles, so named from several small isles lying in and before it. To the projecting land, which next occurred after passing Possession Bay, and which lies from Cape Buller at the distance of 11 or 12 leagues, was given the name of Cape Saunders, beyond which is a pretty large bay which was called Cumberland Bay. In several parts in the bottom of this, as also in some other bays lying between Possession Bay and Cape Saunders, there were vast tracts of snow or of ice not yet broken loose. Further onwards a jutting point which terminated in a round hillock, was named Cape Charlotte, the bay to the westward of it Royal Bay, and its most westerly point Cape George. This last is also the east point of Cumberland Bay, lying from Cape Saunders in the direction of south-east by east, at the distance of seven leagues. Its distance from Cape Charlotte is six leagues. In the direction from Cape Charlotte of south by east, and eight leagues distant, is an island which received the appellation of Cooper's Isle. This is a rock of considerable height, and about five miles in circuit. The coast between this and the just named cape forms a large bay, which was denominated Sandwich Bay. At Cooper's Isle the main coast takes a south-west direction, for the space of four or five leagues, to a point which obtained the name of Cape Disappointment. Off this there are three small isles, the southernmost of which is green, low, and flat, and lies at the distance from the cape of one league. Still further onward in the same direction, and at a distance of about nine leagues, there occurs an island which was named Pickersgill Island, beyond which a little way a point came in sight that exactly united with the part of the coast that had been first seen, and from which the departure had been taken in the circumnavigation, by which the insular character of Georgia was now fully proved.

From what was observed of Georgia in the progress around it, it would appear to abound with bays and harbours, particularly on the north-east coast. These, however, from the great quantity of ice, either within themselves, or in the vicinity, must, for the greatest part of the year, be rendered inaccessible, or at least in respect of the occasional breaking up of the ice-cliffs, they can afford but a very insecure station for ships. The whole coast in general, particularly the south-western parts of it, were observed, notwithstanding that it was then the height of summer, to be in a manner wholly covered, even to the depth of many fathoms, with frozen snow. The sides even, and craggy summits of the lofty mountains, were cased with snow and ice, while the coast at the bottom of the bays was terminated by a wall of ice of considerable height, and the quantity of snow that lay in the vallies was quite incredible. There seemed reason to believe, that though a great deal of ice might be formed upon, or around the island during the winter, which in spring might be partly broken off and dispersed over the sea, yet so little of the quantity that was actually seen there could be so produced, that there must be somewhere, at no great distance, a much more extensive tract of land, though not then discovered, or otherwise the ice must be formed independently of any connection with land. The dangerous nature of the navigation in the circumstances alluded to may easily be conceived. Indeed it is mentioned that from the ice-cliffs, situated at the head, and on each side of one of the bays, pieces were continually breaking off, and floating out to sea, and that the noise from a great fall that took place while our navigators were there, was like that of discharged cannon.

It is stated as a remarkable circumstance in regard to this island, that upon the whole of its coast there was not observed any where a single river, or even so much as a stream of fresh water. The conclusion to which this appearance not unreasonably led, was, that there are in the country no perennial springs, while the interior parts, from their great elevation, never enjoy heat enough to admit of the snow being melted in such quantity as to produce a river or stream of water. Indeed, it is on the coast alone that there is, at any season, a sufficiency of warmth to melt the snow, and that too only on the north-east side; for in the other parts, not only are the sun's rays in a great measure excluded by reason of the uncommon height of the mountains, but even the cold south winds, to which they are so much exposed, might almost of themselves be sufficient to prevent this taking place.

So far as the interior parts of Georgia were observed, the appearance which they exhibited was found to be not less savage and horrible than that of its coast. The wild rocks raised their lofty summits till they were lost in the clouds, while the vallies lay covered with everlasting snow. Not the vestige of a tree, or even of the minutest shrub, was to be seen. The only vegetation that was discovered, was a coarse strong-bladed grass, growing in tufts, wild burnet, and a plant like moss, which sprung from the rocks.

Of animals, seals or sea bears were observed to be pretty numerous; the shores, indeed, even swarming with their cubs. There were also seen several flocks of penguins, of a very large size; some of them that were killed weighing not less than from 29 to 38 pounds. These were of the class of penguins which had previously been noticed at Falkland islands. The oceanic birds were albatrosses, common gulls, likewise that sort of them to which has been given the name of Port Egmont hens, terns, shags, divers, the new white bird, and a small bird like those of the Cape of Good Hope, called yellow birds, which were found to be most delicious food. The only land birds that were observed, were a few small larks. No quadrupeds were seen, nor any vestige met with of the existence in the island of any, except some dung, which it was judged might have proceeded from a fox or some such animal. Though the lands, or rather the rocks, bordering on the sea-coast, were not like the inland parts, entirely covered with snow, the only vegetation that could be seen on the clear places, was the grass already mentioned. These rocks seemed to contain iron. They are of blackish horizontal slate, probably approaching to hornblende. See Cook's *Second Voyage*, vol. ii. (K)

GEORGIUM SIDUS. See ASTRONOMY, page 649. The new discoveries relative to this planet will be found under URANUS, the name which is now universally adopted among astronomers to designate this celestial body.

GERA, is a town of Saxony, and capital of the estates of the count of Reuss. It is situated in a pleasant meadow on the right bank of the river Elster. The town, which is well built, was destroyed by a dreadful fire, but has been rapidly recovering its importance. The manufactures of this town are so numerous and flourishing, that it has received the name of *Little Leipsic*. They consist principally in woollen stuffs, and of stuffs made of wool and silk, which are well known by the name of stuffs of Gera. The musical instruments manufactured here by M. Frederici, have been greatly esteemed. The house and residence of the Count of Reuss is near the town. The baths of Rennebourg are about 1¼ leagues from Gera, and are situated in a charming country, in which both nature and art have combined their embellishments.

The meadow on which the town stands, is surrounded on the east and the west by fertile mountains, and profitable forests, which produce plenty of wood both for carpentry and fuel, as well as excellent building and paving stones, lime, gypsum, and other valuable minerals. Game and fish abound in the neighbourhood. Gera is a great thoroughfare, as the great roads of Leipsic pass through the town.

GERMAIN EN LAYE, ST. a town of France, in the department of the Seine and the Oise, situated on high ground on the western bank of the Seine. The chateau or palace, which was erected by Francis I. and enlarged by several succeeding kings, is an ugly building surrounded with a fosse, and built chiefly of brick. It has for some time been used as a military school; but in 1814, when visited by the writer of this article, this establishment was removed to some other place. On one side of the palace is the front of a superb church, which has never been completed. The view from the terrace is most extensive and magnificent, the ground before it up to Maisons sloping beautifully down to the river. The principal manufactures in this town are those of leather and skins, similar to those of Liege and Rheims. Population 9000.

GERMANY.

Germany.

GERMANY is divided among such a number of sovereigns native and foreign, and its natural boundaries are so obscurely marked, that it is difficult, and at first sight seems improper, to describe it as a single country. But when it is considered, that, in respect to name, language, and inhabitants, it possesses a unity of character, from which it derives a fair and solid claim to occupy a separate place among the divisions of Europe, and that although its extreme limits are not easily ascertained, the great mass of which it is composed is sufficiently identified, we trust we shall be justified in making it the subject of a separate though short article.

Division of the subject.

In order, however, that this article may not repeat or anticipate what the reader will naturally look for under the heads of AUSTRIA, BAVARIA, HANOVER, PRUSSIA, SAXONY, and the other states of Germany, we shall confine it to the three following points: I. A brief description of ancient Germany, and of the manners, &c. of its inhabitants; II. The principal revolutions and events of the Germanic empire, as separate and distinguished from the respective histories of Austria, Prussia, &c.; and lastly, an outline of the statistics of Germany.

Ancient Germany.

I. Ancient Germany was divided on the west by the Rhine, from the Gallic provinces of the Roman empire; and on the south by the Danube, from the Illyrian provinces of the same empire. It was divided and protected from Dacia or Hungary, by a ridge of hills called the Carpathian mountains, which rose from the Danube. The Hercynian Forest, at that time reckoned impenetrable, and a frozen ocean, described by the ancients as lying beyond the Baltic, if by it they did not mean the Baltic itself, were the limits of Germany on the north and north-west. On the east the boundary was still more faintly marked, or rather, it was frequently varying and confounded, by the mixture of the wavering and confederate tribes of the Germans and Sarmatians. From this description of the boundaries of ancient Germany, it will be seen, that, independently of the province westward of the Rhine, which appears to have been a colony of Germans settled within the limits of Gaul, it extended itself over a third part of Europe.

Tribes that inhabited it.

Our most accurate, full, and important information respecting ancient Germany, is derived from Tacitus. This author first mentions two colonies, the Helvetii and Boii, which had returned from Gaul into Germany. The Vangiones he describes as living on the west side of the Rhine; and the Batavi, in the isle formed by the outlets of that river. Beyond the people between the head of the Danube and the Rhine, he places the Catti; and further up on the Rhine, the Usipii, &c.; next the Bructeri; behind them the Dulgubini; and in front the Frisii. After this he mentions, that the coast of Germany turns to the north, which it does at Friezeland and Groningen. This circumstance sufficiently determines the positions of the tribes hitherto mentioned. Next he mentions the Chauci; then the Cherussi and Fosi; the remains of the Cimbri, so formidable and numerous before the time of Tacitus, but when he wrote *parva civitas*, seem to have inhabited the country near the mouth of the Elbe. The Suevi, divided into many tribes, occupied the greatest part of Germany, viz. all from the Danube to the ocean, south and north; and from the Elbe to the Vistula, west and east. The first tribe were the Semnones, who inhabited Brandenberg; then the Longobardi, in Lunenberg. Seven small tribes follow next, who seem to have occupied the peninsula of Jutland. Among these were the Angli. Having thus proceeded to the utmost north of the west parts of Germany, Tacitus proceeds to the description of the nations along the banks of the Danube: the principal of which were the Hermundurii; then the Narisci about Nuremberg; the Marcomanni, whose country anciently reached from the Rhine to the head of the Danube, and to the Necker, but who afterwards went and settled in Bohemia and Moravia, and some of them in Gaul, whence they forced the Boii to return into Germany. The Quadi were situated next to Bohemia, extending from the Danube to Moravia, and the northern part of Austria. After mentioning the remotest nations in this direction, Tacitus returns northward, informing us that a large chain of mountains divided Suevia, beyond which were the Lygii, consisting of many nations. They inhabited the present Silesia; above these were the Gotthones, at the mouth of the Vistula; next from thence on the ocean, were the Rugii, in Rugen; then the Lemovii, who appear to have dwelt to the west of the Rugii, and hence probably near Lubec. After this Tacitus proceeds to the Suiones, who, by most geographers, are considered as the Swedes, but, as Pinkerton contends, more probably the inhabitants of the Danish islands in the Baltic. After the Suiones, Tacitus passes to the Estii, whom he describes as situated on the right hand, as you sail up the *Suevicum Mare*, or probably in the peninsula beyond the present Dantzic. The Sitones seem to have been the present Swedes; and the Fenni, the inhabitants of Livonia. Such, according to Tacitus, were the principal tribes that inhabited ancient Germany in his time.

The ancient Germans were distinguished by their blue eyes, red hair, and large stature. Their children were always kept naked and dirty; every mother suckled her own infants, and did not commit them to the care of maid-servants or nurses. There was no distinction in the mode of rearing the master and slave. They lived among the same cattle, and lay on the same ground, till age caused them to be separated, and superior valour marked out the free born. They were not permitted to marry early in life: the more numerous a person's kinsmen and relations by marriage were, the more comfortable and respectable was his old age: it was no advantage, but rather considered a misfortune and disgrace, to be childless. The uncle, by the mother's side, regarded his nephews with the same affection as their father: every man's children were his heirs and successors, without any testament: if there were no issue, the brothers of the deceased inherited the property, and then his uncles, by his father's or mother's side. The ancient Germans were utterly ignorant of arts and agriculture. Tacitus expressly says, that in his time they had no cities; and though Ptolemy reckons up 90 places, which he calls cities, in all probability they were only rude fortifications, erected to secure the women, children, and cattle, while the men were engaged in warfare. They had not even regular and connected villages, but each individual fixed his dwelling where it suited his convenience, or pleased his fancy. Neither stones, nor bricks, nor tiles, were employed in erecting their habitations. They were equally rude and ill supplied with respect to their government. The clothing used by all the Germans was a loose mantle, fastened with a clasp, or, when that could not be procured, with a thorn. The rich, however, sometimes were clothed in a garment, girt close, and shewing the shape of every limb. The tribes who dwelt towards the north, clothed themselves in furs: the dress of the women was not different from that of the men, except that they sometimes wore linen robes of their own manufacture, and adorned them with purple. The principal employment of the men, in time of peace, consisted in hunting the various sorts of game, with which the forests of Germany were plentifully stocked: their herds of cattle formed the principal object and source of their wealth. The country, though considerably varied, was in general covered with woods, or deformed by marshes; and the indolence and ignorance of the inhabitants prevented them from rendering any large portion of it fit for the growth of corn. Gold, silver, and iron, were extremely scarce: the scarcity of iron appeared from their weapons, which, for the most part, were spears tipt with a short and narrow piece of iron. With this spear, and with a shield, their cavalry went to battle. The infantry had also missile weapons, which they threw to a great distance, with wonderful force and unerring aim. Their warriors were either naked, or dressed in a loose and light mantle. Their shields of wood, or osier, were distinguished and ornamented with a variety of colours; some of the chiefs wore cuirasses, and a few helmets. Their horses were slow, unmanageable, and not remarkable for their beauty. On their cavalry, therefore, they seldom placed much reliance in the hour of battle, their principal strength in general consisting in their infantry, which were drawn up either mixed with the cavalry, or in several deep columns by themselves. They fought by families and clans; and while they fought, they were encouraged by the presence of their wives and children. Their mothers and wives dressed their wounds; carried refreshments to them while fighting; and exhorted them to deeds of bravery. Their armies were totally devoid of discipline; they rushed to battle with dissonant shouts. Sometimes, by their native valour, they prevailed over the disciplined troops of the Romans; but they knew not how to rally or retire; a repulse was a sure defeat; and when they were defeated, the destruction of their army almost inevitably followed.

The ancient Germans in general enjoyed great freedom; there were, however, some exceptions. Tacitus informs us, that among the Suiones riches were held in honour; and that they were therefore subjects to an absolute monarch, who, instead of entrusting his people with the free use of arms as in the rest of Germany, committed them to the custody of slaves. The same historian mentions, that the Sitones were sunk even below servitude; they obeyed a woman! The rest of the German tribes either had no king, or chose their kings solely on account of their nobility and valour. The power of the former was restrained and defined by law or usage; and the latter commanded rather by example than authority. As soon as a youth, born of free parents, attained the age of manhood, he was admitted into the general council of his nation, invested with a spear and shield, and henceforth regarded as a member of the commonwealth. This general council met either at stated periods, or on sudden emergencies. To it was entrusted the trial of public offences, the election of magistrates, and the concerns of peace and war. Sometimes a select council prepared the business for the assembly; but the executive power was vested exclusively in the people. The applause of the assembly was generally signified by a loud clashing of shields and spears. The magistrates were chosen from a regard to birth and merit. To each was assigned a guard, and a council of one hundred persons. The disposal of the landed property within their district was absolutely vested in their hands, and they distributed it every year according to a new division; but they were not permitted to punish with death, to imprison, or even to strike a private citizen, except such magistrates as had the command in time of war. None but the priests were permitted to put to death, to bind or to scourge, in order that punishment might appear to proceed from the gods, and not from their fellow-citizens.

Their chiefs were desirous of being surrounded by youths of noble birth, and tried valour; and the youths of this description were no less anxious to be numbered among the faithful companions of some renowned chief. In the hour of danger, it was shameful for the chief to be surpassed in valour by his companions, and disgraceful to them not to emulate the behaviour of their chief. To outlive his fall in battle was infamy; while to protect his person was their pride and honour. In time of peace, the chiefs sent their companions into some distant country to acquire renown. The horse, or the lance, were the rewards of valour and enterprise, which the companions expected and received. At his board they were entertained; this was their only pay.

Religion.

The ancient Germans had no temples, but performed their religious rites in groves, or in woods, forests, and desert places. They adored the sun, the moon, the fire, and the earth. Jupiter was worshipped under the name of Thor, or Thoran, the Thunderer. Odin, or Wodin, appears to have been their Mars, or god of battle. The supreme deity was worshipped under the name of Esus, or Hesus, and under the emblem of an oak, which was consecrated to him. They had no druids, though their priests bore some resemblance to them in several points of their authority. The priests exerted the influence which they possessed over the fears and superstition of their countrymen, frequently to very useful purposes. They maintained silence and decency in the popular assemblies; and during a solemn procession of the goddess Ertha, the sound of war was hushed, quarrels were suspended, arms laid aside, and the blessings of peace and harmony were enjoyed. In war too, the influence of the priests was conspicuous. The consecrated standards, which during peace were kept concealed from the vulgar eye in the recesses of the sacred groves, were placed in the front of the battle; and the army of their enemies was devoted in the most solemn manner to the gods of war and of thunder. They were taught by their priests, that a brave man was the favourite of their gods; while the coward, who had lost his shield, was devoted equally to contempt and banishment in this world, and shut out from the enjoyments of a future state. A life spent in arms, and a glorious death in battle, they were taught assuredly led to a happy futurity, either in this or in another world. The Germans paid the greatest attention to omens, particularly to that species of divination that was performed by means of twigs, marked in a particular manner, and laid on a white cloth. One presage of futurity, Tacitus says, was peculiar to them, that derived from the neighing of horses; but this was also much

Germany.

regarded by the Persians; and perhaps may be regarded as an additional proof of the opinion, that the Goths, and consequently the Germans, originated in Persia. Another kind of divination, to which they had recourse in wars of doubtful issue, was to oblige a captive of the enemy to fight with one of their countrymen: the event of the war was supposed to be foretold by the issue of this single combat.

Marriages.

The ancient Germans in general did not practise polygamy; and even when their princes married more wives than one, it was done only for the sake of multiplying their alliances. There was no law prohibiting divorces, but the force of example and customs rendered them extremely rare. The adultress was whipped through the village; and neither wealth nor beauty could save her from this punishment, or procure her a second husband. The Germans treated their women very differently from other barbarous and ancient nations; regarding them with esteem and confidence; consulting them on every occasion of importance, and believing that they were inspired by the gods with a larger portion of sanctity and wisdom than had been bestowed upon the men. The funerals of the Germans were remarkable for their plainness, and freedom from pomp and show; only the bodies of illustrious men were burnt with certain kinds of wood. The funeral pile was not, as among the Romans, covered with garments and rich perfumes. The arms of the deceased, and sometimes his horse, were committed to the flames. A mound of earth was reared for his tomb: they then deposited the ashes in urns. The passion of the ancient Germans for play was extremely powerful. In their sober moments they applied to dice, as to a serious and important concern, and with such resolved and blind eagerness to gain or lose, that when every thing else was gone, they risked their liberty and persons on the last throw. The loser, though more powerful or more noble than the winner, submitted to voluntary slavery, and suffered himself to be bound and sold. Still, however, notwithstanding the strong and general prevalence of the spirit of gaming, some shame was attached to it, which induced the winner, as speedily as possible, to dispose of the slave he had acquired in this way, by commerce, in order to wipe off the scandal of the transaction. The slaves of the Germans were much better treated, and of a higher class than the slaves of the Romans; each had his own dwelling; he was indeed bound to give his master, from the fruits of his own labour, a certain portion of grain, and a certain number of cattle; but when he had given these, his labour was his own. As soon as the ancient Germans rose from sleep, which they seldom did till broad daylight, they first bathed, generally in warm water; they then sat down to their meal, each on a distinct seat, and at a separate table. Their drink was a liquor extracted with very little art, from wheat or barley, and fermented to a spirit. Those bordering on the Rhine, purchased wine: their food was simple, consisting of wild apples, venison, or coagulated milk. They were temperate in what they ate, but quite the reverse in what they drank.

Funerals.

Fondness for gaming.

Slaves, &c.

Such were the ancient Germans; and their manners are not only interesting, as exhibiting the state of a people before they emerged from barbarism; but the contemplation of them is instructive in more than one respect. In the first place, we may clearly trace among the Germans that respect for the female sex, which so decidedly and honourably distinguishes the modern nations of Europe, from the Greeks and Romans. In the second place, even amidst the forests of Germany, as has been frequently remarked, the germs of civil liberty—of that enlightened liberty which Britain enjoys—may be traced; and lastly, among the same people, evidently existed many institutions remarkably similar to the institutions of CHIVALRY, as has already been shewn under that article.

II. Before proceeding to a sketch of the principal revolutions of the Germanic empire, it may be proper to premise a very brief and rapid view of the more prominent and important points in the history of Germany before that empire was formed.

Historic sketch of them.

The invasion of Italy by the Cimbri and Teutones; their defeat by Marius, A. M. 3909; the invasion of Gaul by the borderers of the Rhine, under Arioristus, and their defeat by Julius Cæsar, A. M. 3950, are almost the only events of consequence in the history of Germany, before the Christian era, of which we have any certain account. When Cæsar had completed the conquest of Gaul, he divided it into the Celtic, the Aquitanic, and the Belgic provinces; in the last, all the German provinces on the left side of the Rhine were comprised. In the reign of Augustus, a further division took place, and the country lying between the Meuse, the Scheldt, and the Rhine, was separated from Belgic Gaul, and formed into a province, called Germania cis-Rhonanas. In A. M. 3995, the famous Arminius, at the head of the Cherusci, massacred three Roman legions under Varus, between the Lippe and the Ems. In the third century of the Christian æra, the German tribes formed different associations for their common defence against the Romans. Of these the most remarkable were the Saxons, comprising those who dwelt on each side of the Elbe; the Alemanni, formed by the nations between the Rhine, the Mayne, and the Lech; the Francici, by the nations between the Rhine, the Mayne, and the Weser, and the Thuringians, by the nations between the Mayne, the Danube, and the Hartz. Charlemagne was the first who united Germany under one sceptre. The name of Oriental France, may be traced in Franconia; the people of Hesse and Thuringia were incorporated by a similarity of religion and government. The Alemanni still continued the faithful confederates of the Francs. The hereditary dukes of Bavaria, having repeatedly revolted against the emperor, their power was shared among the counts of the empire. The north of Germany from the Rhine, and beyond the Elbe, was still hostile and pagan; but after a war of thirty-three years, the Saxons were subdued and converted. Beyond the Elbe, the Slavi occupied modern Prussia, Poland, and Bohemia; the first union of the last of these countries with the Germanic body, took place under Charlemagne. Soon after the reign of this monarch, his empire was divided; and one of his grandsons, Lewis the German, obtained for his share all Germany from the Rhine to the Oder, and the three cantons of Mentz, Spire, and Worms. These were called Francia Orientalis, and afterwards the kingdom of Germany. Till the reign of Charles the Bald, the Teutonic or German was the language of the court. In his time, the Romanic, afterwards called the French language, came into use. The three kingdoms were reunited in Charles the Fat; but when he was deposed by his subjects, they were again separated. From the confines of the kingdoms of France and Germany, two new kingdoms arose; viz. Lorraine and Burgundy; the former comprehended part of Ger-

Their associations.

Charlemagne.

Division of his kingdom.

many, viz. Alsace, the Palatinate, Treves, Cologne, Juliers, and Liege. Soon after the division of the empire of Charlemagne, the feudal system gained a consistency and firm footing, so that by degrees it overpowered the influence and authority of his descendants. In consequence of the weakness of the Carlovingian princes, the dukes and counts converted their hereditary possessions, which they parcelled out among their barons, and those among their vassals. The principal of these in Germany were the Dukes of Franconia, Saxony, Bavaria, Suabia, and Lorraine. These usurpations, joined to the incapacity of the Carlovingian princes, caused the house of Charlemagne to decline rapidly. In Germany, on the abdication of Charles the Fat, the people, from respect to the memory of Charlemagne, placed the crown on the head of Arnold, a natural son of Carloman, and after the decease of Arnold, on Louis, his son. On the death of Louis, they elected a duke of Franconia for their king, and then a Saxon line of princes.

...erors of ...ouse of ...ny, ...911— ...1024.

The Emperors of the house of Saxony reigned from A. D. 911, to A. D. 1024. They were Henry I. surnamed the Fowler; Otho I. surnamed the Great; Otho II. Otho III. and Henry II. During the period that the throne was filled by the Saxon Emperors, the limits of the empire were extended, chiefly by Otho the Great. A portion of Gaul, to the west of the Rhine, along the banks of the Meuse and the Moselle, was assigned to the Germans. Between the Rhine, the Rhone, and the Alps, the successors of Otho acquired a vain and doubtful supremacy over the kingdoms of Burgundy and Arles. In the north, the Slavonic nations of the Elbe and Oder were subdued. The marches of Brandenburg and Sleswic were colonized by Germans; and the King of Denmark, and the Dukes of Poland and Bohemia, became the tributary vassals of Otho the Great. The same monarch subdued the kingdom of Italy, delivered the pope, and fixed the imperial crown in the name and nation of Germany. From that era, A. D. 962, two maxims of public jurisprudence were introduced: 1. That the prince, who was elected in the German diet, acquired from that instant the kingdoms of Italy and Rome; and, 2d, That he could not legally assume the titles of Emperor and Augustus, till he had received the crown from the hands of the Pope.

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With respect to the principal states which composed Germany during the reign of the Saxon Emperors, a considerable portion of that part of Germany which lies on each side of the Mayne, was known by the various appellations of Nova Francia, Francia Orientalis, Francia Teutonica, Ostrofrancia, Austrasia, and Franconia. The space between this part of Germany and the Upper Elbe, called Saxonia, and Alemannia, was occupied by the Thuringians. At this period, the Saxons had left the Oder, and were spread from the Elbe to the Ems, reaching Francia and Thuringia on the south. The country between the Weser and the Meuse was called Frisia; that between the Rhine and the Meuse, Austrasia; the tract lying between the Rhine, the Necker, and the Lech, was divided between the Suevi and the Alemanni; and the country between the Lech, the Alps, and the Anisa, was called Boisaria, the modern Bavaria. On the east of this was Austria. Moravia was called Austria Maharensis; modern Bohemia was called Boheim.

Cities.

It has already been mentioned, that in the time of Tacitus, the Germans did not live even in villages; as, however, they spread themselves over the country on the west of the Rhine, they began to inhabit villages, and even to construct towns; so that at an early period, after the Triboci, Nemetes, and Vangiones, settled in the country between the Rhine and the Vosges, the cities of Strasburgh, Spire, Mentz, and Worms, are mentioned. Under the Francic sovereigns, cities were multiplied; and by Henry the Fowler, they were particularly encouraged by a singular institution. From the troops stationed in Germany, he chose every ninth soldier; the remaining eight were to sow and till the land, and to carry the produce to the ninth, whose business it was to build habitations for himself and his companions. By degrees, the lower order of the people united themselves to these soldiers; and the Emperor ordered the courts of justice, fairs, tournaments, &c. to be held in the cities they constructed. His example was followed in the other parts of Germany, so that in a short time it scarcely contained a district of any extent, which had not its city. To each of them exclusive privileges were granted; the most important of which were the *jus stapulæ* and the *jus geranii*; by the former, all commodities brought into them were exposed to public sale; by the latter, all commodities imported or exported, were to be weighed or measured by the public weights or measures of the city, for which it was entitled to a duty. At first, the chief magistrates were of noble birth; but by degrees, the chief offices were opened to the people at large. Thus, soon after the era of the Saxon Emperors, there were in almost every town three different classes,—nobles, citizens, and slaves; but, about the beginning of the 12th century, Henry V. enfranchised all slaves in cities who were artizans.

Emperors of the house of Franconia. A. D. 1027—A. D. 1137.

The emperors of the house of Franconia were called to the throne, after the Saxon emperors; they reigned from 1027 to 1137. They consisted of Conrad II. who conquered the kingdom of Burgundy; Henry III. who conquered the country between the Inn and the Lech, now called Lower Austria; Henry IV. and Henry V.; on the death of the last, Lothaire the Saxon was elected King of Germany. Under Henry III. the empire of Germany had its greatest extent. It comprehended Germany, Italy, Burgundy, and Lorraine. Poland, and other Slavonian districts, were tributary to it; and Denmark and Hungary acknowledged themselves its vassals. The Emperors of Germany at this period affected to consider all Christendom as forming a royal republic, of which the Emperor was chief. In consequence of this assumed supremacy, they claimed the exclusive right of creating kings; and the states of the empire proclaimed war against the Duke of Poland for having taken to himself the title of king, in 1077.

Decline of the empire.

Soon after reaching this point of power and grandeur, the empire began to decline, principally owing to the rapid extension of the feudal system. In every province, the subjects of the law were the vassals of a private chief; and the standard which he received from his sovereign, was often raised against him. The power of the Emperors was also curtailed by the increasing influence and possessions of the clergy; and the bishoprics in Germany became equal in extent and privileges, and superior in wealth and population, to most of the secular states. The emperors were gradually deprived of the privilege of filling up the ecclesiastical and secular benefices; and at length each sovereign was reduced to a recommendation, once in his reign, to a single prebend in each church. The secular governors could be degraded only by the sentence of their peers; the appointment of the son to the

Germany.

duchy or county of his father, which in the first age of the monarchy was solicited as a favour, was at length extorted as a right; and this right was claimed even by collateral or female branches.

Emperors of the house of Suabia, A. D. 1138 —A D. 1224.

The emperors of the house of Suabia succeeded to those of the house of Franconia, and held the empire from A. D. 1138, to A. D. 1254. They were Conrad III.; Frederic I. surnamed Barbarossa; Henry VI.; Philip; Otho IV.; Frederic II.; and Conrad IV. The principal events in the history of the latter princes of the Franconian line, and of all the princes of the Suabian line, were produced or influenced by the contests between the popes and the emperors; and the principal ground of these contests was the claim of the popes to the supreme dominion of every part of the Christian world, both in temporal and spiritual concerns.

Guelphs and Ghibelines.

This claim gave rise to the factions of the Guelphs and the Ghibelines; of which the former were attached to the popes, and the latter to the emperors. These two factions kept Germany and Italy in perpetual agitation during three centuries; and during this period, the imperial authority continued to decline.

Great interregnum, A. D. 1254 —A. D. 1272.

The next period, between 1254 and 1272, is generally called by the German writers, the Great Interregnum. During it, six princes claimed to be emperors. The interregnum was determined by the election of Rodolph, Count of Hapsburgh. From him till the ultimate accession of the house of Austria, the empire of Germany was held by the following emperors. Rodolph Count of Hapsburg, elected A. D. 1273. Adolph, Count of Nassau, elected A. D. 1292. Albert I. Archduke of Austria, elected A. D. 1298. Henry, Count of Luxemburg, elected A. D. 1308. Louis V. Duke of Bavaria, elected A. D. 1314. Charles, King of Bohemia, A. D. 1347. Winceslaus, King of Bohemia, A. D. 1378. Robert, Elector Palatine, A. D. 1400. Sigismond, King of Hungary, A. D. 1410. And Albert II. Duke of Austria, A. D. 1438. During the period between the last accession of the house of Hapsburg and the election of Charles V. the empire was possessed by the following emperors. Frederic III. elected A. D. 1440; Maximilian I. elected 1493; and Charles V. elected A. D. 1519.

Emperors between 1273 and A. D. 1519.

Boundaries at this period.

During this period, the boundaries of the Germanic empire, the form of its government, and the rise of its towns, particularly those which composed the Hanseatic league, are the chief subjects of consideration. Its boundaries were the Eyder and the sea on the north; the Scheldt, Meuse, the Saone, and the Rhone, on the west; the Alps and the Rhine on the south; and the Lech and Vistula on the east. In this great extent of country, the principal provinces were the duchy of Burgundy, comprising Savoy, the Lesser Burgundy, Provence, Dauphiny, and Switzerland: the duchy of Lorraine, which, besides Lorraine, contained Holland, Zealand, Brabant, Limburgh, Hainault, Flanders, Gueldres, and Luxemburgh. Friesland was attached to Lorraine, but was not governed either by a duke or a count. When the line of Suabian princes ceased, the ancient Alemannia and Franconia, in which their possessions chiefly lay, was divided into various principalities. At this period, Saxony was divided by the Weser into Eastern and Western. The former was sometimes called Saxony on the Elbe; the latter Saxony on the Weser. Misnia, Thuringia, and Hessia were usually comprised under Saxony. The Slavic territory, between the Oder and the Vistula, was occupied by the Margraves of Brandenburg, and the Dukes of Poland and Bohemia. To the last, Moravia, Silesia, and Lusatia were subject. Pomerania and Prussia were at this period in a very unsettled state. Bavaria still retained the name of Boisaria. To the east of it, a considerable tract was called *Marchia Orientalis*, or Oostrich; afterwards Austria.

Principal states.

Constitution.

The empire was always elective; but great alterations took place in the mode of election. In early periods, the emperor was chosen by the people at large: afterwards the nobility and principal officers of state possessed the privilege exclusively; by degrees, it was engrossed by the five great officers, the chancellor, the great marshal, the great chamberlain, the great butler, and the great master. At first they contented themselves with proposing a candidate to the general body of electors. Afterwards they confined the whole right of election to themselves. This mode was finally settled in the reign of Charles IV. by the celebrated constitution called the Golden Bull, which fixed the right of election in four spiritual and three temporal electors. These were, the King of Bohemia, the Duke of Saxony, the Margrave of Brandenburgh, the Count Palatine of the Rhine, and the three archbishops of Mentz, Treves, and Cologne. Subsequently, the Duke of Bavaria and the Duke of Brunswick Lunenburgh were added.

Electors.

States.

The multitude of princes, bishops, abbots, and male and female nobles, who, under various names, possessed sovereign rights, though all recognised the emperor as their feudal lord, were divided into the primitive states, or those which had always been held of the emperor, as the duchies of Saxony and Bavaria, the Palatinate, and several bishoprics; those which arose on the ruin of the Guelphic family, in consequence of the confiscation of the possessions of Henry the Lion; those which arose from the ruins of the Suabian family; and those which arose principally during the interregnum.

Diet.

But though the exclusive privilege of chusing the emperor was confined to the electors, they formed only one branch of the diet. The other two branches consisted of the princes, and of the free and imperial cities of Germany. In process of time, the college of princes and prelates purged themselves of a promiscuous multitude. They reduced to four representative votes the long series of independent counts, and totally excluded the nobles, 60,000 of whom had often appeared in the field of election.

Cities.

The cities of Germany, the origin and first state of which has been already noticed, insensibly became divided into the free cities, or those which held immediately of the emperor, and had a voice at the diet; the mixed cities, or those under the protection of some prince, which had no voice; and the municipal cities, entirely subject to the states.

Hanse towns.

The Hanse towns also arose during the same period. They were originally united for the support and encouragement of their commerce. Bremen and several sea-ports in Livonia first established the confederacy. At one time 80 towns were included in it. They were divided into four classes: the Vandallic, or the cities on the Baltic, between Hamburgh and Pomerania; over these Lubeck presided: the Rhinarian, or cities on the Rhine, at the head of which was Cologne: the Saxon, the cities in Saxony and Westphalia, over which Brunswick presided: and the Prussian, the cities in Prussia and Livonia, at the head of which was Dantzic. From the beginning of the 15th century, Lubec was regarded as the head of the whole confederacy. In the following century it declined; in the middle of the 17th, it was almost wholly confined to Hamburgh, Lubeck, and Bremen. Their political existence terminated in 1806.

Inst. of ele-

Another important event in this period of the history of Germany, is the division of the territories of the em-

Germany.

pire into circles. The first division of Germany was into the Upper and Lower, or southern and northern states. The line dividing them was supposed to be drawn easterly from the mouth of the Mayne. It was afterwards geographically divided into the states lying on the principal rivers, as the Danube, Rhine, &c. Maximilian the First divided it into ten circles, viz. Bavaria, Franconia, Suabia, Lower and Upper Saxony, Lower and Upper Rhine, Westphalia, Austria, and Burgundy; but the last, comprising High Burgundy or Franche Compté, and the 17 provinces of the Netherlands, was soon afterwards separated from the empire.

Complete establishment of the constitution, A. D. 1580.

During the same period, the diets which had been frequently held, were regularly and solemnly established, consisting, as has been already noticed, of three classes: the college of electors, of ecclesiastical and secular princes, and of imperial towns. This division was finally established at Frankfort in 1580. The three colleges deliberated separately. The agreement of them all, as well as the consent of the emperor, was necessary to form a resolution or law of the empire.

Imperial chamber and Aulic council.

Maximilian I. also established the imperial chamber and the Aulic council. The president of the former was appointed by the emperor; the assessors by the states. The Court Palatine, or Aulic Council, was established as a check on the imperial chamber. During the vacancy of the throne, its powers were suspended; but the imperial council acted under the vicars of the empire. There was no appeal from one to the other; the dernier resort was the diet. From the accession of the house of Austria to the imperial throne, the history of Germany may properly be sought for under the article Austria. It will be necessary here, however, to notice the leading events; *first*, from the division of the house of Hapsburg into its Spanish and German lines, till the final extinction of the latter in the house of Lorraine, or the period between 1558 and 1745; and, secondly, from the marriage of Maria Theresa, till the abdication by the emperor of Germany of the imperial government of the empire, and the formation of the confederation of the Rhine, or the period between 1745 and 1806.

War of thirty years, A. D. 1618—A. D. 1648.

The principal events in Germany during the first period, were the war of thirty years, which began in 1618 and ended in 1648; the war for the succession of Spain, which began in 1700 and ended in 1713; the war for the succession of Poland, which began 1733 and ended 1735; and the war for the succession of Austria, which began 1740 and ended 1748. The war of thirty years was principally owing to the religious disputes of the 16th century. At the diet of Augsburg, 1530, the Protestant princes of Germany delivered in their confession of faith, and afterwards formed the league of Smalkald against the Emperor. At the peace of Passau, the free exercise of the Lutheran religion was permitted. In consequence of the disputes regarding the succession to the duchies of Cleves and Juliers, the Protestant princes formed a confederacy, called the Evangelical Union, at the head of which was the Elector Palatine. To this the Catholics opposed the confederacy called the Catholic League, and placed at its head the Duke of Bavaria. From 1618, when open war began, till the peace of Westphalia in 1648, Germany was a scene of devastation. By this peace, the empire underwent considerable changes: the Swedes obtained Pomerania; the house of Brandenburg obtained Magdeburg, Minden, &c.; Alsace was conquered by France; and Lusatia ceded to Saxony. The war for the succession of Spain not producing any changes in the Germanic empire, need not be particularly noticed: the same remark applies to the war for the succession of Poland.

War on the decease of Charles VI. and seven years war, A. D. 1757—A. D. 1763.

In Charles VI. the male stock of the house of Hapsburg expired: in his grandson Joseph, the two lines of this family, after a separation of 1100 years, were reunited. On the decease of Charles VI. Maria Theresa, his only daughter, succeeded him. The first event of importance, after her accession, was the war of seven years. In consequence of the King of Prussia invading Saxony and Bohemia, the Aulic Council voted his conduct a breach of the public peace; and the Diet of the empire passed a decree to the same effect. This made it a war of that kind, which the publicists of Germany call a war of execution of the empire. The event of the war was, that a mutual oblivion and restitution took place. The next war was occasioned by the extinction of the house of Bavaria: it ended in the peace of Saxe-Teschen, by which the right of the Elector Palatine to the succession was allowed, with the exception of some districts of land between the Danube, the Inn, and the Salze, which were ceded to Austria.

Extinction of the house of Bavaria.

Consequences of the French revolution on the Germanic empire.

No event affecting the Germanic empire took place after this till the French revolution. By it the German states on the left of the Rhine were first overwhelmed: afterwards the power of Austria was reduced; Bavaria, Wurtemberg, and Saxony, raised to the rank of kingdoms, and their territories considerably increased, principally by the annexation of the smaller states. Shortly after the treaty of Presburg, most of the princes in the western and southern divisions of Germany separated themselves from the Germanic body, and formed themselves into a league under the protection of the Emperor of the French, under the title of the Confederated States of the Rhine. The contracting parties to this confederation were, the Emperor of the French on the one part, and, on the other, the Kings of Bavaria and Wurtemberg; the Elector Arch-Chancellor, and the Elector of Baden; the Duke of Berg, the Landgrave of Hesse Darmstadt, the Princes of Nassau, Weilbourg, Usingen, Hohenzollern Hechingen, Siegmaringen, Salm Salm, Salm Harberg, Isersbourg Bristein, Lichtenstein, the Duke of Aremberg, and the Count of Leyen. By the act of the confederation, all the laws of the empire were abrogated with respect to these states: their common interests were to be discussed in an assembly of the league at Frankfort, divided into two colleges of kings and princes: the members of the confederation to be independent of foreign powers, and not to enter into any kind of service except among themselves; the Emperor Napoleon to be protector of the alliance; all the princes, counts, &c. within the circle of the allied territory to be subject to the confederation; every continental war in which the Emperor of the French or the confederated states might be engaged, to be common to both; the contingents to be as follows: France 200,000 men; Bavaria 30,000; Wurtemberg 12,000; Baden 8000; Berg 5000; Darmstadt 4000; Nassau, Hohenzollern, and the others, 4000: other German princes were to be admitted into the alliance, when conducive to the common interest. See Confederation *of the Rhine*, vol. viii. p. 115, 116.

Confederation of the Rhine. 1806.

The emperor of Germany abdicates that title.

By a solemn act, dated at Vienna on the 6th of August 1806, the Emperor of Germany, after adverting to the consequences of the treaty of Presburg, and to the formation of the confederation of the states of the Rhine, absolved all his German provinces and states of the empire from their reciprocal duties towards the Germanic empire; and the electors, princes, and states, and all that belonged to the empire, from the duties

Germany.

by which they were united to him as their legal chief; at the same time abdicating the imperial government of the Germanic empire, renouncing the title of Emperor of Germany, and assuming that of Emperor of Austria.

Dissolution of the Confederation of the Rhine, A. D. 1814

The confederation of the Rhine was dissolved by the overthrow of Bonaparte, when the Emperor of Austria was solicited again to take the title, and exercise the privileges of Emperor of Germany: this, however, he declined. The internal regulation of the Germanic empire, and consequently every thing that relates to the constitution of the smaller states, and their mutual relation to one another, and to the more powerful princes, it is understood, has been left, by the Congress of Vienna, to a congress of German powers alone, to be assembled for that express purpose.

Statistics.

III. As the most important branches of the statistics of Germany naturally belong to the principal kingdoms which it contains, reference must be had to those kingdoms, under the articles AUSTRIA, BAVARIA, HANOVER, PRUSSIA, &c. for more full information on this point: here we must confine ourselves to an outline.

Boundaries of modern Germany.

We have already seen, that, in ancient times, the Rhine was reckoned the boundary between Germany and Gaul. During the usurpations of revolutionary France, that limit was renewed; but, on the restoration of the Bourbons, the boundaries of Germany, with very little exception or difference, were fixed as they had existed previously to the Revolution. The exception principally related to that corner of Germany in the vicinity of Liege, which was annexed to the new kingdom of the Netherlands. Germany may therefore still be considered as bounded on the west by France and the Netherlands. After the Rhine has reached the border of the Dutch provinces, an indistinct line between them and Germany runs northward to the mouth of the Ems; from which point the ocean takes up the northern boundary, only interrupted by the Danish peninsula, which commences beyond the duchy of Holstein. The German coast of the Baltic then succeeds, terminating with the extreme point of Pomerania. The eastern boundary is very indistinct, in consequence of the mixture of the Slavonian with the German tongue and manners, and the annexation of part of Poland to Prussia and Austria. Brandenburg, Silesia, Moravia, the Austrias, and Carniola, down to the Gulf of Venice, lie on the eastern boundary. The southern or Italian boundary, as far as the country of the Grisons, is formed by the Venetian states. The northern limit of Switzerland is the southern limit of Germany to the borders of France. It lies chiefly between the 46th and 54th degrees of north latitude; its greatest length is about 600 miles; its breadth rather more than 500. Its extent is variously reckoned, from 11,124 German square miles, (15 to a degree,) to 12,796; but, in the latter measurement, Silesia is included.

Climate and face of the country.

The climate is in general temperate, though the winter in the north is sometimes very long and severe. The air is everywhere salubrious, except in a few marshy places towards the North Sea. The northern part is mostly low: the first mountains that occur, on proceeding southwards, are the Hartz in Hanover; to the south-east of these are the Hesse mountains; towards the Rhine and Mayne there are other scattered ridges. That corner which lies between the upper part of the Rhine and Switzerland, comprising the Black Forest, is throughout a mountainous tract. On the east, the whole of Bohemia is surrounded with mountains, which branch on the east to Moravia, and communicate with the Carpathian mountains. To the south of the Danube are the mountains of Carinthia; and to the west of these the Tyrolese Alps.

Mountains and forests.

As might be expected from its extent, there is great variety of soil in Germany. The north-east is covered with sandy plains and heaths; in the north-west are swamps and marshes. Some of the interior and south-western districts possess a very fertile soil. In ancient times, Germany was covered with forests, of which there are only now detached remains; the most extensive is the Black Forest. Thuringia and the Hartz mountains abound in timber; and the passion for the chase has preserved or created many extensive woods in the middle and south.

Rivers.

Five hundred and twenty rivers are reckoned in Germany, sixty of which are navigable to a great length, and six, viz. the Danube, the Rhine, the Mayne, the Weser, the Elbe, and the Oder, rank amongst the noblest and largest in Europe. The Danube rises in the Black Forest; and receiving continual accessions on both banks, soon becomes a copious and navigable stream; it passes Vienna, and a short distance from that city becomes a Hungarian river: it terminates in the Black Sea. The Rhine has neither its source nor exit in Germany. It rises in Switzerland, and after passing Basle, flows for a considerable space, the boundary between Germany and France. From the western side of the former it receives numerous rivers, of which the Mayne and the Necker are the principal; it enters the sea below Rotterdam, affording a noble and highly useful inland navigation from Holland, quite to the borders of Switzerland. Of the rivers that enter the German ocean, the first on the west side is the Ems; next succeeds the Weser, which unites several streams of the north-west, and joins the sea below Bremen. The Elbe, rising on the confines of Bohemia and Silesia, augmented by many rivers from the centre of Germany, flows by Hamburg, and thence in a broad channel enters the sea on the west side of Holstein. The Oder, which derives it source from the foot of the Carpathian mountains, is the principal river that falls into the Baltic. In the duchy of Mecklenburg, there are several lakes. There are also some small lakes in Bavaria, Austria, Pomerania, and Brandenburg. The Boden sea, or lake of Constance, belongs partly to Germany and partly to Switzerland. There are upwards of 1000 mineral springs and baths, of which the most famous are Carlsbad in Bohemia; Toplitz in Austria; Seltzer in the upper Rhine; and Pyrmont in Westphalia. See the articles DANUBE and ELBE.

Vegetable productions.

There is a considerable variety in the vegetable productions of Germany; in general they are those of the northern and middle temperate regions. Besides corn of all kinds, flax of excellent quality, hemp, hops, tobaccco, madder, saffron, rape seed, rhubarb, &c. are grown; rice is cultivated in Moravia. The wine country begins about the junction of the Necker with the Rhine, and accompanies those rivers towards their rise.

Wines.

The most celebrated wines of Germany are those of the Rhine, especially about Manheim and Heidelberg, and in the district called the Rheinzan; here the lofty and romantic banks of the river are clothed with vineyards. The wine of Moselle ranks next; and after it a red wine called Pleiker, which is made near Mentz. Austria also affords wine, some of which is of excellent quality. Franconia, and particularly Bamberg, furnishes a great deal of liquorice; and the lower palatinate contains immense numbers of chesnut trees, and particularly fine walnut trees.

Horses.

The breed of horses, except in Mecklenburg, East Friesland, Oldenburg, Holstein, and some parts of Hanover and Wurtemberg, is very indifferent. The best breeds of oxen are in East Friesland, Oldenburg, and Holstein; but both they and the sheep are by no means sufficiently numerous; of the latter, the number is reckoned not to exceed 13 or 14 millions. The Merino breed has been introduced into Saxony upwards of a century, and now produces wool equal in quality to the finest Spanish; this breed is also naturalized in Prussia, but in general the sheep and wool of Germany are indifferent. The breed of hogs is much neglected; that of goats is encouraged in the mountainous districts. The forests are plentifully supplied with wild boars, which are reared to a large size. Westphalia is particularly noted for this species of game. Poultry is abundant. Some parts of Germany are remarkable for fine larks and thrushes of a delicious flavour. Others abound in singing birds, particularly Canary birds and goldfinches. Silk worms are reared in some of the southern districts. On the whole, agriculture is not in a very advanced state, except in Saxony, which, in every respect, is one of the finest parts of Germany. In the more mountainous parts, the lynx is still found; and in the Tyrolese Alps wolves are by no means uncommon. The only fisheries of Germany, with the exception of those carried on by the small towns on the Baltic and German Ocean, are those of the rivers, in some of which, besides the more common fish, the sturgeon is found.

Small particles of gold are found in the Rhine, the Danube, the Elbe, &c.; in most other mineral productions this country is very rich. The chain of hills between Saxony and Bohemia yields silver, copper, tin, lead, iron, cobalt, bismuth, &c.; most of these metals are also found in the Hartz mountains. Bavaria has mines of silver, copper, and lead, and is noted for its salt springs. There are also extensive salt works near Halle; and salt mines near Saltzburg. The iron of Carinthia and Stiria is particularly famous, as convertable to the finest steel. The quicksilver mines of Idria are also very productive, and of great fame. Besides the rarer and more valuable stones, Germany possesses large quarries of curious marble, and excellent mill and burr stones. In Misnia are found various sorts of fine earth, such as tripoli and porcelain earth, fullers' earth, &c. There are some coal mines, particularly in Westphalia, and abundance of peat mosses.

The manufactures are very various: pearl ashes and pitch are made in various parts. Linens are made in almost every part; but principally in Austria, Saxony, Lusatia, and Silesia; the cotton manufacture is establishing itself in Austria, Prussia, and Saxony. Woollen manufactures are spread throughout the empire, but with the exception of the cloths of Silesia, chiefly of the coarser kind. The silk manufacture was established in Brandenburg, by the refugees driven from France, at the time of the revocation of the edict of Nantz; silk is also manufactured in Austria and Saxony. There are many iron works at Nuremberg, and in Silesia, Saxony, and Holstein; here also are copper works. The porcelain of Saxony is still good, though not so famed as formerly.

The principal sea ports of Germany are Hamburg, Kiel, Lubeck, Wismar, Rostock, Stralsund, Stettin, Embden, and Bremen; its inland towns of great trade are Magdeburg, Leipsic, Naumburg, Francfort on the Mayne, Francfort on the Oder, Vienna, Augsburg, Nuremberg, Breslaw, and Ulm. The principal articles of exportation are timber, corn, fruit, wine, tobacco, madder, cobalt, smalts, potash, horses, oxen, salt and smoked meat, butter, cheese, wax, leather, wool, linen cloth to a very large amount, linen yarn, lace, lead, copper, brass, quicksilver, mirrors, glass, wooden toys, and trinkets. It imports corn, oxen, and horses, chiefly from Hungary, Poland, and Denmark; hogs from Hungary; butter from Ireland and Holland; all sorts of colonial produce, cotton stuffs, hardware, &c. It carries on a lucrative trade by means of the Danube, with European Turkey, whence it imports an immense quantity of raw cotton.

The Roman Catholic, Lutheran, and reformed religions, are established in Germany; but all other sects are tolerated. The German language is derived from the Gothic: it is strong, copious, abounding in compound words, but rough in the sound, and involved in the syntax: the purest dialect is that of Saxony; the least pure is spoken in the southern provinces. It has been much studied of late years, in the others parts of Europe. The literature of Germany, till lately, was more distinguished by erudition than by taste or genius; and even yet, the history of literature and statistics are more cultivated in Germany than elsewhere. There are upwards of 30 universities, some of which are of great repute; particularly those of Jena, Leipsic, Gottingen, &c. The most distinguished of its learned societies are at Vienna, Berlin, Gottingen, Manheim, &c.

Before the peace of Luneville in 1801, the population of Germany was rated at 27 millions; by the cession of the country situated on the left shore of the Rhine, it lost 3,700,000 inhabitants; but as most of that territory is restored, its present population may be reckoned at nearly 27 millions.

"The German people, from the earliest times, have borne a high character for bravery, and the masculine qualities of the mind They are in general frank and open, but inclined to be boastful and boisterous. They are indefatigable in their pursuits, and engage in them with a seriousness and sense of importance, which not unfrequently lead them to laborious trifling."

Tacitus, *de Moribus Germanorum.*
Nouvel Abregé Chronologique de l'Histoire et deo Droit public d'Allemagne, par M. Pfeffel.
Dr Robertson's view of the progress of Society in Europe, prefixed to his *History of Charles V.*
De la Ligue Hanseatique, par M. Mallet, 1805.
Tableau des Revolutions de l'Europe dans le moyen age, par M. Koch, 1790.
Dornford's translation of Putter's *Historical developement of the Constitution of the Germanic Empire,* 1790.
Histoire des Allemands, traduite de l'Allemand de Smidt, par Le Veaux, 1784.
Butler's *Revolutions of the Germanic Empire.*
Reisbeck's *Travels in Germany.*
Reise in Deutshland, von Nicolai. (w. s.)

GERMINATION. See Botany.

GERONA, the *Gerunda* of the ancients, is a town of Spain, in the province of Catalonia, situated on both sides of the Ter, on the side and at the base of a steep mountain. It is encircled with good walls, flanked with fortifications, and is defended by two forts erected upon the mountain. Gerona is nearly of a triangular shape, and the houses are well built, though the streets are crowded and narrow. The principal public buildings are the cathedral and collegiate churches. The cathedral stands on the ridge of the mountain. It exhibits a magnificent front at the top of three grand terraces, adorned with granite ballustrades, and the ascent is by a flight of 86 steps, as broad as the whole extent of the church. The front, which is flanked with three hexagon towers, is ornamented with the Doric, Corinthian, and Composite orders. The interior is large and handsome, but the nave only is Gothic. The treasury of the cathedral was very rich before the revolution. The collegiate church of St Felix, formerly St Mary's, is built in the Gothic style, and has a body and two aisles, divided by pillars, with a large and fine casement in the middle. In front of the façade is an old and lofty tower.

In the Capuchin convent, there is a curious Arabian bath constructed in the most elegant style. It consists of columns standing on an octagonal stylobate, or low base, which surrounds a reservoir for water. The Benedictine nunnery of St Daniel is about a mile from Gerona. It is one of the principal nunneries in Catalonia of the order of St Benet, and those ladies only are admitted who can bring proofs of nobility.

The university of Gerona, founded in 1521 by Philip II. was abolished in 1715 by Philip V. After the suppression of the order of Jesuits, the means of public instruction were concentrated in one college, where there are 900 students, who are instructed in Latin grammar, rhetoric, philosophy, and theology. The library of the Jesuits, which is now open to the public, is extensive and well selected. Other three professors chairs are supported at the expence of the town. Schools for the gratuitous instruction of poor girls, and a boarding-school for young ladies, are kept by the community of Beguine nuns. This institution is owing to the generosity of the bishop Don Thomas de Lorenzana, who encouraged in his diocese, agriculture, manufactures, and all the useful arts. The civil and military administration of the town resides in a governor, a king's lieutenant, a mayor, a governor of the little castle of Mountjouy, an alcade major for the administration of justice, and a municipal body of twelve regidors, and a small garrison.

Very little trade is carried on in this town. It possesses a few looms for stockings, coarse cloths, and woollen and cotton stuffs, which have been established within the last thirty years.

Gerona is the see of a bishop suffragan of Tarragona. The diocese consists of 4 arch-deaconries, 470 parishes, 2 collegiate chapters, and 8 abbeys or priories. In the town there are five parishes, 9 convents for men and 3 for women, a nunnery of Beguines, a college, seminary, general hospital, and charitable asylums. Population about 14,000, a fourth of whom consisted before the revolution of priests, monks, nuns, scholars, and students. See Laborde's *View of Spain*, vol. i. p. 13, &c.

GERS, the name of one of the departments of France, is so called from the river of the same name by which it is traversed from north to south. It is bounded on the north by the departments of the Lot and Garonne, on the west by that of the Landes, on the south by those of the Higher and Lower Pyrenees, and on the east by that of the High Garonne. The soil of this department is far from being fertile. The western part of it is the best, and produces some wheat, and a considerable quantity of wines, some of which are esteemed. It has almost no manufactures, and its principal trade is in brandy. The forests occupy from 12,000 to 13,000 hectares, or about 25,000 acres, of which one half belongs to individuals, and the rest to the nation and the communes. The Adour also waters the department. The following are the principal towns:

	Inhabitants.
Auch	7696
Condom	6917
Lectoure	5453
Mirande	1558
Lombez	1443

The population of the department is 291,845; and its contributions in 1803, 2,660,310 francs.

GERSAU, or GHERSAU, is a village of Switzerland, situated on the lake of Waldstettes, at the foot of Righi, in an angle between the mountain of Gersau and the Rothe-Schouth. Its territory is only about one league broad and two leagues long, and it constitutes the smallest republic in the world. There is not a single horse in the republic; and, excepting a narrow path down the side of the steep mountain, the only way of arriving at the town is by water. Gersau forms part of the canton of Schweitz. It contains 1500 inhabitants, who are employed principally in spinning silk for the manufacturers at Basle.

GERTRUYDENBERG, is a fortified town of Holland, situated on the river Merwe, which forms a good harbour, and expands into a considerable lake, called Bies Bosch, across which there is a two hours passage to Dort. The town is remarkable, principally for the abundance of salmon, sturgeons, and shad, which are caught in the neighbourhood. It has sometimes happened, that 18,000 shads have been taken in one day. The town enjoys the staple right for this species of fish, and therefore its principal trade consists in salting and smoking them, and in sending them to the neighbouring towns. Distance from Dort ten miles south-east, from Breda seven north-east.

GESNER, or GESSNER, CONRAD, a learned Swiss, was born at Zurich in the year 1516. He received the rudiments of his education in his native city, and discovered an early genius for literature and science; but he experienced many serious difficulties and discouragements in the course of his zealous pursuit of knowledge. His father's circumstances were insufficient for his maintenance as a scholar; and he was in consequence about to discontinue his studies, when Ammien, professor of Latin and eloquence at Zurich, generously took young Gesner into his own house, and charged himself with the care of his education. The death of his father, however, again reduced him to great extremities; and his misfortunes were increased by his falling into a dropsical complaint. Having in some measure recovered his health, he determined to travel and seek his fortune; and after the termination of the troubles in Switzerland, the Academy of Zurich allowed him a pension, in order to enable him to make the tour of France. On his return, he accepted an invitation from the university of Zurich to take charge of a school; but having married, and finding his appointment inadequate to the support of a family, he resolved to study physic, and accordingly devoted all the time he could spare from the duties of his school to books of medicine. Being at length disgusted with his situation at Zurich, he removed to Basle, and employed himself in reading the works of the Greek physicians, until he was appointed Greek professor at Lausanne. Having now acquired the means of attending to his favourite pursuits, he was enabled to repair to Montpelier, where he studied anatomy and botany for some time, and then returned to Zurich to prosecute his profession as a physician. He was admitted to the degree of Doctor, and was soon afterwards appointed professor of philosophy; a situation which he held during the remaining twenty-four years of his life. In the year 1565, he was carried off by the plague.

Boerhaave emphatically styles Conrad Gesner *monstrum eruditionis*, "a prodigy of learning." Mr Coxe, in his Letters on Switzerland, justly observes, that "those who are conversant with the works of this great scholar and naturalist, cannot repress their wonder and admiration at the amplitude of his knowledge in every species of erudition, and the variety of his discoveries in natural history. Their wonder and admiration," says he, "are still farther augmented, when they consider the gross ignorance of the age which he helped to enlighten, and the scanty succours he possessed, to aid him in thus extending the bounds of knowledge; that he composed his works, and made those discoveries, which would have done honour to the most enlightened period, under the complicated evils of poverty, sickness, and domestic uneasiness." On account of the variety of his attainments, and the extent of his learning, he was distinguished by the name of the German Pliny.

His works are numerous; of these the principal are, 1. *An Universal Dictionary*, published at Zurich in 1545. 2. *A History of Animals*, in four volumes folio, Zurich, 1551. 3. *A Greek and Latin Lexicon*. 4. *Opera Botanica*, Nuremberg, folio. (z)

GESNER, or GESSNER, JOHN MATTHEW, an eminent German philologer, was born at Roth, a village in the territory of Anspach, on the 9th of April 1691. He was reduced to great poverty by the death of his father, at a very early age; but by the kindness of a relation, he was enabled to acquire the elements of learning at the public school of Anspach. In 1710, he repaired to the university of Jena, where he studied theology, and supported himself partly by occasional poems, until he obtained the patronage of Buddeus, by whose recommendation he was appointed, in 1715, to superintend the public school at Weimar; from whence he was removed to a similar situation at Anspach in 1728, and in 1730 to Leipsic. Having greatly distinguished himself as a profound philologer, he repaired to Gottingen, where, in 1734, he was appointed professor of humanity in the newly erected university, to which were added the offices of public librarian, and inspector of schools throughout the electorate of Hanover. In the year 1751, he was made director of the Royal Academy of Sciences at Gottingen; and in 1756, he received the honorary title of Aulic Counsellor. In every situation, he exhibited proofs of uncommon industry and erudition; he was zealous in promoting the interests and prosperity of the university, to which he was so great an ornament; and endeavoured to discharge his duties as a public teacher in a manner at once agreeable and useful. He died at Gottingen in the year 1761.

To this eminent scholar, we are indebted for some excellent editions of the classics, particularly Quintilian, Pliny, Claudian, and the poems of Orpheus, which last were published, after his death, by Hamberger. Besides these, his principal work is the *Thesaurus Latinæ Linguæ et eruditionis Romanæ*, Leipsic, 1747, 1748, in four volumes folio. The great value of this work is well known to every scholar. Gesner also published several learned memoirs in the Transactions of the Gottingen Academy of Sciences. (z)

GESNER, or GESSNER, SOLOMON, a celebrated German poet and landscape painter, was born at Zurich on the first of April 1730. In the early period of his youth he made very slow progress in his education, and was considered by his teachers as a pupil of very mean capacity. But this backwardness must be ascribed to the perverse method of instruction at that time in use, and not to any deficiency of intellect on the part of the pupil. During his school hours, instead of devoting his attention to the study of grammatical rules, he often employed himself in modelling figures of various kinds, groups of men and animals in wax, and thus discovered an early genius for the imitative arts. By some accident, a copy of Robinson Crusoe fell into his hands, and awakened a poetic fancy, which his preceptors endeavoured to stifle by every means in their power.

His parents, however, perceiving the education of their son advance so slowly, resolved to try a different method, and accordingly sent him to the country, to the Rev. Mr Vögeli, a gentleman who had acquired great reputation as a teacher. Here, under a milder system of discipline, Gesner made sufficient progress to enable him to read the Roman poets in the original, and the Greek writers in the Latin version. His intercourse with the son of his instructor, a passionate admirer of ancient literature, and a lover of the *belles lettres* in general, was likewise of great advantage to him. Through him he became acquainted with the works of the German poet Brockes, which he perused with avidity, and to which he was indebted for the developement of his poetical talents.

After a residence of about two years at Berg, he returned to his family, and resolved to follow his father's profession of a printer and bookseller. At Zurich he had an opportunity of increasing his knowledge and improving his genius, by cultivating the society of men distinguished for their talents and learning. In the year 1749, he was sent to an eminent bookseller at Berlin, in order to learn his business. But the mechanical occupations in which he was employed by his master were by no means suited to the taste of Gesner, who already began to feel the consciousness of his own abilities. He therefore quitted his employer, hired an apartment for himself, and resolved to devote himself to the study of landscape painting, which had long been his favourite pursuit. This hasty step excited the displeasure of his parents, who determined to make him feel his dependence, by withdrawing from him their support. A reconciliation, however, soon took place; and Gesner obtained their permission to remain at Berlin, with the liberty of following his own inclinations. Here he formed an acquaintance with several eminent literary characters, and was particularly intimate with Ramler, by whose advice he was induced to resolve his poetical compositions into harmonious prose, instead of verse, which presented many serious difficulties to an author who was not conversant with the more improved dialect of the German language.

After paying a visit to Hamburgh, Gesner returned to Zurich, and published, in succession, those pieces which have procured for him an extensive and well-merited reputation. In 1751, his *Song of a Swiss to his Mistress on her appearing in Armour*, was inserted in a periodical publication. His next essay was the piece entitled *Night*. In 1754, he published a larger poem, entitled *Daphnis*, which was suggested to him by Amiot's translation of Longus. These were followed by a volume of *Idyls*, in 1756; *the Death of Abel*, 1758; a collection of his poems, in four volumes, 1762, including *The First Navigator*, which was always a favourite production with the author, and the two dramatic pieces, *Evander* and *Erastus*. In 1772, he published a second volume of *Idyls*, with a letter on landscape painting, addressed to M. Füssli.

When about thirty years of age, Gesner married Mademoiselle Heidegger, a young lady endowed with rare accomplishments of mind and person. Finding, however, that the resources of his pen were inadequate to the support of a family, he resolved to apply more seriously than ever to his favourite art of landscape painting, in which he ultimately attained a very high degree of excellence. Indeed, his pictures have been by some esteemed superior to his poems. He died on the 11th of March, 1787, at his country seat in the forest of Sihl. A monument, on which Nature and Poetry are represented weeping over his urn, was erected to his memory by some of his fellow-citizens, on a charming spot in his favourite walk, near the confluence of the Sihl and the Limmat.

The works of Solomon Gesner are too well known to require any particular notice. His poetry is all of the sentimental kind; and he excels especially in the description of natural scenery. He is undoubtedly the first writer of pastorals in modern times; and it is not the least of his merits, that his productions uniformly breathe a spirit of purity highly favourable to innocence and virtue. In private life, he was modest, ingenuous, and amiable; and the cheerfulness and natural gaiety of his temper, combined with great goodness of heart, endeared him to a numerous circle of friends. (*z*)

GHAUTS is a name which properly signifies a pass through a range of lofty hills, but it has been extended to designate the mountainous chains which support the centrical table land in the south of India.

The *Eastern Ghauts* commence in N. Lat. 11° 20′ to the north of Caverey, and stretch nearly and almost uninterruptedly in a straight line to the banks of the Khrisna, in N. Lat. 16°, separating the two Carnatics, which are named the Carnatic Balaghaut, or above the Ghauts, and the Carnatic Payeenghaut, or below the Ghauts. The greatest height of this ridge, which is about the latitude of Madras, is nearly 3000 feet.

The *Western Ghauts*, or *Hills of Sukkien*, extend from Cape Comorin to the Tuptee, or Surat River, where they leave their southerly elevation, and bend eastward in a waving line parallel to the river, till they are lost among the hills near the river Boorhanpoor. With the exception of a single opening, 16 miles wide, which admits the Paniany, the Western Ghauts include 13 degrees of latitude. Their distance from the coast is commonly 40 miles, and seldom more than 70.

GHEE is the name of a kind of clarified butter, made from the milk of buffaloes. It may be preserved sweet for a considerable time, and forms a great article of commerce in various parts of India. It is generally put up in duppers or bottles made of hides, each containing from 10 to 40 gallons. In some parts of Bengal the price varies from 6 to 8 seers for a rupee.

GHENT, or *Gand* in French, *Gandavum* in Latin, is a town in the Netherlands, and formerly capital of Austrian Flanders. It is advantageously situated at the conflux of the rivers Scheldt, Lis, Moere, and Lieve, which intersect it in various directions, and divide the town into 26 small islands. The town is encircled with walls about 15 miles in circumference, comprehending numerous corn fields and gardens. Many of the houses are excellently built; some of the streets are broad and well paved, and the market places are spacious. In one of these is a statue erected to the Emperor Charles V. who was born in this city. The cathedral church is the principal edifice in Ghent. The pulpit, which was made by the celebrated Delvaux of Nivelles, has been particularly admired. The musical bells of the cathedral have been much noticed by strangers. The principal altars, the magnificent tombs of the bishops, and the subterraneous church, are well deserving of examination. Besides the cathedral, there are six churches and a collegiate church. The church of St Michael is admired on account of the boldness of the nave. There is a beautiful promenade along the canal, which is called *De la Coupure;* one of the sides is for foot passengers, and the other for carriages. The other public establishments are the library, the academy of painting, and the botanic garden, which is reckoned extremely beautiful.

Ghent communicates with Bruges, and afterwards with Ostend, by means of the canal which was begun in 1613, and with the western Scheldt by the Saas-de-Gand, by means of another canal. The principal articles of commerce in Ghent are French wines, grain, flax, hemp, and colza for the manufacture of oil. The manufacture of linen cloths is carried on to a great extent in this town and its neighbourhood. Twilts for beds, table linen, and lace, are also made here to a great extent. There are likewise manufactures of glue, woollen stuffs, cottons, soap, paper, vinegar, tobacco, hats, and stockings, besides refineries of sugar and salt. Population 58,000.

GHERIAH, or Corepatam, is a sea-port of Hindostan, in the county of Concan. The fort stands on a rocky promontory, about one mile long, and a quarter of a mile broad. This promontory is joined to the continent by a narrow neck of land, beyond which, where the ground expands, is a large open town. On the neck of land are docks where grabs are built and repaired. The river runs in a south-westerly direction, and washes the north side of the town, the neck of land, and the promontory. The point, which bounds the entrance on the south side, is high and broad, and is situated in 73° 25′ East Long. The fort consists of a double wall, with round towers; the inner wall being several feet higher than the outer one. The harbour is very good, without any bar, and has at its entrance a depth of from five to seven fathoms, and from three to four fathoms at low water. Vessels are here completely sheltered from every wind.

This town was formerly the capital of Angria the Pirate. In 1756 it was taken by the British fleet under Admiral Watson, who found in it 200 pieces of cannon, six brass mortars, great quantities of military and naval stores, and money and effects to the amount of £125,000. Angria's fleet was also destroyed, and the town was given up to the Mahrattas, in whose possession it has since continued. Latitude of Gheriah point 16° 31′ N. See Milburn's *Oriental Commerce*, vol. i.

GHILAN, or Kilan, the *Gela* of the ancients, is a province of Persia, which stretches along the south-west shore of the Caspian Sea, from Kizilagatch to beyond Rudizar. On the south and south-east it is bounded by Irak and Mazanderaun, on the north by Shirvan, and on the west by Azerbijan. It extends about 200 miles from north to south, and 150 from west to east. This province, which is one of the most beautiful and picturesque in Persia, is encircled with lofty and almost inaccessible mountains, and like Mazanderaun is intersected with forests and morasses. There are whole forests of oak, boxwood, mulberry, and walnut trees; and honey-suckles, flowers, sweet-briars, and roses, cover the vallies. The soil, which is excellent, affords hemp, hops, olives, rice, wheat, tobacco, and various kinds of fruit, such as lemons, oranges, peaches, and pomegranates. Grapes, though not of a good quality, are very plentiful; and, as in Georgia, the vines which grow wild on the mountains support themselves on the trunks and branches of trees.

The manufactures and silk of Ghilan have been reckoned the best in Persia. The cultivation of silk is the principal employment of the inhabitants, and constitutes the chief trade of the province. It is annually exported in great quantities to Astracan from Resht and Lankeroon. The finest kind is usually white, and is either sold to the Turks, or sent into the interior of Persia. The inferior kind, which is yellow, is exported to Russia.

The principal river in Ghilan is the Kizilozien, or Golden Stream. It is the Gozan of Scripture, and rises eight or nine miles to the north-west of Sennah in Kurdistan. After running along the north-west frontier of Irak, and passing under the Kufulan Koh, or Mountain of Tigers, it is joined a little to the east of Meanna, by the Karanku, which has its origin in the mountains of Sahund to the west of Meanna. Their united streams force a passage through the great range of Caucasan, and receives in their course the Shahrood. These collected currents traverse the province of Ghilan, under the name of the Sifud Rood, or white river, and throw themselves into the Caspian. The road from Hamadan to Resht is upon the edge of the deep chasm through which the river flows, and is described by Captain Sutherland as one of the grandest and most terrific scenes.

The principal town of Ghilan is Resht, on the Caspian. In rough weather, its harbour is less safe than that of Lankeroon in the district of Talish.

The inhabitants of Ghilan are said to have a language of their own, different from the Persian and Turkish. Ghilan was ceded by Persia to Russia in 1724, taken by Catherine in 1780, and restored to Persia in 1797. The nett revenue of the province is 149,490 tomarins, and 9058 dinars. See Kinneir's *Geographical Memoir*, p. 159, 160; and Morier's *Travels in Persia*, p. 288.

GHILJIE Country, is the name of a district of Afganistan, inhabited by the Ghiljie tribes. It forms a parallelogram about 180 miles long, and 85 broad. The climate is in general severer than that of England, and the summer not much hotter. The Ghiljies were formerly the most celebrated of the Afghans. About the commencement of the last century, they conquered all Persia, and defeated the Ottoman armies. A full account of these wars, and of the tribe itself, will be found in Hanway's *Travels*; Jones's *Histoire de Nadir Chah*; and Elphinstone's *Account of Cabul*, p. 433, &c.

GHIZNEE, Ghizne, or Ghizni, was formerly the capital of an extensive empire, extending from the Tigris to the Ganges, and from the Taxartes to the Persian Gulf. It is situated on a height, washed by a pretty large stream, and is encircled with stone walls. Beside several dark and narrow streets, the town contains three bazars, with high houses on each side, and a covered chaursoo. Among the few remains of the ancient grandeur of this city, are two lofty minarets, at some distance from each other, the least of which is above 100 feet high. "The tomb of the great Sultan Mahmood," says Mr Elphinstone, whose excellent account of Cabul contains all the information we have on this subject, "is also standing about three miles from the city. It is a spacious but not a magnificent building, covered with a cupola. The doors, which are very large, are of sandal wood, and are said to have been brought by the Sultan as a trophy from the famous temple of Somnaut in Guzerat, which he sacked in his last expedition to India. The tombstone is of white marble, on which are sculptured Arabic verses from the Koran, and at its head lies the plain but weighty mace, which is said to have been wielded by the monarch himself. It is of wood, with a head of metal so heavy that few men can use it. There are also some thrones or chairs, inlaid with mother-of-pearl, in the tomb, which are said to have belonged to Mahmood. The tombstone is under a canopy, and some Moollahs are still maintained, who incessantly read the Koran aloud over the grave. There are some other ruins of less note, among which are the tombs of Behlole Dauna, or Behlole the Wise, and that of Hukeem Saunauee, a poet still greatly esteemed in Persia; but nothing remains to shew the magnificence of the palaces of the Gaznavide kings, or of the mosques, baths, and caravanseras, which once adorned the capital of the East. Of all the antiquities of Ghiznee, the most useful is an embankment across a stream, which was built by Mahmood, and which, though damaged by the fury of the Ghoreé kings at the capture of Ghiznee, still supplies water to the fields and gardens round the town. The immediate environs of the city are inhabited by Taujiks and Hazaurehs." Ghiznee contains only about 1500 houses, besides the suburbs without the walls. East Long. 68° 58′, and North Lat. 33° 10′. See Elphinstone's *Account of Cabul*, p. 432. Lond. 1815.

GIANTS, is the name given to men whose stature greatly exceeds the ordinary size of the human race.

On surveying the field of nature, we sometimes discover aberrations from her usual course. Animals are seen of dimensions infinitely surpassing those which commonly belong to their kind; and vegetables of a bulk so remarkable, as to excite astonishment in the beholder. We are thence led to enquire, What secret principle is it that limits the expansion of animal and vegetable matter? How is it confined within definite boundaries, those which at once mark the identity of species by the most prominent analogies? We should find it difficult to solve these questions, and perhaps our knowledge of the vital and material economy of the two great kingdoms now alluded to, is still too imperfect for us to hazard conjectural explanations.

In most of the ancient histories of the world, we read of giants. They also find a place in many of those of modern date; and the name is so universally employed by poets and romancers, that nothing can be more familiar to our ears. Not only are individual giants repeatedly referred to, but the existence of whole nations of those who have viewed their fellow-men as a pigmy race, has been admitted as a fact not to be called into dispute. During a retrospect of many centuries, likewise, successive degradation in the stature and strength of mankind is maintained to have taken place, which, were it true, would scarcely allow our contemporaries to reach the knees of their ancestors, and bestow no more power upon them, than the others possessed in their fingers. Those, however, who are accustomed to reason from facts, who disregard conjecture, and are enabled to separate truth from fiction, feel inclined to question whether there ever was a race of giants, as generally understood by that name; and whether the race of mankind

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under the same latitude, has decreased in any respect since the days of our original parents.

Perhaps the discordant opinions on this subject are not so irreconcileable as at first sight may appear; and by carefully analysing all that has been recorded in history, we shall find that individuals of gigantic stature have existed at different æras; and that at the present day, there are one or two tribes of South Americans, whose size considerably surpasses the dimensions commonly allotted to mankind. But it is essential to beware of the exaggerations to which men have ever been prone; and not to allow our credulity to be imposed upon by what is utterly beyond belief, from whatever source the narrative shall be received.

Giants described in sacred writ.

In scripture it is related, at a period apparently contemporary with Noah, or immediately antecedent to the flood, "that the sons of God saw the daughters of men, that they were fair, and they took them wives of all which they chose." Further, "there were giants in the earth in those days, and also after that, when the sons of God came in unto the daughters of men: and they bare children to them, the same became mighty men which were of old, and men of renown." These passages, it is true, contain some obscurities; but we do not conceive that they warrant the conclusion which certain critics have deduced, of this gigantic race being the offspring of divinities and human females. At Hebron, in Judea, there was a celebrated tribe of giants, the sons of Anak; and the spies sent out by Moses to reconnoitre the country, seem to have made their report in these words: "And there we saw the giants, the sons of Anak, which come of the giants; and we were in our own sight as grashoppers, and so we were in their sight." Although only three individuals, Ahiman, Sheshai, and Talmai, are previously named as the children of Anak, it is elsewhere said, "it is a land which eateth up the inhabitants thereof, and all the people that are in it are men of great stature." Thus the context proves the correctness of the translation of this part of scripture; and that the appellation giants is not the proper name of a particular tribe, or nation, or tyrants, or evil doers, as commentators have inferred. Further, their history is continued, and Og, King of Bashan, in the same regions, is specifically described, somewhat later, as the last of the race; as also, "Bashan which was called the land of giants." This king was encountered and slain by Moses at the head of the Israelites, apparently at the gates of his own city; and it is said, "for only Og, King of Bashan, remained of the remnant of giants: behold his bedstead was a bedstead of iron: is it not in Rabbath of the children of Ammon? nine cubits was the length thereof, and four cubits the breadth of it, after the cubit of a man." This extraordinary bedstead, therefore, must have been between 14 and 16 feet long, and about 7 in breadth, according as the cubit is taken, at 18 or 20 inches. The next giant of whom we read in scripture was Goliath; but before leaving the gigantic king of Bashan, we may remark, that a spacious cavern is said to have been found near Jerusalem some thousand years after his death, containing a grave or tomb, with an inscription in Chaldaic, *Here lies the giant Og.* A tooth weighing four pounds and a quarter was found in the tomb, which, being sent from Constantinople, was offered to the emperor of Germany as a curiosity for 2000 rixdollars, in 1678. The emperor, however, being doubtful of the fact, ordered the tooth to be returned. The stature of Goliath must have been considerably inferior to that of Og; but his corporeal strength is undoubted, on considering his weapons and armour. Commentators conclude that six cubits and a span, described to be his height, make about eleven feet, though we should be inclined to reduce it to about ten at the utmost. He was a professed warrior, and a champion of the Philistines; "the staff of his spear was like a weaver's beam, and his spear's head weighed 600 shekels of iron." "He was armed with a coat of mail, and the weight of the coat was 5000 shekels of brass." No profane history is equally explicit as scripture regarding a distinct race of giants of extraordinary size; and we have united the passages to be found concerning them, previous to descending to a later date.

Gigantic remains.

The ancients considered persons whose stature exceeded seven feet as gigantic. Living giants have certainly been seen who were somewhat taller; but the existence of those who greatly surpassed it, or were double the height, has been inferred only from remains discovered in the earth, and not from the ocular testimony of credible witnesses. Were we to admit what has been reported on the subject, there would be no bounds to the dimensions of giants; the earth would seem unsuitable for them to tread upon. Thus Strabo speaks of the skeleton of a giant 60 cubits in length, found near a city in Africa now called Tangier; and without bestowing due reflection on the improbability of the fact, it is ascribed to Antæus, a reputed gigantic sovereign of Mauritania, whose very existence is still more problematical. The same observation will apply to another skeleton 46 cubits in length, alluded to by Pliny, which was exposed by the overthrow of a mountain in Crete by an earthquake. In the year 758, during the darker ages, we are told, that at a place called Totu in Bohemia, a skeleton was found whose head could scarcely be compassed by the arms of two men, and whose legs, which are said to have been kept a long time in the castle, were 26 feet long. Possibly this last measurement belongs to the entire skeleton rather than to a part of it. Simon Majolus relates, that in the year 1171, a skeleton 50 feet long was discovered in England in consequence of a breach made by a river; but we are not aware that his account, which is in these words, has any corroborative testimony. *Longe ante Fulgosi seculum, annis plus trecentis, anno scilicet* 1171, *in Anglia, illuvione fluminis relectæ sunt humani olim hominis ossa, adhuc ordine composita. Longitudo totius corporis inventa est longa ad pedes quinquaginta.* In the year 1516, the skeleton of a giant 30 feet high is reported to have been found near Mazarino in Sicily. The skull was as large as a hogshead, and each of the teeth weighed five ounces, which it may be remarked in passing, is not a tenth part as heavy as the reputed tooth of the gigantic king of Bashan. In the same island, other remains of a giant 30 feet high were discovered in 1548, and two years afterwards, those of a third, whose height attained 33 feet. Instead of these being entire skeletons, however, it is infinitely more probable that they were only detached fragments of bones, while conjecture enlarged the wanting parts to the size which is ascribed to the whole body.

Florus, the Roman historian, in narrating a battle between Marius and the Teutones, at the foot of the Alps, describes the king of that people as of wonderful stature. *Certe rex ipse Theutobochus, quaternos, senosque equos transire solitus, viz. unum quum fugerit, ascendit: proximoque in saltu comprehensus insigne spectaculum triumphi fuit, quippe vir proceritatis eximiæ super trophæa ipsa eminebat.* The first part of the sentence is obscure, but the historian in the rest apparently infers, that the stature of the captive king was such, that he could overlook the trophies exhibited at the triumph of the consul. In the year 1613, the French journals relate, that while some workmen were digging near the ruins of a castle in Dauphiny, in a field which had long bore the name of the Giant's Field, they discovered, at the depth of 18 feet, a brick sepulchre, 30 feet long, 12 feet wide, and eight deep, whereon was a grey stone, inscribed *Theutobochus Rex*. On opening the tomb, a skeleton appeared, 25½ feet long, 10 feet broad across the shoulders, and five feet deep from back to breast. Each of the teeth was the size of an ox's hoof, and the leg bones were four feet loug. These bones continued to be exhibited for some time as the identical remains of the Teutonic king mentioned by Florus, and carried under that name through Flanders into England. A convent of Dominicans at Valence, in Dauphiny, lately had part of a human leg bone, and articulation of the knee, found near the banks of the stream Morderi, which they affirmed belonged to a certain tyrannical giant, Bucant, 22 feet high. He lived on a mountain, and was slain by one of his own vassals, the Count de Chatillon; but to perpetuate his immense stature, the monks preserved a painting of him in Fresco. Rioland, a celebrated anatomist, is said to have written a specific account, in 1614, of the discovery of a tomb in the suburbs of St Germains at Paris, which contained the remains of Isoret, a giant 20 feet in height. But we have understood that the same physician called in question the identity of the bones as being of a human subject, which were exhibited for those of the Teutonic king. It is recorded, that in the course of digging a ditch at Rouen, near the Dominican convent, in the year 1519, a tomb was found, with a plate of copper inscribed: "In this tomb lies the noble and puissant lord, the Chevalier Ricon de Vallemont and his bones." The tomb contained a skeleton whose skull held a bushel of corn, and whose leg bone, about four feet long, reached up to the girdle of the tallest man in company. Platerus, a physician, declares, that at Lucerne he saw real human bones of a person who must have been 19 feet high; and it is calculated, that in the preceding instance, the Chevalier can have been scarce more than a foot shorter. A voyager to the Canary Islands speaks of the body of one of the ancient Guanches, in a cavern in the Peak of Teneriffe, as being 15 feet long, and having a head of enormous dimensions. Several navigators to the Straits of Magellan, both foreigners and Englishmen, affirm, that on examining graves at Port Desire, they found human skeletons ten or eleven feet in length, and on passing somewhat farther to the westward, as appears, other bones, in no respect inferior, were discovered. We shall say nothing of the giants referred to by Olaus Magnus, who, independent of men, says that a woman was found who had been killed by a wound in the head, clothed in a purple cloak, 50 cubits in length, and four in breadth between the shoulders: *Reperta est puella, in capite vulnerata, morta, induta chlamyde purpurea longitudinis cubitorum quinquaginta, latitudinis inter humeros quatuor.* But if we are to confide in history, here are examples of gigantic human remains, progressively decreasing from 60 cubits to 10 feet as the height of the living being. Whether the historians were competent judges of the fact they relate, is a different enquiry; few, however, will hesitate to reject the gigantic skeleton spoken of by Strabo, ascribed to Antæus; or that supposed to be the body of Orion, exposed by the dislocation of the Cretan mountain. The existence of enormous giants is conjectured from nothing but their remains, and it is extremely doubtful if there be authentic accounts of any living giant having been seen whose size exceeds the lowest term of the remains we have quoted.

The ancients acquaint us, that in the reign of Claudius, a giant named Galbara, 10 feet high, was brought to Rome from the coast of Africa. An instance is cited by Goropius, an author with whom we are otherwise unacquainted, of a female of equal stature. A certain Greek sophist, Proæresius, is said to have been nine feet in height. Julius Capitolinus affirms, that Maximinian the Roman emperor was eight feet and a half: there was a Swede, one of the life guards of Frederick the Great, of that size. M. Le Cat speaks of a giant exhibited at Rouen, measuring eight feet and some inches; and we believe some have been seen in this country, within the last 30 years, whose stature was not inferior. In Plott's *History of Staffordshire*, there is an instance of a man of seven feet and a half high, and another in Thoresby's account of Leeds, of seven feet five inches. Examples may be found elsewhere of several individuals seven feet in height, below which, after the opinion of the ancients, we may cease to consider men gigantic. A porter belonging to the Prince of Wales, commonly called Big Sam, though long esteemed of much larger stature, we believe proved to be only six feet ten inches. Entire families sometimes, though rarely, occur of six feet four, or six feet six inches high.

From all this we may conclude, that there may have possibly been seen some solitary instances of men who were ten feet in height; that those of eight feet are extremely uncommon, and that even six feet and a half far exceeds the height of men in Europe. Neither, as we shall afterwards explain, is there any reason to suppose that the human race has degenerated with the progress of time. But first let us say a few words on a subject which has excited much controversy, the existence of a nation of giants on the continent of South America.

Gigantic tribes still exist.

The earlier navigators towards the Straits of Magellan and the neighbouring coasts, soon remarked the extraordinary size of the natives repairing to the coast; and in the narrative of Magellan's own voyage, is an account of the first Patagonians, so called by the Portuguese in allusion to a long measure, who came on board a European vessel. The strangers were also visited by others displaying the same good nature, and those properties which still characterize the inhabitants of the coast; they were pleased with every thing they saw; the shackles with which Magellan prepared to make them prisoners, they took for play-things, and innocently allowed themselves to be fettered, and carried into captivity from a barbarous curiosity. Sir Richard Hawkins, and Nodal, a Spanish navigator, describe the natives of the coast as a head taller than Europeans, and of such stature that the crew of their vessels called them giants; and Sir Thomas Cavendish, speaking of those at Port Desire, says one of their feet measured eighteen inches long. The Spaniards also, who had formed settlements in South America, seem to have been acquainted with a tribe of large stature; and a woman, who had been many years in captivity, returned with an account of a whole army of giants. Still there was but a very imperfect knowledge of their history in Europe, until the public curiosity was roused by the narratives of the English circumnavigators, between the years 1760 and 1770; for the preceding notices of Turner, who said he had

Patagonians.

Giants. Patagonians.

seen a giant 12 feet high on the coast of Brazil, and of Knivet who had seen a youth 13 spans in height, attracted no attention. In the year 1764, Commodore Byron visited the coast of Patagonia, and, in describing the inhabitants as of gigantic stature, concluded from his own size, that they could not be less than six feet and a half, or seven feet high; but he did not measure any of them. This omission, however, was supplied by Capt. Carteret of the Swallow sloop of war, which reached Cape Virgin Mary near the eastern entrance of the Straits of Magellan in 1766. When he went ashore, 60 or 70 of the natives had assembled, and the number continually increasing, had augmented next morning to several hundreds of men, women and children. They were a fine race of people, their features large, with tolerably clear complexions and long black hair; and on measuring the size of many, Captain Carteret found it in general from six feet to six feet five inches high; some were six feet seven inches, but none taller. This proves the hazard of conjecture, for Mr Charles Clarke, who had accompanied Commodore Byron, concludes, that of about 500 people, there was hardly a man less than eight feet high, most of them considerably more, and some who certainly attained the height of nine feet, if not above it. The women also, he infers, were from seven and a half to eight feet. Except with regard to the height, the accounts of Captain Carteret and Mr Clarke coincide; but Captain Wallis further corroborates the words of the former. In the course of several interviews, he found by "measuring rods," that the tallest man among the Patagonians was 6 feet 7 inches high; that several were within an inch or two of that height, but the ordinary size was from 5 feet 10 inches to 6 feet. Both sexes were clothed in skins, and so much alike, that at first sight it was not easy to distinguish them. Their manners were mild and courteous; they had a ready apprehension, and were extremely intelligent. Many rode horses of the Spanish breed, fourteen or fifteen hands high; and it appeared their residence was inland, not on the coast. Mr Clarke seems aware, that the credibility of his relation might be called in question: Captain Carteret's was written very soon after the interview, and was accompanied with regrets, that the orders of his commanding officer were of such a description, as to preclude a more familiar intercourse with the Patagonians. We call them Patagonians, in coincidence with the name bestowed on them by their earlier visitors; but their proper appellation is Tehuels, or Tehuelhets,—as we learn from a missionary who resided many years in the country, and whose remarks will probably solve the difficulties which have been excited by the accounts of transient navigators. The Tehuelhets occupy a mountainous tract of South America, intersected by deep vallies, and wanting rivers of considerable size, bounded on the east by a vast desert, and on the north by a tribe called Chechehets. Their stature rarely exceeds seven feet in height, and often does not reach six feet. About forty or fifty years ago, they had a chief seven feet and some inches high, with whom the missionary Mr Falkner was well acquainted; but he affirms, that he never saw any Indian above an inch or two taller; that is, we conceive, seven feet and a half. The brother of this chief did not exceed six feet. They are a strong well made people, not so tawny as the other Indians, and some of their women as white as Spaniards: They are restless and nomadic, chiefly mounted on horseback, and always in motion. Another tribe, or, as some suppose, a different division of the same tribe, called Puelches, dwells on the western side of the continent, where bounded by the straits of Magellan on the south. They are very large, several being nearly seven feet six inches high. One branch of the tribe Huilliches, in the same vicinity, is denominated *Great* Huilliches, from their larger stature; and the Chechehets are tall and stout, like their neighbours the Tehuelhets, but speak a different dialect: and both acknowledge the Levuches, of whom we have no particulars, as their head. Most of those tribes are equestrian; but there is one called Yacanacunnees, or *foot-people*, because they always travel on foot, and have no horses in their country. Many concurring circumstances tend to prove, that the Patagonians of the older authors, and also of more recent navigators, are the various races of South Americans now described, though at this day greatly reduced from their former numbers. Larger stature, personal appearance, courteous disposition, a nomadic life, and a variety of peculiarities, are common to both. Thus it seems undoubted, that certain tribes of mankind exist on the South American continent, whose size considerably exceeds the common stature of mankind, that they might reasonably be esteemed giants when compared with their Portuguese or Spanish visitors, who probably were of very ordinary dimensions; but that the extreme height to which the tallest reach at present, does not exceed seven feet and a half. We read, that the ancient Germans, Gauls, and Caledonians, were men of great bulk and strength: *magna corpora et tantum ad impetum valida,*—as expressed by the historian of Agricola. Had these nations been preserved pure, and without intermixture, perhaps their stature might have been preserved also: Yet it is scarcely to be denied, that the stature, or at least the strength, of mankind, improves with civilization. The savages of no part of the New World, if we except the Patagonians, of whose powers we have never obtained a comparative view, are equally strong as the inhabitants of Europe; and it has been ascertained, that the natives of Great Britain are individually the strongest of all the human race hitherto known. The warmer climates, as well as those where extreme cold prevails, are equally unfavourable to strength and stature; and each seems to have a decided influence on the mind: It is within the temperate regions of the earth, that nature has endowed mankind with the most distinguished mental and personal energies.

Analo[gies] betwe[en] dwarfs [an]d giants.

From all that has hitherto been explained, the solitary instances of gigantic stature occurring in Europe, as well as uncommon diminution of the human size, ought to be assimilated to that species of monstrosity, where the aberrations of nature tend either to excess or defect. Symmetrical giants are seen, it is true, though very rarely, and also symmetrical dwarfs; but more generally there is some disordered organization in their persons, particularly in the head and extremities. These are small in giants in proportion to their other members; but the head of dwarfs is almost invariably very large. Giants are seldom endowed with physical power or mental energy: the period of life is, for the most part, abridged in dwarfs. Nature seems to languish in the preservation of both, but more conspicuously in regard to the former: They want strength, and are deficient in courage; nay, it is said, that on some extraordinary occasion, when several dwarfs and giants were assembled at Vienna, a quarrel ensued, and one of the dwarfs fought a giant to considerable advantage. Did we not view these beings as mere exceptions, the scale of disparity in the human stature would not be so limited as is wont to be supposed. The difference between a person of two feet four inches, said to be the shortest dwarf, and another of eight feet, whom we shall here esteem the tallest man, being five feet eight inches, is enormous. But, in Great Britain, the scale of size does not, at an average, range through five inches, nor probably in the rest of the world. That gigantic and pigmy stature is a simple accident, is proved from numerous facts. They are alike the children of ordinary parents; and their descendants, instead of resembling themselves, resemble their forefathers. Besides, all the other members of their own generation are usually of the common size. Nevertheless, with proper precautions, the human race, as that of other animated beings, may be improved; of which a notable instance is said to exist at Berlin, in the posterity of a very fine grenadier regiment formed by Frederic. Thus the stature of an entire tribe may be preserved, as in South America. In Europe, it is observed that men of the largest dimensions are generally of fair complexion, but that their muscles are soft, and their pulse slow and languid.

There are several reasons why mankind have been prone to believe in gigantic nations. First, among the Jews, from its being recorded in scripture; secondly, from the mythologies and fabulous histories of the Greeks and Romans; thirdly, from the discovery of enormous bones in the earth, belonging to no existing race of animals in the place where they were found. This last has been deemed one of the strongest confirmations; and unquestionably, without due consideration, it might stagger the most incredulous. Suetonius tells us, that in the time of Augustus huge bones were shewn as those of former races of men; and St Augustine reasons on the existence of giants before the deluge, from observing a tooth an hundred times exceeding the common size on the shores of Cilicia. At the present times, bones of immoderate dimensions are frequently dug out of the earth, which it has been reserved for modern anatomists to prove are those of extinct animals, instead of gigantic men. But it is not surprising, if, in the ages of ignorance, they were supposed to be such; and even now, osteology is so little understood by the vulgar, that few can tell, on the first discovery of a bone or a fragment of it, whether it has belonged to a man or an animal. Those enormous skulls or leg-bones, which would have created a race of giants sixteen or twenty feet high, have therefore been the relics of elephants, or of some of those extinct animals, whose dimensions surpassed those of any which at present inhabit the known world.

There is no evidence whatever, that the modern tribes of mankind have degenerated in size. The catacombs of ancient Egypt and Palestine; the cenotaph, if it be truly such, in the great pyramid; the tomb of Alexander the Great, are all calculated for bodies of ordinary dimensions. The truth is still more satisfactorily established from the mummies which are yet withdrawn from their subterranean receptacles in Egypt, and the caverns of the Canary Islands. In the most ancient sepulchres of Britain, those apparently anterior to the introduction of Christianity, no remains are discovered which indicate the larger stature of the inhabitants than our own. In every part of the world, domestic implements and personal ornaments, many centuries old, are obtained from tombs, from bogs and mosses, or those cities overwhelmed by volcanic eruptions, which would be ill adapted to a gigantic race of ancestors. See *Philosophical Transactions*, vol. xxxiv. and lx.; *Journal de Physique*, 1778; Hawksworth's *Voyages*, vol. i. ii.; Kircher, *Mundus Subterraneus*, lib. viii.; Cuvier, *Ossemens Fossiles*; Hieronymus Magius, *Miscellanea*; *Florus*, lib. iii. cap. 3.; *Pliny*, lib. viii. cap. 16.; Augustine, *De Civitate Dei*. (*c*)

GIANT's CAUSEWAY. To traditionary ignorance we may safely attribute a name, by which a basaltic portion of the coast of Antrim has been distinguished. Fin M'Coul, or, as he is classically denominated, Fion Mac Cumhal, desirous to punish the daring inroads of the Scots, resolved to

> " Bridge the ocean for the march of war."
> DRUMMOND.

And as all the heroes of his standing were either gods, demigods, or giants, we cannot be surprised, that an appearance bearing such close resemblance to artificial combination, should have been attributed to one or other of these agents.

The Giant's Causeway must not be limited to the particular mole or quay to which the traveller is conducted, when he approaches the coast from Bush Mills, the usual resting-place. It extends, as we have already observed under the article FAIRHEAD, throughout the whole of Bengorehead, from Port Moon on the east, to Port na Ganye on the west; a district of coast extending to more than a mile and a half in a direct line; and in every part of it, deeply indented with the most beautifully diversified bays.

Upon approaching the Causeway, the tourist is sure to be assailed by a host of ragged natives, whose attentions it is utterly impossible to get rid of: he must therefore quietly submit to take a few of them into his pay in the character of guides, in order to defend him from the importunities of the rest. Accompanied by these unwelcome guests, he is conducted down a steep path, which was formed at a great expence by the late Earl of Bristol, Bishop of Londonderry, to a natural mole which projects considerably into the sea; and here he is told, that this is the Giant's Causeway. The impression which generally follows is something like disappointment, so much has been heard, and consequently so much expected of the place. This feeling, however, is only of a momentary nature; for the mind has no sooner time to reflect on the admirable symmetry of an object with which nature seems purposely to have sported, in order to baffle the feeble intellect of mankind, than wonder and delight replace the apathetic feeling, which had nearly produced an ejaculation of discontent.

This mole or quay is entirely composed of basaltic columns: it is part of an immense bed, which here dips into the sea, and rises, as it is traced eastward, until it reaches a height of 200 feet above the level of the sea. These columns are arranged perpendicularly, and so accurately fitted into each other, that the point of a knife is not to be introduced between them, excepting where the seams have been opened by the action of the weather. This collection of columns extends from the base of the cliff into the sea about 725 feet, part of it at low water being still covered. It is divided into three parts, which are denominated the Great, the Middle, and the Little Causeway. These separations are occasioned by two parallel dykes, which traverse the columns in a northern direction; and to these perhaps the preservation of this mole is to be attributed; for although they are excavated, and worn down on the surface, still they remain firm at the base, and afford an immoveable support to the columns. These are of all shapes, from the triangular prism to

Giant's Causeway.

figures of nine sides. It is seldom that any among the multiplicity of forms which present themselves are very symmetrical, those of the pentagon and hexagon are most common; and they sometimes, though rarely, occur perfectly equilateral. In the highest part of the mole, the columns are from 25 to 30 feet in length, extremely straight and well proportioned: to this place the name of the Loom has been given. The prisms are wonderfully sharp in the angles, and present the very curious phenomenon of articulation throughout their whole extent. This articulation is not performed by a simple section of the column, but the joints are let into each other in the manner of the ball and socket, so that the angles of the under joint extend in the form of triangular projections, over those of the one above it. These projections, or spurs as they have been denominated, are easily detached; and in some places, particularly among the columns at the Organ a little east of the mole, where they are 45 feet in height, this mutilation renders the articulation particularly remarkable. The joints are from eight inches in length to a foot and a half, and sometimes even two feet; they are often longest towards the bottom. In diameter, the columns may average about 16 or 20 inches; they are wonderfully uniform in this respect; those of a triangular and square form are very rare, as well as those of nine sides.

The height of the cliff which overhangs this mole, is about 330 feet above the level of the sea, and varies from that to 400 feet, which is the elevation of Pleskin, one of the principal promontories towards the eastern extremity of this basaltic district. This portion of the coast is deeply indented; each little bay is denominated a port, and distinguished by its particular name, as Port Nofer, Port na Spania, &c. and along the whole coast the basaltic formation is beautifully exposed to view, in one of the most magnificent façades perhaps in the world. In some of the promontories, the ranges of columns placed over each other, and separated by amorphous trap, extend to the number of four or five. This is particularly the case in the great headland which bounds the east side of Port na Spania. At Port Pleskin, the visible ranges of columns are only two, but here they are magnificently displayed, and on a larger scale than in any other part of the causeway. The number of beds of trap are altogether about 16, partly very soft amygdaloid mixed with much zeolite, and partly irregular prismatic basalt. These are here and there interspersed with beds of bright red ochre; on one of which, at an elevation of about 200 feet from the sea, the first bed of columnar basalt rests, measuring about 44 feet in thickness. On this a bed of irregularly prismatic basalt lies, 54 feet thick; and on it another colonnade, still more magnificent than the first.

Pleskin is the highest elevation of this basaltic district; from it the beds all dip to right and left, and that which we have just mentioned, as resting on a surface of red ochre, 200 feet above the level of the sea, on the west, sinks below its surface at the mole, which in fact is merely a portion of it, and on the east it disappears in the middle of Port Moon. The view from the summit of Pleskin, is one of the most imposing that can be imagined; the series of headlands, which are seen in perspective from this point, form one of the grandest pictures of coast scenery, that it is possible to conceive.

The substance of the columnar basalt is extremely compact, of a dark iron grey colour, fine grained in the texture, and conchoidal in the fracture, with sharp-edged angular fragments. It is totally different from the substance of which Fairhead is composed; and perhaps we could not point out where the distinction between basalt and greenstone is better defined, than at Fairhead and the Giant's Causeway. The blocks or joints are extremely sonorous. Small pieces of calcedony, fine semi-opal, and even precious opal, have been found imbedded in it: it is occasionally cellular, and in some places presents the very singular phenomenon of containing fluid water; a circumstance which may be observed in the columnar basalt that occurs in a quarry not far from the summit of Pleskin. This fact has been urged by Dr Richardson as an incontestible proof of the impossibility of basalt being of igneous origin; but the theorists on that side of the question have no difficulty in accounting for it; we may remark, however, with regard to the value of the fact itself, that it cannot be of much consequence; for if pieces of the stone be removed for a time from the quarry, water will no longer be found in them, having made its escape; hence, if the stone be sufficiently porous to admit of the escape of the fluid, it cannot be denied that water may also be admitted through the same channel.

The Causeway has one considerable advantage over its rival Staffa, being much more accessible; it is distant about six miles from Colerain, between which and Belfast there is a regular mail-coach communication.

See the Rev. Mr Dubourdieu's *Statistical Survey of Antrim;* Dr Hamilton's *Letters on the County of Antrim;* the *Giant's Causeway,* a Poem, by W. H. Drummond, D.D.; the Rev. Richard Pocock's Account of the Giant's Causeway, in the *Phil. Trans.* 1747-8, vol. xlv. page 124; and Dr Richardson's Paper on the basaltic country in Ireland, in the *Phil. Trans.* 1808, vol. xcviii. p. 187. (S. N.)

Gibbon.

GIBBON, Edward, Esq. celebrated for the elegance and depth of his literary and historical works, was the first child of the marriage of Edward Gibbon, Esq. and Judith Porten. He was born at Putney in the county of Surry, on the 27th of April O. S. 1737. His maternal grandfather was Mr James Porten, a London merchant. By the father he was descended from John Gibbon, who is recorded to have been the *marmorius* or architect of Edward III. The strong and stately castle of Queensborough, which guarded the entrance of the Medway, was a monument of his skill, and obtained for him the reward of a hereditary toll on the passage from Sandwich to Stanar, in the isle of Thanet. The family was at that time possessed of lands in Kent, and the elder branches continued to possess them without much alteration till the present time. Our author, who was descended from a younger branch of the family, counts among his kindred several individuals of rank, learning, and political eminence. He was the only surviving member of a family, consisting of six sons and one daughter, all of whom, himself only excepted, were snatched away in infancy. In his Memoirs of himself, published by his friend Lord Sheffield, he makes use of the following tender expression of his feelings: "My five brothers, whose names may be found in the parish register of Putney, I shall not pretend to lament; but *from my childhood to the present hour,* I have deeply and sincerely regretted my sister, whose life was somewhat prolonged, and whom I remember to have seen an amiable infant." His own constitution was so extremely feeble even from his birth, that, anticipating his early loss, his father's prudence had the name of Edward repeated in the baptism of each of his sons, that this hereditary appellation might assuredly belong to the heir.

Gibbon.

It is strange to say, that such a succession of melancholy casualties did not wean the parents of this last hope of their family from the ceremonies and gaieties of life; and that the historian acknowledges, with grateful warmth, that even the maternal office was supplied by his aunt Mrs Catherine Porten, to whose gentle and unremitted assiduities he does not hesitate to ascribe the wonderful preservation of his life. His tender attachment, and his filial duty to this lady, place his character in a very amiable point of view. At the age of fifteen, "the mysterious energies" of his constitution began to display themselves, and from that time till within a few years of his death, he enjoyed an extraordinary and uninterrupted course of good health. In his nursery lessons, and at the day school at Putney, he shewed some quickness of apprehension, and such a readiness in arithmetical exercises, as leads him to suppose, that, had he persevered in such studies, he might have acquired eminence as a mathematician. At the age of seven, he was committed to the care of Mr Kirkby, a domestic tutor, who remained with him eighteen months, and taught him, among other things, the elements of the Latin language. Young Gibbon was sent in his ninth year to the grammar school of Kingston-upon-Thames, where he continued one among a crowd of boarders for two years, (with the exception of intervals occasioned by illness and vexations,) and from which he was removed home in consequence of the death of his mother. As his grandfather Mr Porten's house at Putney was near his father's, he again enjoyed the society and kindness of his beloved aunt; and having acquired some taste for reading poetry and romance while at Kingston, she encouraged his taste, and supplied him abundantly with books from her father's library. Some months having thus elapsed, Mr Gibbon, senior, finding himself inconsolable for the death of his wife, removed from Putney, where every object was associated with afflicting remembrances, to the rustic and retired family residence at Buriton, in Hampshire. Soon after, Mr Porten's affairs fell into disorder, so that he judged it prudent to abscond for a time. Mr Porten's unmarried daughter, Catherine, now found herself destitute, and partly with the design of being independent, but chiefly actuated by the motive of superintending her nephew's education, and watching over his health, she resolved to open a boarding house for Westminster school; and she and her young charge removed to her new house in College street, in January 1749. In the autumn of 1750, she accompanied him to Bath, on account of his bad health, where her own avocations compelled her to leave him under the care of a faithful domestic.

After various changes of place, and the complete establishment of his health, Gibbon was entered a gentleman commoner of Magdalen College, Oxford, in April 1752. At this ancient and far-famed seat of learning, he passed fourteen months, which, with bitterness of spirit, he declares to have been the most idle and unprofitable of his life. For this he does not blame himself, for he declares he had now a keen appetite for knowledge; but the relaxed discipline and customs of the university. He describes it as a place in which a young man may keep terms, spend money, and acquire bad habits, but totally unfit for stimulating genius to exertion, or promoting the attainment of knowledge and wisdom.

He declares that all the direct advantage which he received from Oxford was the reading of some of the comedies of Terence; and while he admits that some colleges may be better regulated than that to which he belonged, that many eminent men have been educated there, and that some practical improvements have been adopted since his time, he still insists on the necessity, at the same time that he admits the difficulty of a great reformation. He even complains that his moral conduct, and religious instruction, were completely neglected, and that, without a single exhortation or lesson, he was left, by the dim light of his catechism, to grope his way to the chapel and communion table. His sedentary habits, and infirm health in early life, had led him to indulge in desultory reading; and though his father was a man of the world, who cared little about religious controversy, yet his pious aunt had taken pains to instruct him, and had encouraged him to ask questions and propose objections, which she was not always well qualified to answer. At Oxford he read with avidity certain of the writings of Parsons the Jesuit, and of the learned and profound Bossuet, in defence of the doctrines of the Catholic faith, and having formed an intimacy with a young man of the same college to which he belonged, who had imbibed opinions favourable to the Church of Rome, he actually became a proselyte, and with the zeal of a martyr he went to a Catholic priest in London, renounced the Protestant faith, and was admitted into the pale of the Romish church.

He then wrote a long letter to his father, explanatory of his new profession, and the grounds of it. His father, equally indignant and amazed at the intelligence, somewhat imprudently spoke of his son's change of religion, and the gates of Magdalen College were thenceforth shut against him. This only added zeal to the faith of the young disciple, and his father, after much deliberation and sorrow, determined to exile him for some years from his native country, and to fix him at Lausanne in Switzerland, under the roof of Mr Pavilliard, a Calvinistic minister, in the hope that his errors would be corrected. Thither young Gibbon accordingly went, rejoicing that he was counted worthy to suffer for what he deemed the cause of truth. In his new situation, he enjoyed few of the comforts, and none of the luxuries to which he had been accustomed. His accommodation was mean, and the economy of the house by no means suited to the elegance of an English taste. Yet he soon became not merely reconciled to, but even pleased with his situation. The conversation, the books, but above all, the kindness and confidence of his amiable host, promoted his intellectual improvement, and his happiness. His mind too was amply gratified in its appetite for religious controversy; and Monsieur Pavilliard, who, in his letters to Mr Gibbon, senior, extols the progress of his pupil, informs him from time to time of the tenacity with which he held his opinions, and the obstinate perseverance with which he debated every point of his faith. At length the various articles of the Romish creed vanished like a dream, and after full conviction, he was a communicant on Christmas day 1754, in the Presbyterian church of Lausanne. As this forms a most important part of Mr Gibbon's life, and as it tends to throw light on the subsequent scepticism which too plainly marks his writings, we have dwelt more fully on it than we should otherwise have done. The following oracular sentence contains the only allusion which he himself makes to its influence on his opinions. "It was here that I suspended my religious inquiries, acquiescing with implicit belief in the tenets and mysteries which are adopted by the general consent of Catholics and Protestants."

The incident next in importance, which distinguishes Mr Gibbon's residence at Lausanne, was the honourable attachment which he formed for the accomplished Mademoiselle Susan Curchod, the daughter of an obscure Protestant clergyman in the neighbourhood. The lady favoured his addresses, but they were opposed by his father, on whom he found himself completely dependent, and to whose *veto* he submitted with a degree of apparent *sang froid,* not easy to be explained consistently with the professed warmth of his affection. This interesting female attained afterwards a melancholy eminence as the wife of Neckar. As the sensitive Rousseau speaks in terms of keen disapprobation of the conduct of Gibbon on this occasion, it is fair to state, that the latter afterwards renewed his intimacy with her as the wife of the celebrated ex-minister, and lived for many years on a footing of easy and affectionate familiarity with herself and her husband.

At length, after an absence of nearly five years, he was permitted to return to England about the beginning of summer 1758. In the interval, his father had formed a new connection by marriage, and our learned stranger was received with a degree of kindness which filled him with satisfaction. After two years passed in study or amusement, his father and he rashly offered their services in the Hampshire militia, in which they were appointed major and captain, and kept under arms and in constant service for nearly two years. During this time, young Gibbon, though deeply disappointed at the sacrifice he had made, and of which he had by no means anticipated the extent, endeavoured to acquire a knowledge both of the art of war and of British tactics, and acknowledges, with great honesty, that "the captain of the Hampshire militia has not been useless to the historian of the Roman empire!"

When at Lausanne, he meditated, and began, the composition of a small work, entitled *Essai sur l'Etude de la Literature,* which he finished in England, and published, with a dedication to his father, in 1761. This work was written in French, a language in which his daily habits of conversation and study when at Lausanne, had rendered him more adroit than in his vernacular tongue. His chief object in this *coup d'essai,* was to revive on the continent, and especially in France, the decaying taste for the languages and literature of Greece and Rome. This juvenile production was well received, both at home and abroad. After the peace of 1763, he again went to the continent, and on his way to his favourite Lausanne he visited Paris, where he remained for three months, and was introduced to the acquaintance of D'Alembert, Diderot, and many other of the literati of the day. Having passed through Dijon and Besançon, he arrived at Lausanne in May 1762, and, fascinated with the renewal of the scenes, studies, and associates of his early years, he remained there till the following spring. Having prepared himself, by extensive study, for a projected tour through Italy, he set out in April 1764, and going by Parma and Florence, proceeded through Sienna to Rome, on entering which renowned city he was almost overwhelmed with emotions of enthusiasm. It was at Rome, on the 15th of October, that, as he sat musing amidst the ruins of the capital, while the bare-footed friars were singing vespers in the Temple of Jupiter, that, as he informs us, he conceived the idea of writing the Decline and Fall of the Roman Empire! He proceeded south to Naples, revisited Rome and Paris, and arrived at his father's house in June 1765. Every spring he attended the monthly meeting of the militia, and was promoted to the rank of lieutenant-colonel commandant. Wearied with the details of this service, he resigned his command in 1770. An annual visit at Buriton, from his much-loved friend M. Deyverdun of Lausanne, formed the most agreeable enjoyment of his life during this period; and, with the aid and encouragement of that learned and elegant scholar, he proceeded some length in preparing a history of the rise and progress of liberty and independence in his adopted country, Switzerland. The great difficulty of procuring materials, and his ignorance of the German language, induced him to desist from the completion of this interesting design. In 1767 and 1768, he in his turn materially assisted M. Deyverdun in the publication of a work intended to be annual, entitled, *Memoires Literaires de la Grande Bretagne.* This work, of which the third volume was nearly ready, was discontinued, in consequence of Mr Deyverdun agreeing to accompany on his travels as tutor, a young friend of Mr Gibbon's. The next publication of Mr Gibbon, is an able and spirited, but most severe answer to that chapter in Warburton's "Divine Legation of Moses," which represents the sixth book of the Æneid as containing a veiled account of the initiation of Æneas, in the character of a lawgiver, into the Eleusinian mysteries. This essay was published in English anonymously early in 1770; and the author, with great ingenuity, shews, that the sixth book is not an allegory, but a fable founded on the popular belief, and that there is not a shadow of probability in the hypothesis of Warburton. The Bishop and his friends remained silent under this attack, and the voice of the learned pronounced that Gibbon was master of the field.

The grand project of "the History of the Decline and Fall of the Roman Empire," which had been formed in the interesting circumstances already alluded to, was ever present to the mind of the author, though its execution was for some time delayed; and the embarrassment of his father's affairs, as well as the decline of his health, prevented Mr Gibbon from pursuing his studies with his usual ardour. In November 1770 his father died, and during the two succeeding years, the arrangement of his affairs occupied much of his time and attention. Finding himself at length comfortably settled in a house in London, furnished with a valuable library, and having long prepared for the task, he entered seriously on the composition of his great work; and when he published the first volume in quarto, his success was so great, that the first impression was exhausted in a few days, and a second and third edition were speedily called for. Letters of compliments flowed in upon him from various quarters. These were speedily succeeded by the strictures, attacks, and confutations of those who were offended with his 15th and 16th chapters, which contain an unfair and insidious account of the rise and progress of Christianity. The principal assailants were Dr Watson, now Bishop of Landaff, Taylor of Norwich, Mr Milner of Hull, Lord Hales, Mr Davies of Oxford, and Dr Priestley. That he was much stung by these publications, he does not attempt to deny. But the only one of them which he answered from the press was the pamphlet of Mr Davies, because, as Mr Gibbon alleges, he had attacked not so much the *faith* as the *fidelity* of the historian. This answer is entitled, *A Vindication of some Passages in the 15th and 16th Chapters of the History,* &c. and if he does not shew great candour in his defence, the praise of ingenuity and learning will not be denied to him. After the lapse of a con-

Gibbon.

siderable interval, the second and third volumes were published. The three last volumes, chiefly composed at Lausanne, were printed in England, and published in May 1788.

In 1774, Mr Gibbon was returned as a member of parliament from the borough of Leskeard, and was a uniform but silent supporter of administration during the American war. Timidity, he says, was fortified by pride, and even the success of his pen discouraged the trial of his voice. He held his seat during eight sessions, and seems to have enjoyed the confidence, and occasionally assisted the councils, of the administration. Through the favour of Lord North, of whom Gibbon always speaks with high respect and esteem, he was appointed one of the lords commissioners of trade and plantations, and had thus a clear addition to his income of between L. 700 and L. 800 a year. The board was abolished in the following session by a small majority of votes in the House of Commons, but was soon afterwards revived. Mr Gibbon held the place for three years, that is, till the board was abolished by Mr Burke's bill. Mr Gibbon having got into next parliament through Lord North's influence, for Lymington, tells us, that he uniformly supported the famous coalition between that minister and Mr Fox *from a principle of gratitude.* This confession, to be sure, though hardly becoming the dignity of a historian, or the morality of a philosopher and patriot, who may be expected to act in a public cause, not from private feeling, but from conviction, does yet sound as a weakness leaning to virtue's side; but most unfortunately for his reputation, *even as a friend,* he adds: "My vote was counted in the day of battle, *but I was overlooked in the division of the spoil.* There were many claimants more deserving and more *importunate* than myself." A more unblushing and more unvarnished acknowledgment of venality we do not recollect to have seen; and we must confess that it lessens Mr Gibbon, in our moral estimate, to a degree that is painful to contemplate. One wonders that the man who had the meanness thus to act, had the candour to acknowledge such meanness in a memoir designed for the public eye. But, in truth, with all the extent of his learning, and all the force of his genius, he does not appear to have discovered the unworthiness of thus betraying the interests of his country for a private end.

The attachment of Mr Gibbon to Lausanne, and his friendship for Mr Deyverdun, who was now residing at his delightful villa there, induced him to form the romantic design of settling at that place, and living as an inmate with his friend. This wish, no importunities of his friends at home could prevent him from accomplishing; and accordingly he realized his project in 1783. His friendship with Mr Deyverdun continued uninterrupted till the death of that respectable man, which happened in 1789. Mr Gibbon often lamented this event in language that shews how deeply he estimated his loss; but by an arrangement with the heir, he continued to reside in the house till 1793, when the horrors of the French Revolution, and the domestic affliction of his friend Lord Sheffield, induced him to return to England. He was looked up to while at Lausanne with respect and admiration, and his house was the centre of learning and hospitality. The preference which he shewed to that little *paradise,* as he used to call it, made the inhabitants regard him as a father; and the regrets that followed his departure are a most honourable tribute to his name. He arrived at the house of Lord Sheffield in London about the beginning of June, and spent the summer and autumn chiefly at Sheffield Place, where he seemed to enjoy good health, and where his conversation was the delight of all who heard it. For several years he had been subject to occasional attacks of gout. Towards the close of this autumn he was attacked with a dropsical tumour, the formation of which he had too long concealed. After submitting to several operations, after each of which he anticipated a complete recovery, inflammation came on, and he expired in London on the 16th of January 1794, in the 57th year of his age. We understand that the friendship of Lord Sheffield induced him to erect a handsome monument to his memory.

That Mr Gibbon possessed, in an eminent degree, many of the qualities which constitute a good historian, will readily be admitted, even by those who most disapprove of some of his sentiments. Extensive, varied, and profound learning, unwearied perseverance, great coolness of judgment, belonged to him in a high degree; and though his own diffidence leads him to disclaim a place beside our two great Scottish historians, Robertson and Hume, we apprehend that he is not much inferior to either. He has ably supplied a most important desideratum in historical knowledge, and has filled up the chasm which divided ancient from modern history. Though the history of his early life cannot excuse, it leads us, in some degree, to extenuate the disingenuousness with which he appears to be chargeable in discussing the nature and propagation of Christianity; and the able answers which have appeared, have, we hope, effectually counteracted the baneful effects of his misconceptions or misrepresentations. (*l*)

GIBRALTAR.

Gibraltar.

Gibraltar, the *Mons Calpe* of the Romans, is a celebrated promontory in Andalusia, the most southern province of Spain, stretching into the Mediterranean towards the opposite promontory of Ceuta on the Barbary coast. It is situated in Lat. 36° 6′ 30″ North, and Long. 5° 19′ 31″ East, from the meridian of Greenwich.

Situation.

General description.

The mountain of Gibraltar is of an oblong form; its summit consists of a sharp craggy ridge, running in a direction nearly from north to south. The line of this ridge is undulated, being somewhat higher at the two extremities than in the centre. The whole rock is about seven miles in circumference, and forms a promontory about three miles in length. Its breadth varies with the indentations of the shore; but it no where exceeds three quarters of a mile. It is joined to the continent by a low sandy isthmus, the greatest elevation of which, above the level of the sea, does not exceed ten feet; and its breadth, at the base of the rock, is about 900 yards; but it grows considerably broader towards the country. This isthmus, with the mountain and the opposite coast of Spain, forms the Bay of Gibraltar, which is nearly eight miles and a half long, and upwards of five miles broad. The most elevated point of the promontory, towards the south, which is the summit of the Sugar Loaf, stands 1439 feet; the Rock Mortar, the highest point towards the

Gibraltar.

north, 1350; and the Signal House, which is nearly the central point between these two, 1276 feet above the level of the sea. The western side of the mountain presents a gradual slope, interspersed with abrupt precipices. The northern front, facing the Spanish lines, is perfectly perpendicular, with the exception of a narrow passage of flat ground towards the north-west, which leads to the isthmus. The eastern side consists, in a great measure, of a range of precipices; but about a third of its perpendicular height is covered by a bank of sand, which rises from the Mediterranean in a rapid acclivity. The southern extremity of the mountain falls, in a rapid slope, from the summit of the Sugar Loaf into a rocky flat, of considerable extent, called Windmill Hill. This flat is bounded by a range of precipices, at the southern base of which there is a second rocky flat, of similar form and extent, and surrounded also by a precipice, the southern extremity of which is washed by the sea, and forms Europa Point.

History.

This promontory has become famous, in modern times, for the site of a fortress, which nature and art have conspired to render the strongest in Europe, perhaps in the world. The Bay of Gibraltar affords so commodious a harbour for shipping, and the promontory itself seems so completely formed by nature for commanding the narrow entrance into the Mediterranean from the ocean, that a town of considerable strength probably stood somewhere in this bay from the earliest times. Indeed, ruins of great antiquity are still distinguishable at the bottom of the bay, on the banks of the Guadaranque, about four miles north-west from Gibraltar, which are supposed to be the remains of the ancient city of Carteia, or Heraclea. But the mountain itself does not appear to have been an object of particular attention in early times; and the present town and fortress are indebted for their name and existence to the Moorish invaders of the peninsula.

The Saracens, under the conduct of Tarif, invade Spain,

About the commencement of the eighth century, Count Julian, a nobleman of great wealth and influence, whose daughter had been violated by Roderick, the last of the Gothic monarchs of Spain, determined to revenge the dishonour done to his family; and having secretly retired into Africa, acquainted Mousa, the Saracen governor of the western provinces, with the distracted state of the kingdom, and promised to assist him in an attempt to dethrone the Gothic monarch. Mousa communicated the proposal to his sovereign, the Caliph Al Walid Ebn Abdalmalic, who resolved to try the practicability of the project; and accordingly a small detachment, consisting of 100 horse, and 400 foot, was embarked in the year 711, under the command of Tarif Ebn Zarca, who landed near the present town of Algeziras, and finding the country almost defenceless, ravaged the neighbouring towns, and returned laden with spoils. In the following year an army of 12,000 Saracens was assembled for the invasion of Spain, and Tarif was again appointed to the chief command. He landed on the isthmus between Mons Calpe and the continent; and having determined to establish a port on the coast, by means of which he might secure a communication with Africa, and at the same time cover his retreat, in case he should be unfortunate in his future operations; he preferred the strong natural situation of Mons Calpe, and gave orders to erect a castle on the face of the hill, which the Saracens now called, in compliment to their general, *Gibel-Tarif*, or the mountain of Tarif; whence the modern name of Gibraltar. From an inscription discovered over the principal gate of this once magnificent pile, the period of its completion is ascertained to be about the year 725. Having left a garrison at Gibraltar, Tarif marched into the country, and seized upon several of the towns in the neighbourhood. In the mean time, King Roderick, having received intelligence of his approach, assembled a numerous army to oppose his progress. A battle was fought near Xeres, in Andalusia; and after a long and sanguinary contest, victory declared in favour of the Saracens, and left them in possession of the whole kingdom.

and founds Gibraltar. A. D. 725.

Gibraltar taken by Ferdinand King of Castile.

From this period the Moors continued masters of Gibraltar, until the beginning of the 14th century, when it was wrested from them by the victorious arms of Ferdinand, King of Castile. In the year 1333, Abomelique, son of the Emperor of Fez, was dispatched with assistance to the Moorish King of Granada, and landing at Algeziras, immediately laid siege to Gibraltar. Alonzo XI. who was then upon the throne of Castile, was prevented from marching to its relief by a rebellion in his kingdom, and by the approach of Mahomet, King of Granada, towards his frontiers. The fortress was attacked with great judgment and bravery, and defended, with equal obstinacy, by the governor, Vasco Perez de Meyra, who was compelled, however, to surrender, after a five months siege. Having quelled the rebellion, and obliged Mahomet to retire, Alonzo had advanced within a short distance of Gibraltar, when he was informed of the capitulation. Having resolved, however, to attempt its recovery, before the Moors could victual and repair it, he encamped before the town five days after it had surrendered. But after several serious attacks had been made upon the castle, Mahomet, King of Granada, having joined Abomelique's forces, their combined army encamped in the rear of the Spaniards, extending across the isthmus from the bay to the Mediterranean. Being thus placed in an extremely critical situation, Alonzo was at length obliged to listen to an accommodation, in consequence of which he was permitted to retire unmolested. In the beginning of the year 1349, Alonzo again encamped before this important fortress; and, in the course of several months, the castle was almost reduced to capitulate, when a pestilential disorder carried off a great number of the besiegers, and, among the rest, Alonzo himself, who died, much lamented, on the 26th of March 1350. The Spaniards immediately afterwards raised the siege. The descendants of Abomelique continued in quiet possession of Gibraltar till 1410, when it was seized and retained by Jusaf III. King of Granada. In 1435, Henry de Guzman, Count de Niebla, lost his life in an unsuccessful attack upon Gibraltar. In 1462, a great part of the garrison having been withdrawn, to assist one of the parties in a civil war which broke out in Granada, a Spanish army was collected from the neighbouring garrisons, and Gibraltar was besieged. The inhabitants defended it with great resolution; but the besiegers having been reinforced, the garrison surrendered to John de Guzman, Duke of Medina Sidonia, son of the unfortunate Count de Niebla; and thus was this important fortress finally wrested from the Mahometans, after they had possessed it during 748 years. This conquest was so acceptable to Henry IV. of Castile and Leon, that he added it to his royal titles, and gave it for arms, *gules*, a castle, *proper*, with a key pendant to the gate, *or;* which arms have ever since been continued. In the year 1540, Gibraltar was surprised and pillaged by Piali Hamet, one of Barbarossa's captains. During the reign of the Emperor Charles V. the fortifications of the town were modernised and augmented by Daniel Speckel, a Ger-

Retaken by Abomelique, 13[illegible]

Besieged by Alonzo [illegible]

who is obliged to retire.

Again besieged by Alonzo;

who dies before the place, 1[illegible]

Gibraltar seized by Jusaf III. King of Granada 1410.

Besieged by the Spaniards, and surrenders 1462.

Surprised and pillaged by Piali Hamet, 15[illegible]

Gibraltar.

man engineer; after which the garrison was thought to be impregnable.

Gibraltar taken from the Spaniards by the English, under Sir George Rooke, 1704.

From that period there is a chasm in the history of Gibraltar down to the year 1704, when this fortress was wrested from the dominion of Spain by the English, under Sir George Rooke. Sir George had been sent into the Mediterranean with a strong fleet, in the spring of that year, to the assistance of Charles, Archduke of Austria; but not having been able to succeed in any enterprise of importance, it was at length resolved, in a council of war, to make a sudden and vigorous attempt upon Gibraltar. The fleet arrived in the bay on the 21st of July; and 1800 English and Dutch, commanded by the Prince of Hesse d'Armstadt, were landed on the isthmus. The governor having refused to surrender upon being summoned, the cannonade was commenced with such vivacity and effect, that, in five or six hours, the enemy were driven from their guns, especially from the New-mole head. The armed boats were then dispatched to take possession of that fortification; but some pinnaces having pushed ashore before the rest came up, the Spaniards sprung a mine, which blew up the works, and killed a number of men. The assailants however advanced, and took a small bastion half way between the mole and the town; upon which the governor, being again summoned, thought proper to capitulate; and, on the 24th, the Prince of Hesse took possession of the gates.

Besieged by the Spaniards and French, 1705.

The capture of Gibraltar by the English could not fail to excite considerable alarm in the courts of Madrid and Versailles; and its recovery being considered as of the last consequence to the cause, the Marquis de Villadarias, a grandee of Spain, was ordered to besiege it. On the 11th of October, the Marquis opened his trenches against the town; and on the night of the 29th he had resolved to attack the place by sea and land, at five different points, had it not been most opportunely reinforced and supplied, on that very day, by the fleet under Sir John Leake. Nevertheless, the Spaniards still entertained hopes of taking the fortress, and formed the desperate design of surprising the garrison, although the British admiral was before the town. On the 31st of October, 500 volunteers took the sacrament never to return till they had taken Gibraltar. Fortune at first favoured the enterprise, and they succeeded in scaling Charles the Fifth's wall, and surprised and put to death the guard at Middle Hill; but having been at length discovered, they were vigorously attacked by a strong detachment of grenadiers, and the whole party were either killed or made prisoners. In the beginning of December, the garrison received the long-expected succours; and the Spanish general being also reinforced with a considerable body of infantry, on the 11th of January 1705, made an attack with 60 grenadiers on the works at the extremity of the King's Lines; but two officers and several others being killed, the rest retreated. The attack, however, was renewed on the following day, by 500 or 600 grenadiers, French and Walons, supported by 1000 Spaniards, under Lieutenant General Tuy. Their disposition was to storm a breach which had been made in the Round Tower, at the extremity of the King's Lines, and another in the intrenchment on the hill. The detachment for the upper breach mounted the rock at dead of night, and concealed themselves in the clefts. At day-break, they advanced to the point of the intrenchment, and compelled the party who defended it to retreat. At the same time the Round Tower was stormed by 300 men, in spite of a vigorous defence. But the garrison being at length alarmed, the assailants were charged with such bravery, that they were repulsed; and the Tower was retaken after it had been in their possession upwards of an hour. The Marquis de Villadarias was soon afterwards superseded by the Marshal Tessé, a French general; but the place was now so well supplied, that the Marshal withdrew his troops from the trenches, and converted the siege into a blockade; drawing an intrenchment across the isthmus to prevent the garrison from ravaging the country. The Prince of Hesse remained in the place while the batteries were repaired. He also made some additions to the fortifications, and left the garrison much stronger than it was before the siege. Major General Ramos, who had been present during the siege, was then appointed governor. He was succeeded by Colonel Roger Elliot; during whose government, in the month of April 1706, Gibraltar was made a free port, by a special order from her Majesty Queen Anne.

The siege turned into a blockade.

Gibraltar made a free port by Queen Anne, 1706.

The Spaniards form a secret design of surprising Gibraltar; but are obliged to abandon it, 1720.

In the year 1720, the Spaniards formed a secret design of surprising Gibraltar, under the pretence of relieving Ceuta, then besieged by the Moors. A formidable force was accordingly assembled in Gibraltar Bay, under the command of the Marquis de Leda; but the British ministry had timely notice of these proceedings; and such precautions were taken, that the Spaniards were obliged to abandon the project. From that period, Gibraltar remained unmolested, till the latter end of the year 1726, when the Spaniards, having assembled an army in the neighbourhood of Algeziras, encamped on the 20th of January 1727, on the plain below St Roque, and began to erect a battery on the beach to protect their camp. The fortress had undergone considerable alterations since the siege in 1705. Several new works had been constructed on the heights above the lines, which were distinguished by the name of Willis's batteries; the Prince's lines were also extended to the extremity of the rock; and an inundation was formed out of the morass in front of the grand battery. The Count de Las Torres commanded the Spanish forces, amounting to near 20,000 men; and soon after his camp was formed, he advanced within reach of the garrison. The British military and naval commanders, having no instructions, were for some time at a loss how to act; but the Spaniards having, at length, sufficiently discovered their hostile intentions, the lieutenant-governor withdrew the out-guard, and on the afternoon of the 11th of February, opened the old mole, and Willis's batteries, on the enemy's workmen. The enemy, however, still persisted in carrying on their works; and on the morning of the 22d, the Count opened on the garrison, with 17 pieces of cannon, besides mortars. On the 3d of March he opened a new battery of 22 guns on the old mole and town; and on the 8th another of 15 guns, bearing also upon the old mole, which, it seems, proved a troublesome battery to the western flank of their approaches. On the 21st of April, Lord Portmore, the governor, arrived with reinforcements to the garrison. On the 26th the Count opened a new battery against Willis's, and the extremity of the Prince's lines. Their batteries now mounted 60 pieces of cannon, besides mortars. The firing continued on both sides, until the evening of the 12th of June, when dispatches arrived with a copy of the preliminaries of a general peace, upon which all hostilities ceased.

Gibraltar besieged by the Spaniards, 1727.

Hostilities terminated by the preliminaries of peace.

Overtures had been made by his Majesty George I. to restore Gibraltar to Spain, if the parliament would consent to the restitution; but the measure being strongly opposed, was relinquished by the minister. In

Gibraltar.

Spanish lines erected, 1730.

1730, Lieutenant General Sabine was governor of Gibraltar. During his government, the Spaniards erected the forts and lines across the isthmus, about a mile from the garrison, which effectually prevent any communication with the country, and are of considerable advantage in case of a siege.

Famous siege of Gibraltar by the Spaniards and French, 1779—1783.

Although the Spaniards had been defeated in three different attempts to recover Gibraltar, they still continued to look upon that fortress with a jealous eye, and seemed only to wait for a favourable opportunity of wresting it, if possible, from the dominion of Great Britain. No such opportunity, however, occurred, until the war in which England was engaged with her American colonies. France having espoused the cause of our Transatlantic enemies, the court of Madrid thought proper to come forward with an offer of mediation, upon terms to which the belligerent powers could not accede. The refusal of Great Britain was followed by a declaration of war on the part of Spain. It was obvious that this war was undertaken principally with a view to the recovery of Gibraltar; and accordingly a contest ensued for the possession of that celebrated fortress, which will be ever memorable in the military annals of this country.

Preparations for the attack and defence, June, 1779.

At this period, General Elliott was governor of Gibraltar, Lieutenant-General Boyd lieutenant governor, and the garrison consisted of 5382 men. On the 21st of June 1779, the communication between Spain and the garrison was closed, by an order from Madrid. In the mean time, preparations had been privately made for the defence of the place, as soon as intelligence was received of the probability of a war; and when the first hostile indications of the Spaniards were perceived, the northern guards were reinforced, land port barriers were shut, and an artillery officer was ordered to Willis's batteries, to observe the movements of the enemy, and protect the Devil's-tower guard. In short, every precaution was taken to insure the safety of the garrison. In the month of July, the Spaniards formed a camp on the plain below St Roque, which was daily reinforced with additional regiments of cavalry and infantry; and large parties were constantly employed in landing ordnance and military stores at Point Mala.

The Spaniards form a camp at St Roque, July.

The garrison erect new batteries.

The garrison, in the mean time, were not less active. The works at Willis's were put in the best repair, and new batteries erected on the heights of the north front. A new battery was also begun in the navy-yard, as a resource, in case the enemy's operations should make it necessary to lay up the ships. In the month of August, the enemy were enabled to enforce a strict blockade; their army was now in force before the place; their squadron under Admiral Barcelo, who commanded in the Bay, could prevent succours from being thrown in by neutral vessels; whilst their grand fleet, united with that of France, would be superior to any which Great Britain could equip. The plan, therefore, seemed to be, to reduce Gibraltar by famine; and the place, indeed, might have been in imminent danger, had not the garrison fortunately received a supply of provisions, &c. in the preceding month of April. On the 27th, a fascine-work was observed to be begun upon the glacis north of Fort St Philip, which afterwards proved to be a mortar-battery. The enemy's camp was now considerably increased. It consisted of two lines, (independent of the Catalonians, who were separately encamped,) extending from Point Mala in an oblique direction into the country, towards the Queen of Spain's Chair. In the beginning of September, their workmen in the lines were busily employed in filling up with sand the north part of the ditch of Fort St Philip, completing the mortar-battery before mentioned, and raising the crest of the glacis of their lines in different places. From the noise often heard during the night, and the number of lights seen, it was conjectured that they worked without intermission. These operations of the enemy now began to engage the attention of the garrison; and the governor did not think it prudent to allow them to proceed any longer with impunity. A council of war was accordingly summoned on the 11th, to confer upon the measures proper to be pursued; and on the morning of the 12th, the artillery officers were ordered to the batteries on the heights, the Devil's-tower guard was withdrawn, and the governor opened on the enemy from Green's lodge, (a battery constructed since the blockade commenced,) Willis's and Queen Charlotte's batteries. This fire disconcerted the enemy; their advanced guards were in a short time compelled to retire, the workmen assembled in the lines were obliged to disperse, and the cavalry galloped off towards the camp. For some hours afterwards, scarcely was there an individual to be seen within the range of the guns of the garrison. The firing was continued on the subsequent days, as circumstances directed. The enemy, however, appeared to bear our fire very patiently in their lines; their parties continued working on the mortar-batteries, and a *boyau*, or covered-way, was begun, to make a safe communication from the lines to their camp. In the beginning of October, the enemy's army, according to the intelligence received by the garrison, consisted of sixteen battalions of infantry, and twelve squadrons of horse; which, if the regiments were complete, would amount to about 14,000 men. The whole were under the command of Lieut. Gen. Don Martin Alvarez de Sota Mayor.

The enemy enforce a strict blockade by sea and land, August.

They strengthen their lines, and erect new batteries, Sept. 1779.

The governor opens his fire upon the enemy's lines.

A gun mounted on the summit of the northern front, and called the Rock-gun, October.

The great command which the garrison had over the enemy's operations from the Green's lodge battery, induced the engineers to mount still higher, and endeavour to erect a battery on the summit of the northern front. A place was, therefore, levelled, and a road for wheeled carriages begun at Middle-hill. On the 12th of October, the platform on the summit of the rock was completed; and the gun being mounted, the enemy's forts were, on the following day, saluted with a few rounds of shot and shells. This gun was mounted on a traversing carriage, and was distinguished by the name of the Rock-gun. On the evening of the 19th, the enemy's working parties were uncommonly busy; and on the following morning at day-break, the garrison were surprised on observing 35 embrasures opened in their lines, forming three batteries; two of fourteen guns each bore on our lines and Willis's, and one of seven apparently for the town and Waterport. They were cut through the parapet of their glacis, and situated between the barrier of the lines and Fort St Philip. The governor ordered the artillery to direct their fire on these works, and on the seven-gun battery in particular, where the enemy had a party finishing what was left imperfect in the night. Our workmen now became extremely diligent; new communications and works were raised in the lines; and on the 27th, guns were carried up, to be in readiness for a new battery to be erected below the Rock-gun. Nothing remarkable occurred during the months of November and December. Both parties were occupied in improving and augmenting their works. The garrison, however, now began to be greatly distressed for want of provisions; not only bread, but every article necessary to the support of life, was procured with difficulty, and only to be purchased at exorbitant prices. This distress was considerably re-

The garrison distressed for want of provisions;

lieved in the month of January, when Sir George Rodney arrived in the bay with a convoy, after having defeated the Spanish fleet under Langara. At the same time, the garrison was reinforced by the second battalion of the 73d regiment. After the departure of Sir George Rodney with the fleet, in the month of February 1780, the Spaniards resumed the blockade with the same vigilance as before. No other event of importance occurred until the month of June, when the enemy made an unsuccessful attempt to destroy our vessels in the bay by means of fire-ships, which was defeated by the skill and intrepidity of the seamen. This attempt, however, induced the governor to direct particular attention towards that quarter of the garrison. Batteries for heavy metal were made on the rock above Parson's lodge, at Rosia; and orders were given to clear the new mole of shipping, that the ordnance might have more liberty to play. On the morning of the 1st of October. it was observed that the enemy had raised an *epaulement*, about six or seven hundred yards in advance of their lines. It was about thirty yards in extent, and was erected near the windmill, or tower, on the neutral ground, about 1100 yards distant from our grand battery. The garrison were at a loss to conceive what could induce the enemy to act in a manner so contrary to the usual mode of approaching a besieged place, by erecting a work so distant, and which had no connection with their established lines. But it now appeared evident, that they had determined on a more serious attack, in case the second blockade should prove unsuccessful. On the night of the 21st, the enemy threw sand in the front of their *epaulement*, to cover it from our fire; and on the 26th, they lengthened it to the west about thirty yards. The night of the 28th, they erected two large traverses in the rear for magazines. From the compact appearance of this new work, which was distinguished by the name of the Mill battery, the garrison concluded that it was intended for a mortar battery. On the night of the 17th of November, two *places d'armes* for musketry were thrown up on the flanks of the Mill battery; the parapets formed semicircles adjoining the battery, but afterwards extended, in an oblique direction, towards the lines. On the night of the 23d, the enemy began an approach from the lines to this battery, which they completed during the month of December. On the 12th of April 1781, the garrison, who for some time had been greatly in want of provisions and necessaries, was relieved by the arrival of the fleet under Admiral Darby. As soon as the van of the convoy had come to an anchor off the new mole and Rosia bay, the enemy opened a smart fire from all the batteries which bore upon the garrison. The fire was returned by the latter; and the bombardment was continued during the 13th and 14th. On the 15th and following days, it was continued with greater vivacity on the part of the enemy; but the batteries of the garrison discontinued their fire, and the guns at Willis's were drawn behind the merlons, to secure them against the enemy's shot. On the 16th, 18th, and 19th, the enemy's gun-boats attacked the shipping in the bay; but were obliged to retire, after doing some mischief. At this time, the batteries at Willis's exhibited a very disorderly and ruinous appearance; the merlons were considerably damaged, and some of the cannon dismounted and injured. The engineers and workmen were therefore employed in repairing them. The remainder of the month of April was remarkable for excessive rains, attended with most dreadful thunder and lightning, which, in addition to the fire from the enemy, had an awful and tremendous effect during the night. The bombardment continued warm and well supported, but apparently without any particular object on the part of the besiegers. In the month of May, their fire became more regular, and amounted, upon an average, to 1500 rounds in the twenty-four hours. Their cannonade was directed principally against our upper batteries. On the 23d, the gun and mortar boats renewed their attack upon the camp, with more dreadful effect than upon any former occasion; seven individuals within the garrison were killed, and twelve or thirteen wounded. The boats continued to repeat their vexatious visits during the month of June, and kept the garrison in a constant state of alarm, as experience had proved their destructive effects. The governor, therefore, resolved to retaliate, by endeavouring to annoy the enemy's camp from the old mole head, and this experiment was found to succeed. At the same time, some brigs were ordered to be cut down and converted into *prames*, which were to be moored between the new mole and Ragged Staff, at such a distance from the works as to be easily protected, and yet far enough out to keep their boats at a respectful distance.

ut relieved by Sir George Rodney, Jan. 1780.

The enemy erect works in advance of their lines, Oct.

d begin approach from their lines to the new battery, November.

e garrison again relieved by Admiral Darby, April 12th 81.

The enemy's gun and mortar boats make an attack upon the camp, May 23d, 1781.

The governor retaliates from the old mole head.

In the month of November, the besiegers had advanced so far in completing their approaches, and their batteries exhibited so perfect and formidable an appearance, that the governor thought the time was now come to strike a blow, which should frustrate all their views, by destroying these stupendous works, which had cost them such immense labour and expence. Having procured the necessary information from deserters, this important design, which had not been previously communicated to the garrison, was put in execution on the night of the 26th. A strong detachment was formed into three columns, and tools for demolishing the works delivered to the workmen. The destination of the columns having been made known to the different officers, and the necessary orders given, the detachment began its march, about a quarter before three in the morning of the 27th. The enemy, thus taken by surprise, and assailed with irresistible ardour, gave way on every side, and precipitately abandoned the works. The business was completed by the exertions of the workmen and artillery. The batteries were soon in a state for the fire-faggots to operate; and the flames spread with astonishing rapidity. In the course of an hour, the object of the *sortie* was fully effected; and trains having been laid to the magazines, the troops were drawn off. Not the smallest effort was made by the enemy to save their works, or avenge their destruction. Scarcely had the rear of the detachment got within the garrison, when the principal magazine blew up with a tremendous explosion; throwing up vast pieces of timber, which, falling into the flames, added to the general conflagration. This important object was accomplished with little loss on the part of the garrison. For some time the enemy did not think proper to take any measures towards extinguishing the flames; on the 30th their batteries continued burning in five different places; and when they ceased to smoke, the works seemed to be completely destroyed, nothing but heaps of sand remaining. In the beginning of December, they seemed as if suddenly roused from their reverie; upwards of a thousand men were at work, making fascines, &c. From these operations the garrison concluded that they were resolved to restore their works, when sufficient materials were prepared. For some months the enemy continued to repair their works, but apparently only for defence. In the month

The garrison make a sortie, and destroy the enemy's advanced works, Nov. 27th.

Gibraltar.

The besiegers resolve to attack the garrison from the sea, by means of floating batteries. May 1782.

of May 1782, it was discovered that the besiegers had a new plan of operations in view. On the 14th several of the large ships at Algeziras struck their yards and top-masts, and a great number of men appeared on board them; which circumstances led to the belief, that they were intended to be fitted up as *floating batteries*, for a grand attack to be made upon the garrison from the sea; and this opinion was confirmed in the afternoon, by their beginning to cut down the poops of two of them. The garrison, on the other hand, made various dispositions to repel this meditated attack. The works at Waterport were strengthened; an additional number of grates for heating shot were distributed along the line-wall; and the navy lowered their yards and top-masts, to be in readiness to act on shore at a moment's notice. In the month of June, the army of the besiegers was reinforced by a strong body of French troops; and the Duke de Crillon assumed the command of the whole. The Duke had recently returned from the conquest of Fort St Philip, in Minorca, and brought with him M. d'Arçon, a famous French engineer, who had projected the plan of attacking Gibraltar with battering-ships, constructed upon such principles, that they were considered as equally impregnable and incombustible. In the beginning of August, the enemy completed the first parallel of their approaches. On the 15th the Count d'Artois arrived in the camp of the combined army, to serve as a volunteer at the siege.

Dispositions made by the garrison to repel the attack.

The Duke de Crillon assumes the command of the besieging army. June.

The Count d'Artois arrives in the enemy's camp.

The advanced batteries of the besiegers again destroyed, by means of red-hot shot. Sept.

The enemy's works, on the land side, were now rapidly advancing to perfection; but being still in an unfinished state, and not sufficiently protected, it was judged proper to make another attempt to destroy them. Lieut. Gen Boyd, the lieutenant governor, recommended the immediate use of red-hot shot against the land-batteries; and General Elliott acquiesced in the proposal. Accordingly, on the morning of the 8th of September, a brisk fire was opened from all the northern batteries which bore upon the western part of the parallel, and was supported through the day with great vivacity. The effect of the red-hot shot and carcasses exceeded the most sanguine expectations. In a few hours, the Mahon battery, with the two-gun battery on its flank, and great part of the adjoining parallel, were on fire; and the flames, notwithstanding the enemy's exertions to extinguish them, burnt so rapidly, that the whole of their works were consumed before night. The St Carlos's and St Martin's batteries were likewise so much deranged, that the enemy were obliged to take down the greater part.

The combined fleets of France and Spain arrive in the bay. 12th Sept.

On the 12th, the combined fleets of France and Spain arrived in the Bay from the westward; and every thing now seemed to indicate the approach of the grand attack. The garrison of Gibraltar, at this time, scarcely consisted of more than 7000 effective men. The accumulated forces of the besiegers, on the other hand, assumed the most formidable and imposing attitude. There were assembled in the bay 47 sail of the line; ten battering ships, deemed perfect in design, and esteemed invincible, carrying 212 guns; innumerable frigates, xebeques, bomb-ketches, cutters, gun and mortar boats, and smaller craft, for disembarking men. On the land side were most stupendous batteries and works, mounting 200 pieces of heavy ordnance, and protected by an army of nearly 40,000 men, commanded by a victorious and active general, and animated by the immediate presence of two princes of the royal blood of France. About seven o'clock in the morning of the 13th, the battering-ships got under way, and stood to the southward, to clear the men of war; then *wore* to the north, and a little past nine, bore down in admirable order for their several stations, taking their places successively to the right and left of the admiral, who was moored in a two-decker about 900 yards off the King's bastion. They were permitted to chuse their distance without molestation; but as soon as the first ship dropped her anchors, the fire from the garrison commenced. The cannonade then became tremendous; which may be easily conceived, when it is considered that 400 pieces of the heaviest artillery were playing at the same moment. While the battering-ships attacked the garrison from the sea, the besieged were at the same time warmly annoyed by the flanking and reverse fire of the enemy's land-batteries on the isthmus. The latter, however, they totally disregarded, directing their undivided attention to the battering-ships. For some hours, the attack and defence were so equally well supported, as scarcely to exhibit any appearance of superiority on either side. The red-hot shot began to be used about twelve o'clock, but did not become general till between one and two. Incessant showers of hot balls, carcasses, and shells of every species, were now poured upon the enemy from all quarters; and as the masts of several of the ships were shot away, and the rigging of all in great disorder, the garrison began to entertain hopes of a speedy and favourable result. Smoke was observed to issue from the upper part of the flag-ship, which seemed to increase, notwithstanding the constant application of water; and the admiral's second was perceived to be in the same condition. Confusion was now apparent on board several of the vessels; in the course of the evening their cannonade gradually abated, and about seven or eight, it almost totally ceased. As the evening advanced, signals of distress were made to their friends on shore, and several boats were seen to row round the disabled ships. At this period, our artillery caused dreadful havoc among them. A little before midnight, a wreck floated in, upon which were 12 men, who alone escaped, out of threescore who were on board their launch. About an hour after midnight, one of the battering ships was completely in flames; and by two o'clock, she appeared as one continued blaze from stem to stern. Another to the southward was also on fire; and between three and four o'clock, other six indicated the efficacy of red-hot shot. The sea now presented a spectacle of horror; men crying from amidst the flames for pity and assistance; others, on board those ships where the fire had made little progress, imploring relief with the most expressive gestures and signs of despair; while several, equally exposed to the dangers of the opposite element, trusted themselves on various pieces of the wreck, in hopes of reaching the shore. Brigadier Curtis, with the marine brigade, humanely exerted himself in endeavouring to save as many as possible of these wretches; and he succeeded in bringing off about 350, many of whom were severely, and some of them dreadfully wounded. Meanwhile the flames reached the magazine of one of the battering-ships to the northward, which blew up about five o'clock with a terrible explosion. In a quarter of an hour afterwards, another in the centre of the line met with a similar fate. Of all these formidable floating-batteries, upon which the enemy had rested their most confident hopes of success, not one escaped destruction; and on the 14th of September, the patient and intrepid garrison had the satisfaction of contemplating one of the most signal and complete defensive victories on record.

Grand attack made by the battering ships. 13th Sept.

They are entirely destroyed by red-hot shot from the garrison.

Gibraltar.

Gibraltar relieved by Lord Howe, Oct. 1782.

The remainder of this celebrated siege presents few incidents of moment. About the middle of October, the garrison was relieved by Lord Howe, in the face of the greatly superior combined fleets of France and Spain. In the beginning of the month of February 1783, intelligence arrived of the signature of the preliminaries of a general peace; and thus terminated an enterprise, upon which the resources of France and Spain were lavishly but fruitlessly expended; an enterprise towards which the eyes of all Europe had long been directed in anxious expectation; and which, in its glorious result, threw additional lustre on the military character of Great Britain.

The siege raised on receiving accounts of the signature of preliminaries of peace, Feb. 1783.

Since the period of this memorable siege, no serious attempt has been made upon Gibraltar; nor is it likely, considering the greatly improved state of the defensive works, that any future attack will be attended with the slightest probability of success.

Description of the town and fortifications.

In an account of Gibraltar, a brief description of the town and fortifications will be thought necessary. The town is situated at the foot of the north-west face of the hill, and is irregularly fortified. It communicates with the isthmus by a long narrow causeway, (serving as a dam to an inundation,) which is defended by a curtain, with two bastions, mounting 26 pieces of cannon, a dry ditch, covered way, and glacis, well mined. These are strongly flanked by the King's, Queen's, and Prince's lines; works cut in the rock with immense labour, and scarped to be almost inaccessible. Above the lines are the batteries at Willis's, and others at different heights, until they crown the summit of the rock. These elevated batteries mount between 50 and 60 pieces of heavy ordnance, and entirely command the isthmus below. The Old mole, to the west of the Grand battery, forms also a very formidable flank, and with the lines, a cross fire on the causeway and neutral ground. This battery has been found so great an annoyance to the besiegers, that, by way of distinction, it has long been known by the appellation of the *Devil's tongue*. From the Grand battery, along the sea line, looking towards the bay, the town is defended by the North, Montague's, Prince of Orange's, King's, and South bastions. King's bastion is a very complete piece of fortification, commanding the bay from New to Old mole heads. It mounts twelve 32 pounders, and four ten-inch howitzers in front, ten guns and howitzers on its flanks, and has casemates for 800 men, with kitchens and ovens for cooking. Montague's is much smaller, mounting only 12 pieces of cannon, with a casemate for 200 men, communicating with the Old mole. In 1782, a cavalier, for two guns, was erected upon this bastion; and another work of a similar nature, for five guns, on the north bastion of the Grand battery. From the south bastion a curtain extends up the face of the hill, and terminates, at an inaccessible precipice, the works of the town. In this curtain is the south-port gate, before which and the south bastion is a dry ditch, with a covered-way and glacis. At the east end, above the gate, is a large flat bastion, connected with the curtain, and mounting 13 guns, bearing on the bay, &c. This work is covered by a demi-bastion, that joins the precipice. Above the precipice, an old Moorish wall is continued to the ridge of the rock; in the front of which a curtain with loop-holes and redans, built in the reign of Charles V. and called after his name, extends to the top, effectually cutting off all communication in that quarter. From the south bastion, a line-wall is continued along the beach to the New mole, where there is an irregular fort, mounting 26 guns. This line-wall is divided by a small bastion of eight guns, with a retired work in the rear, called the Prince of Wales's lines. Near the south bastion is a quay or wharf, called Ragged Staff, where the supplies for the garrison are usually landed. The communication to it is by spiral wooden stairs, and a draw-bridge opening into the covert-way; in front of which is a small work of masonry, mounting two guns. At the New mole head is a circular battery for heavy metal, joined to the mole fort by a strong wall, fraised; having a banquet for musketry, with two embrasures opening towards the bay. From the New mole fort to the north end of Rosia bay, a parapet is continued, and batteries erected, as situations dictate. The works at Rosia are strong, and act as flanks to each other; they are close along the beach, which is low, and have a retired battery of eight guns in the rear. From the south point of Rosia bay, the rock continues to ascend, by Parson's Lodge, to Camp-guard, and Buena Vista. In this direction, a line-wall is raised, with cannon at different distances. At Buena Vista there are several guns *en barbet*, which have great command; and the hill towards Europa, is slightly fortified. The rock then descends, by the Devil's Bowling-green, to Little Bay. At this post, which is entirely surrounded with precipices, there is a barbet battery, flanking the works to the New mole; from thence the rock continues steep for a considerable distance, when the line-wall and batteries recommence, and extend irregularly to Europa Point, the southern extremity of the garrison. A few batteries at Europa advance, and a post at the Cave-guard, terminate the works. But this part of the garrison is greatly strengthened, by the retired and inaccessible lines of Windmill-hill, which are situated within musket-shot of the sea, and have great command in that quarter.

Alterations and improvements since the siege.

Considerable alterations have taken place in the town and fortifications, since the celebrated siege. The town, indeed, was entirely destroyed at that period by the enemy's fire; but it has been since completely rebuilt, and greatly enlarged. The actual number of inhabitants, exclusive of the military, amounts to about 12,000. The British settlers constitute but a small proportion of this population, which is principally composed of Jews, Genoese, Spaniards, and Moors. The strength of the garrison generally consists of five regiments of infantry, six companies of artillery, and two companies of military artificers; in all about 4500 men. The fortifications have recently undergone great improvements. The Waterport front has been entirely rebuilt, and greatly strengthened, and carried farther out into the bay. The inundation at Landport has been carried close into the body of the rock by two deep ditches, so as to render the approach to the garrison from the land side completely inaccessible, except by the narrow causeway between the bay and the inundation. The upper batteries at Willis's have been entirely rebuilt and greatly improved, and a new magazine erected there. Extensive subterraneous galleries have been cut in the rock, with numerous embrasures in them, bearing on the isthmus and the causeway leading to the garrison. These batteries present a most formidable flanking fire, which it would never be in the power of a besieging army to silence. A new line of defence has also been erected at Europa Point, at the southern part of the rock, to guard against any attempts of an enemy to land in that direction. At Rosia Bay, immense naval storehouses have been built; and a tank has been sunk there, which is capable of containing water sufficient for twenty sail of the line for six months. A new pier

Gibraltar.

is also in the course of being erected there, extending nearly three hundred yards into the sea; which, when completed, will afford perfect shelter to four sail of the line, besides double that number of transports. The Spanish lines and forts, erected on the neutral ground, about a mile from the garrison, and which afforded great advantages to a besieging army, were blown up and completely destroyed by the British, on the 14th of February 1810, on the approach of a French force towards that quarter. The guns and stores were previously brought into Gibraltar. It is to be hoped that the British government will never consent to the restoration of these works.

Spanish lines and forts destroyed. 14th Feb. 1810.

Among the most remarkable buildings at Gibraltar, the remains of the old Moorish castle are the most conspicuous. It was erected by the Moors on their first invasion of Spain, and still retains the traces of its former magnificence. This antique structure is situated on the north-west side of the hill, and originally consisted of a triple wall, the outer inclosure descending to the water's edge; but the lower parts have been long since removed, and the grand battery and Waterport erected on their ruins. The walls, at present standing, form an oblong square, at the upper angle of which is the principal tower, where the governor or alcaide resided. A Moorish mosque still exists within the walls, in a state of entire preservation, having been used as one of the grand powder-magazines during the siege; and there is also a neat Morisque court, and a reservoir for water. The other principal buildings are the Convent, or governor's quarters; the lieutenant-governor's house, a modern structure; * the admiralty house, or naval provision store-house, † formerly a monastery of white friars; the soldiers' barracks, victualling-office, store-house, south barracks, and the navy hospital.

Remarkable buildings.

Mineralogical structure of the mountain.

The principal mass of the mountain of Gibraltar, consists of a grey, dense, calcareous rock, by mineralogists called primary marble; the different beds or strata of which may be examined, with great accuracy, in the north front, where there is a complete vertical section, of upwards of 1300 feet of the rock. The strata are from 20 to 50 feet in thickness, running nearly from east to west, and having a dip in that direction at an angle of about 35 degrees. This species of rock, when it occupies large districts, is always found to be cavernous. At Gibraltar, the caves are many, and some of great extent. The most remarkable is St Michael's cave, situated upon the southern part of the mountain, about 1000 feet above the level of the sea. The mouth is only five feet wide; but on descending a slope of earth, it widens considerably, leading to a spacious hall, incrusted with spar, and apparently supported in the centre by a large massy stalactitical pillar. To this succeeds a long series of caves of difficult access. The fossil bones which are found, of various sizes, in the rock of Gibraltar, have frequently attracted the attention of naturalists. It was formerly supposed that these bones existed in a petrified state, and were enclosed in the solid calcareous rock; but Colonel Imrie, who examined them with great attention, is of opinion that they have been swept, by heavy rains, at different periods, into the situations where they are now found, and having remained, for a long series of years, exposed to the permeating action of water, have become enveloped in, and cemented by, the calcareous matter which it deposits. And in confirmation of this opinion, he observes, that the appearance of these bones indicates calcination rather than petrifaction.

Caves.

Fossil bones.

Climate.

The climate of Gibraltar is temperate and salubrious, during the greater part of the year. From the circumstance of its being surrounded on three sides by the sea, the summers are generally cooler, and the winters milder, than on either of the neighbouring continents. Snow falls seldom, and ice is a rarity. Violent showers of hail, however, are not uncommon during the winter. Heavy rains, high winds, and most tremendous thunder, with dreadfully vivid lightning, are the usual attendants on December and January. The summer months are extremely warm; but the heat is frequently alleviated by a constant refreshing westerly breeze from the sea, which, from its invigorating and agreeable coolness, is emphatically called the *Doctor*. During an easterly wind, or a *Levanter* as it is called, the top of the rock is commonly covered with a heavy dense vapour, through which the sun is seldom visible. At such periods, the effects of the climate are peculiarly severe upon persons of delicate constitutions, particularly such as are subject to pulmonary or rheumatic complaints. Consumptions generally prove fatal.

Animals.

The summit of the mountain is inhabited by a large species of ape; an animal not to be found in any other part of Spain, and which is therefore thought to have been originally imported from Barbary by the Moors. Red-legged partridges are often found in coveys; woodcocks and teal are sometimes, though rarely, seen; and wild rabbits are caught about Europa and Windmill hill. Musquitoes are exceedingly troublesome towards the close of summer; and locusts are sometimes found. The scorpion, centipede, and other venomous reptiles, abound amongst the rocks and old buildings; and the harmless green lizard and snake are frequently caught by the soldiers, who draw their teeth, and treat them with fondness. The mountain of Gibraltar presents an interesting field to the botanist; as it connects, in some measure, the Flora of Africa with that of Europe. Colonel James, in his elaborate history of Gibraltar, enumerates no less than 300 different herbs, which are to be found on various parts of the rock

Botanical productions.

Trade and revenue.

The trade of Gibraltar is very considerable; that port being the great *depot* from which the neighbouring countries are supplied with British manufactures. During the last war, between four and five thousand square rigged vessels arrived there upon an average yearly. The imports from Great Britain, in some years, exceeded three millions sterling, being more than the whole of the exports to the West Indies. The expences of Sicily and Malta, and the money for the pay and maintenance of the British army in Spain and Portugal, were chiefly defrayed by bills drawn on the British government, and discounted by the merchants at Gibraltar; to the amount, it is believed, in some years, of 11 millions of dollars annually. The public revenues arise from the ground-rent of houses, the duties on wine and spirits sold in taverns, the licence-duties on wine-houses and taverns, and the auction duties; amounting, altogether, to about £35,000 sterling per annum.

Authors.

See Colonel James's *History of the Herculean Straits;* Colonel Drinkwater's *History of the Siege of Gibraltar*; *Annual Register*, vol. xxv. for 1782; Colonel Imrie's *Mineralogical Description of Gibraltar*, in the 4th volume of the *Transactions of the Royal Society of Edinburgh*.—For the information relative to the present

* This building was destroyed during the siege, and is still in ruins, having never been rebuilt.

† It has been since sold, and the provisions removed to the new stores at Rosia.

Gilbert.

state of Gibraltar, the writer of this article is indebted to the liberality of Colonel Wright, Commandant of the Artillery at Leith Fort, whose professional talents, and opportunities of observation, during a long residence in the garrison, render his communications on this subject peculiarly valuable. (z)

GILBERT, or Gilberd, William, an eminent philosopher and physician, was born at Colchester, in the year 1540, and was the son of the recorder of that town. After having attended the two English universities, he set out upon his travels, and graduated at some of the foreign universities. Upon his return to England, he settled in London in 1573, was admitted a member of the College of Physicians, and practised medicine with great success and reputation. His fame became so great, that he was appointed first physician to Queen Elizabeth, who generously allowed him a pension for the purpose of carrying on his philosophical experiments. He retained his pension and his office after the accession of James I. but he did not long enjoy the patronage of the new sovereign. He died on the 20th November 1603, in the 63d year of his age, and was interred at Colchester, where a handsome monument was erected to his memory by his brothers. His library, minerals, globes, and mathematical instruments, were left to the College of Physicians. His picture is placed in the gallery over the schools at Oxford. He appears to have been a man of tall stature, and cheerful disposition,

The reputation of Gilbert is founded on his work entitled, *De Magnete, magneticisque corporibus, et de Magno Magnete Tellure, Physiologia novo, plurimis et argumentis et experimentis demonstrata.* It appeared in London in 1600, in folio, and was afterwards reprinted in Germany. The following analysis of this admirable work has been given by our countryman, Dr Robison, and is too valuable to admit of abridgment.

"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 ferrugineous substances alone can be made magnetical. 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 enquirers, 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 take 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.

Gilbert, Gilding.

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 philosophy), find more facts in it than in the two large folios of Scarella." *

Besides this work, there appeared a posthumous publication of Gilbert's, entitled, *De Mundo nostro sublunari Philosophia nova*, Amst. 1651, 4to. It was printed from two MSS. in the library of Sir William Boswell, and consists of an attempt to establish a new system of natural philosophy upon the ruins of the Aristotelian system. It was edited by the learned Gruter. Dr Gilbert invented two very ingenious instruments for ascertaining the latitudes of places without the aid of celestial observations. See Magnetism.

GILDING, is the art of ornamenting various articles, by covering them with a superficial coat of gold, to obtain the brilliant appearance of that valuable metal.

For some purposes the appearance is not the only object; for, in situations where wood or metal work is much exposed to the weather, gilding forms a more durable protection from decay than any kind of paint or varnish, as the gold, if well put on, is equally impenetrable to the sun, rain, wind, or frost.

Gilding is an art with which the ancients were acquainted, although they had not discovered the means of extending the leaves of gold to such a surprising de- Ancient gilding.

* See Robison's *System of Mechanical Philosophy*, vol. iv. Art. Magnetism.

gree as is done at present. From the information of Pliny we learn, that their thickest leaves were called *bracteæ prænestinæ*, because a statue of Fortune at Prænestina was gilded therewith. An ounce of gold formed 750 of these leaves, each being 4 fingers or 3 inches square: this is 9 square inches in each leaf, or 47 square feet very nearly for the whole ounce. The Romans employed thinner leaves, which they called *bracteæ questoriæ*. From the great malleability of gold, the moderns have discovered means by which it can be reduced to such extremely thin leaves, that, notwithstanding its high specific gravity, a given weight of gold can be made to cover a greater surface than any other metal. An experiment by M. Reaumur shewed the superficies of a grain troy weight of gold leaf to be 42 square inches and three-tenths. This is at the rate of 141 square feet per ounce, and the thickness of such a leaf has been estimated at the $\frac{1}{207355}$th part of an inch. Mr Boyle found that a grain might be spread to 50 square inches and seven-tenths. This gives 169 square feet for the ounce; and, by the same mode of estimation, the thickness would be only the $\frac{1}{248532}$d part of an inch. Gold is not at all liable, like other metals, to tarnish or oxidate by the action of the air or damp; and therefore this thin covering is very durable. It is not susceptible of any other decay or waste, than from those causes which produce friction or abrasion of the gilded surface.

Superficies of a grain of gold leaf.

Three kinds of gilding.

Gilding is performed either upon metals, or upon wood, leather, parchment, or paper; but three distinct methods are employed; the first called wash or water gilding, in which the gold is spread whilst reduced to a fluid state by solution in mercury; 2d, Leaf gilding, either burnished or in oil, is performed by cementing thin leaves of gold upon the work, either by size or by oil; 3d, Japanners gilding, in which gold dust or powder is used instead of leaves.

By amalgam.

Wash or water gilding.—The method of gilding by a solution of gold is only applied to metals. The gold is first dissolved or reduced to the consistency of a semifluid, by amalgamation with mercury. In this state, by the assistance of an acid, it can be spread or washed evenly upon every part of the surface of the article to be gilded; the mercury is afterwards evaporated by heat, and leaves a covering of pure gold, the thickness of which is inconceivably small, although forming a most perfect surface. By this method, brass ornaments, watch-cases, buttons, and jewellery of all descriptions, are made to represent gold. The latter branch of the art is carried to such a high degree of perfection, that the deception can only be detected by the weight of the article, by cutting into it, or by some chemical test.

Its applications.

A mixture of copper and brass is the metal most commonly employed for this kind of gilding: pure copper does not readily receive the mercury amalgamated with the gold; and, being of a soft and rather porous nature, requires more gold to produce an equally brilliant covering. About one-seventh part of brass, being mixed with the copper, renders it harder, and makes the gold spread very readily: brass itself will receive a very fine surface of gilding. The endeavour of the workman is, to make such a mixture of brass and copper as will produce nearly the same colour as the gilding is intended to have; for a great variety of shades in the colour of the gold can be produced by a subsequent process, after it has been laid on; but it requires less trouble to give the gilding the same colour as the metal which is beneath, than to make a different shade.

Proper metals for wash gilding.

In effect, the gold adheres to the metal by forming a very superficial amalgamation or alloy therewith; hence the gold will partake of the colour of the metal. A second coat of gilding laid on will have a greater appearance of pure gold, and will have a more durable brilliancy than an equal quantity of gold spread upon the metal at one process.

Silver takes a fine surface of gold, and of a yellow colour, unless it is gilt twice over, and coloured afterwards.

Iron and steel will not take the amalgam, as the mercury has no affinity for these metals.

Tin, zinc, lead, or other of the baser metals, are never gilded by amalgam: they would deteriorate the gold too much, nor would they bear a sufficient heat.

To amalgamate the gold for wash gilding, a small quantity is put into a crucible, or an iron ladle, with about six times its weight of mercury. The ladle or crucible should be rubbed on the inside with whitening, to prevent any waste; and being put upon a charcoal fire, and gently heated, the mercury will soon dissolve the gold. To assist the solution, it should be stirred with an iron wire. The heat should not be sufficient to evaporate the mercury, at least not until the solution of the gold is nearly effected; the heat may then be increased for a moment, till a vapour is seen to rise from the crucible. The amalgam being made, is thrown out into water, where a small portion of mercury will be seen to separate itself. This contains very little if any gold; but the real amalgam forms a small lump of paste, of nearly the same consistence with butter; but it will be observed to have particles of mercury intermixed with it. To remove these, the amalgam is twisted up in a piece of fine wash leather, and gently pressed with the finger and thumb: the mercury will pass through the pores of the leather, and leave the amalgam fit for use. In this state it is the colour of silver, without any appearance of gold, and does not contain more than twice the weight of mercury to that of the gold. The mercury which has passed through the leather, should be reserved for making future amalgam, as it will probably contain a small proportion of the gold.

Amalgam of gold and mercury.

Some workmen vary this process by heating the gold to redness, and heating the mercury to the point of evaporation; then, throwing the hot gold into the mercury, the amalgam is quickly effected. We do not know any difference of effect which should give the preference to either of these processes.

It is essential that both the gold and the mercury should be pure. The mercury of commerce is almost always adulterated with lead, which is very prejudicial to the gilding. It should be separated by distilling the mercury in an iron retort, with a gentle heat: this will leave the lead in the retort; or the mercury may be revived from cinnabar in a very pure state. Nothing can be gained by employing gold of an inferior quality, as it will always require a greater proportion to produce the same covering, and the brilliancy will be much impaired.

Material should be pure.

It has been recommended to grind the amalgam on a marble stone, or in a glass mortar, and to wash it continually with a solution of common salt in water. This will carry away a blackish colour, occasioned by the oxide of the mercury; and the washing is to be continued till it ceases to colour the salt and water. We have never met with any artist who practises this washing; for if the gold and mercury are pure, and the amalgam is not overheated, so as to oxidate the mercury, it will be unnecessary.

ilding.

Cleaning of metal,

The first circumstance to be attended to in wash-gilding, is to make the surface of the metal perfectly free from all scurf, tarnish, or oxidation; for the covering of gold upon the metal unites therewith by a kind of amalgamation, and forms a superficial alloy, which would be discoloured by the smallest coat of tarnish.

ickle.

The cleaning is performed by pickling the metal, in a solution of aquafortis and water: the strength of the solution is immaterial, except with respect to the time that the metal must remain in it. A quantity of acid, equal to one-fourth of the water, will clean the metal in a few minutes; but if weaker, is equally effective in a longer time: and if the article is accidentally left in the pickle for a long time, it will not be injured. For cheap and coarse articles, a strong solution of sal nixon, or sal ammoniac, is employed; and to render it more active, the metal is heated and plunged into it: this raises a black or brown oxide over the whole surface. It is then dipped in the pickle of aquafortis, which throws off a slight scale from the surface, and renders the metal clean at once; and it is put into clean water, to prevent the farther action of the acid from producing a tarnish before the gilding is performed.

Acid.

ratch-ush.

For the best work, the aquafortis pickle is used cold, and the cleaning is performed by the friction of a scratch-brush, formed of fine brass wire instead of hairs. The brush is sometimes made of a circular form, and mounted on a spindle, turned rapidly by the motion of a foot-wheel and treddle, in the manner of a lathe, whilst the work is presented to the brush. But for delicate work, such as the wheels and other parts of watches, a very delicate hand brush is used; and here it must be noted, that when the steel arbors of the wheels, or any other part of steel, are attached to the work, it must not be dipped into the pickle, but the pickle should be made stronger, and only the scratch-brush dipped into it, before the work is brushed with it. The steel must be frequently dipped into clear water during the brushing, to prevent the action of any acid which may touch it.

ckening metal.

To spread the amalgam perfectly upon the surface of the article which is to be gilt, an acid, called the quickening, is used. This is made of aquafortis, (nitrous acid) with a small quantity of mercury dissolved in it, so as to give it a milky whiteness. The article being dipped into this, attracts a coat of the solution of mercury, over the whole surface, in an instant; and with this preparation, the amalgam is applied with the pencil. This is a piece of flattened copper wire, fixed in a handle: it is occasionally dipped into the quickening, then touching the amalgam with it, it will take up a small quantity, which is rubbed upon the work, and spreads or flows in an instant over all the parts which have been touched by the quickening. The action of the quickening appears to arise from the greater affinity of the nitrous acid for copper than for the mercury; in consequence of which, the acid takes to the copper the instant it is applied upon it, and leaves the mercury precipitated upon the surface. This coating of mercury facilitates the spreading of the amalgam when it is applied, although it may be spread without it, by merely dipping the pencil into the aquafortis, then into the amalgam, and afterwards applying it upon the surface of the work. This is the method employed for delicate works, particularly where there are any parts of steel. Another method of applying the amalgam, is to mix it up in a cup or jar, with mercury and aquafortis, to the consistency of thin cream. Into this the articles are dipped, and become at once perfectly coated with the amalgam. We have seen this method used by a button manufacturer, and it succeeded very well, with scarcely any trouble; but it is only applicable on a large scale, for this amalgam will not keep long, because the acid turns the mercury black, by an oxide which will not pass off in the drying. They can only mix up, in this way, as much amalgam as they intend to use in a very short time. Without acid, the amalgam will keep any length of time.

lication ie amal-

Gilding.

Drying off stove.

The next step in the operation is the *drying off*, or evaporating the mercury. For this a small charcoal stove or oven is used: it is merely a square opening, surrounded by brick on every side, except the front, and a flue proceeds from the top. It is made of a size proportioned to that of the work intended to be dried in it. As it is not intended that the draught of air shall be rapid, the stove may be placed in the lower part of a chimney, which is open all round the stove, so as to admit part of the current of air to ascend into the chimney without passing through the fire; and the charcoal being laid upon a small stone hearth, without any grate, it does not burn away very rapidly. The front of the chimney should be closed by a window-sash, which draws up and down, leaving just room enough beneath for the gilder to put his arms and hands into the chimney, while he sees his work in the stove through the glass, which prevents his inhaling the pernicious vapour of the mercury. A drawing of an apparatus of this kind is represented in Fig. 9. of Plate CVII. Button, Manufacture, with an additional apparatus to condense and preserve the mercury dissipated by the evaporation. The gilder is generally seated before this stove, and holds the work in a pair of iron pincers, over the burning charcoal, till he sees it change colour from the white silvery appearance produced by the amalgam, to a gold colour, which gradually comes on as the mercury passes off.

Operation of drying off.

At the first application of the heat, before it is sufficient to make the mercury evaporate, the amalgam will be seen to grow more fluid, and flow as it were upon the surface. In this state it is liable to collect more to one part of the work than others, probably because the heat is not equal in all parts, but renders the amalgam more fluid in some places than in others.

Spreading the gold by a brush.

To counteract the effect of this tendency, a brush of soft hog's hair is frequently drawn over the work, to spread the amalgam perfectly equal over the whole surface. This is a part of the process which requires much attention from the workman; for if he does not spread it well, the parts where the mercury accumulates will form whitish spots when dry; and these spots will afterwards tarnish, and at length turn black, having very little of the gold laid upon them. A great deal depends upon the heat being very equally and regularly applied, until the mercury begins to dry off, and the amalgam becomes fixed. The common gilder's stove is very ill calculated to attain this equality of heat. If the work has any cavities or hollow parts, into which the amalgam is liable to be accumulated by the brush, it must be dislodged by shaking the work. The hair of the brush must be very soft and pointed, by rubbing it upon a piece of pumice-stone; and where there is any extent of surface to be gilt, the brush must be drawn in one direction, because it leaves a sort of grain, which will have a disagreeable appearance if it is not laid straight.

Gilding pan,

It is usual for the gilder to have a small iron pan, into which he puts a few of the pieces he intends to

Gilding.

gild, and places it upon the fire; and he takes them one by one with the tongs, out of this pan, to brush them, and then returns them to heat, whilst he brushes others: at last, to finish the operation, he holds them in the tongs over the hottest part of the charcoal; this completes the evaporation of the mercury, and leaves the gold of a dull yellow, or gold colour. Small articles of which there are a great number of the same size, such as buttons, rings of watch chains, &c. are put all together into an iron frying pan to heat, and when the mercury begins to flow, they are all together thrown out into a cap, in which they are shaken up, and well stirred about with a painter's brush. This operation effects the spreading of the gold with very little trouble. It should be repeated several times, and the heat brought on very gradually, which the pan admits of doing more conveniently than any other means. As the heat continues to increase, the mercury begins to evaporate, and soon leaves the amalgam, or rather the gold, fixed upon the surface. The work being now dried off, presents only a dull scarfy appearance; but being brushed by a few strokes of the scratch-brush, it assumes a polished surface. The brushing is done with small beer or ale grounds, which however contribute nothing more to the operation than to soften the strokes of the brush, and prevent the work having any appearance of scratches. If a thicker coat of gilding is required, the operation is repeated once or twice, and every time the colour will approach nearer to that of fine gold. The scratch-brush must be applied to clean the work between each gilding.

Gilding cap.

Colouring the gilding by heat,

The simplest mode of heightening the colour, is to hold the work over the charcoal of a small stove, similar to the gilders stove, and heat it till the colour increases. During the heating, if any spots appear of a different colour, they are touched with a stick dipped in aquafortis, which restores them. It is then thrown into a weak solution of aquafortis and water, which will discover any spots where the coating of gold is deficient. This method is supposed to act by making a perfect dissipation of the mercury; but we think it rather operates to produce a farther alloy or amalgamation of the gold with the metal upon which it is spread. The work being again polished with the scratch-brush, is finished unless a very high polish is required: it must be produced by burnishing with a blood-stone, using water to prevent the gold being rubbed off.

or gilder's wax,

When a higher colour is required, the work is covered with a composition called gilding wax; and being held over the fire till the wax smokes, and is on the point of inflaming, it is then suddenly cooled in water, and the scarf of the wax is cleared off by the scratch-brush and beer.

Gilding wax is compounded of bees wax and red chalk in equal quantities, with French verdigris and alum or green vitriol, which are added in small portions. The use of the wax seems to be only to flow, and carry the other ingredients to every part of the surface, and to determine the proper degree of heat to be applied. There is another preparation of sal ammoniac, nitre, green vitriol, and verdigris, in equal parts, which they use after the wax is cleared off, and they desire to produce a very high colour. It is spread over the work in a state of paste, to which it is mixed by urine, and heated till it smokes in the same manner as the wax. This composition may be used instead of the gilding wax; or, by repeating the application of the gilding wax two or three times, it will produce the same colour, which is a deep and brilliant copper colour, but very superficial, and wears off long before the gilding is worn away.

or saline preparation.

Dead colour.

Dead yellow is a preparation of gilding which presents a frosted surface, without any polish, and of a beautiful yellow colour. It is produced by a saline preparation like that above, but some yellow colouring matter is employed instead of the green verdegris. When the work is heated with this upon it, it is thrown into aquafortis and water, and the ebullition which this occasions produces the dead colour.

Improved stove for drying off.

The operation of drying off, as formerly practised, was very prejudicial to the health of the workman, who always inhaled the fumes of the mercury. The application of a glass front to the chimney in which the stove is placed, has obviated this inconvenience; but still the stove is not judiciously constructed with a view of producing a gradually increasing heat. A considerable improvement might be made by employing an iron box, or oven, set in brick-work, over a close fire, and surrounded by flues, in the same manner as a boiler. It should be open in front, and have two or three shelves within it. The whole stove should be inclosed within a chimney, with a glass window in front, and a sufficient draft up the chimney window to carry off all the fumes. In using this stove, the work should at first be laid on the top of the box, where it will be gradually warmed; then the workman removing it to the upper shelf, it would become more heated, and fit for brushing. When this is done, he should place it on the second shelf, which would produce a greater heat. Being again brushed, and afterwards placed on the bottom of the box or stove, the heat would be sufficient to complete the drying off.

Gilding iron.

Iron or steel, may be ornamented by wash-gilding, if the surface is first covered with copper, by dipping the iron into a strong solution of blue vitriol, (sulphate of copper.) Upon this the amalgam can be applied; but such gilding presents a very indifferent colour, and is not durable.

By burnishing.

Another method is, to spread a thin plate of gold upon the steel, then heating them both, and burnishing the gold down, it will adhere, but so slightly as to have but little durability; and the heat must be so considerable, that it frequently injures the temper of the steel.

By ether and gold.

In the Philosophical Magazine, vol. ii. a new mode of gilding steel is described, as being the same by which the Sohlinger sabres are ornamented. A solution of gold in nitro-muriatic acid, (*aqua regia*,) being poured into about twice as much ether, the latter will float upon the surface of the acid; but if shaken together, the gold will be taken up from the acid by the ether; which may then be separated, by pouring the mixture into a long glass funnel with the tube stopped, and when it is completely at rest, the tube being opened, will run off the acid; and being again stopped, will leave the ether, with gold in solution.

This solution of gold being spread upon the surface to be gilt, the ether evaporates and leaves the gold, which, however, does not adhere very strongly, but may be fixed, by heating the steel moderately, and burnishing the gilding down.

Leaf gilding.

Leaf Gilding.—It is so called, because the gold is laminated, by the operation of gold beating, into very thin leaves, which are cemented upon the article to be gilded, by gum, size, white of an egg, or drying oil. Leaf gilding can be applied on metals as well as wood; or, with an appropriate cement, it may be laid on any substance which presents a surface sufficiently even, and

Of two kinds.

free from pores. It is distinguished into burnished gilding and oil gilding. In the former, the leaves being cemented upon the work by gum or size, admit of being burnished or polished. This is sometimes called water gilding, because the size or gum is mixed up with water; but as this term is also applied to the wash gilding by mercury, it should be avoided, as tending to confusion. Oil gilding, is that in which the leaves are stuck on by fat or drying oil. The advantage is that it will bear the weather, but, on the other hand, it will not admit of being burnished.

Size. *Burnished Gilding.*—When this is laid upon wood, the surface must be prepared for it by a thin coating of size whitening, to fill up the pores, and make a closer ground for the gold leaf. The size used to mix up the whitening, is made from cuttings of parchment, or of glovers' leather. These must be gently boiled in water for several hours, till the water extracts sufficient size to form a jelly when it cools. This size is strained through a flannel to clear it from the cuttings, and fine powder of whiting is added, being stirred up with the size until it forms a coarse paint whilst hot, but will congeal into a very close solid substance when cold. With this composition when heated, the surface of the wood is coated or primed over several times, spreading it evenly with a painter's brush, and carefully laying it into all the hollows or cavities of the work where it is carved. Each coat should be suffered to dry perfectly before another is applied, and the last must be rendered as smooth and even as possible. For this purpose, it is brushed over with water before it is quite dry, and any lumps removed at the same time the whole surface is rendered closer. When perfectly dry, the priming of whitening must be examined to fill up the cavities, and the carved parts must be cut or scraped sharp with a knife, and polished up in parts with a Dutch rush. After this, the parts where the gilding is intended to receive a burnish, must be rubbed gently with a rag wetted with water. This produces a surface, which has a polish when dry.

The gilding size which is to cement the gold leaf, is now applied hot with a brush over all the parts intended to be gilt. This is made of the same size as before mentioned; but instead of the whitening, a mixture of bole ammoniac and tallow is ground together upon a marble slab; and, in order to render the mixture more easy, a little soap suds is put upon the slab. The size of parchment before mentioned, being diluted by double its quantity of warm water, this composition is added till it becomes as thick as cream. Some artists add black lead to the bole, at the rate of one-sixteenth of black lead; and instead of tallow, they use a mixture of equal parts of olive oil and bees-wax. Others add colouring matter, such as vermilion and fine yellow; but these are quite useless, if they intend to cover the work completely with gold. The gilding size is laid on in a thin coat, which is repeated when the first is dry, and sometimes a third time, which prepares the work for the application of the gold leaf.

The gold leaf is kept in small books, the leaves of which are rubbed with red chalk. To take up the leaves, and particularly the small pieces, the gilder has a small pair of tweezers made of two slips of cane, united together at one end by glue, so that they will spring open; but the ends, which are to take up the leaves, are cut extremely thin, though left sufficiently broad to take up the leaves by the corners without breaking them. The gilder is also provided with a cushion, upon which he spreads out the leaves when it is necessary to cut them to any particular size. The cushion is made of leather, stuffed with tow or wool upon a square board, which has a projecting handle to hold it by. To divide the leaves, a common pallet knife is used. The article upon which the gold is to be applied is placed in an inclined position, and the size is wetted by a camel hair pencil. This wetting renders the size sufficiently adhesive to cement the leaves, which are removed from the book, by sliding them upon the paper of the book with a squirrel's tail, until the edge of the leaf overhangs the edge of the paper. This overhanging edge is applied upon the sized work, and fastened down, by touching it with a piece of soft carded cotton wrapped up in a piece of fine linen. The gilder then withdraws the paper upon which the leaf lies, and thus spreads the gold upon the surface. This drawing away the paper from beneath the leaf extends the leaf in every direction, and lays it flat upon the work. If any folds or wrinkles appear, the gilder blows on the leaf, to press it against the paper, and cause a very slight adhesion, though sufficient to draw the leaf straight without tearing, which would not be practicable if it was pressed upon the paper by any other means than a current of air. This part of the operation requires much dexterity; and if the workman breaks a leaf, it must be taken up with the tweezers, which, indeed, are frequently requisite to place the leaves straight. It is very difficult to place a broken leaf sufficiently exact upon the size that no joint shall appear. The gilder endeavours to lay the leaf, by first fastening the top of it, or that edge which is most distant from him; then he withdraws the book downwards, and for this reason he begins the work at the top. In some cases the right or left hand side of the leaf must be first stuck on, and then the book must be withdrawn sidewise, to the left or right. The gold leaf being by these means spread on the work, is first pressed close by blowing upon it, and afterwards by dabbing it with a squirrel's tail, or with a ball of very soft cotton wrapped in a fine linen rag. The gilder does not wet a greater extent of the size than he can cover with gold before it becomes too dry; but if this happens, he wets it again, and thus procceeds until the whole is covered. The leaves are overlapped, to ensure that every part shall be covered; but, of course, the overlay is as little as the workman can make it.

Application of the leaves.

Any small spots which remain uncovered from deficient corners of the leaves, or other causes, are covered with pieces cut by the knife upon the cushion. The gilder reserves for this use those leafs which are broken in attempting to lay them on: They are removed from the book with the pincers. and laid upon the cushion. The pincers are likewise used to apply these pieces upon the work; but if they are very small, they may be taken upon the cotton dabber, when rendered damp by breathing upon it. These repairs should be performed as the defects occur, before the size becomes dry; but, if any escape, the size in the defective places must be carefully wetted by a camel hair pencil, the surrounding gold being preserved from the water. When all the work is covered, and sufficiently dry, it is brushed over with a large and soft hogs' hair brush, which takes off the loose gold; it is then minutely examined, and defects removed, by painting them over with shell gold mixed with gum-water. But for common work a colour resembling gold is used: it is composed of vermilion and yellow ochre, or red lead and Dutch pink, ground up with the white of an egg or isinglass size.

Burnishing. The gold remains only to be burnished by rubbing

Gilding.

it over with an agate fixed in a handle, or a dog's tooth. It is requisite to attend to the state of dryness of the work before burnishing: for if the size is not sufficiently dry, the gold rubs off or scratches; and if too dry, it is tedious to raise a fine surface, because the size becomes hardened with those small irregularities, which prevent the surface of the gold from presenting a polished surface.

Gilding in oil.

Gilding in oil.—This is used for work which is exposed to the weather, and is therefore performed on wood, lead, or other metals, and sometimes on stone.

Ground of paint.

The ground must be laid of oil paint instead of size, and whitening as for burnishing gilding. White lead is a very proper colour for the first coat; then a second coat of yellow ochre and vermilion mixed up with drying oil. This has a colour which will render any slight defects in the gold less apparent. If great nicety is required, the last coat of paint, when dry, should be rubbed smooth with pumice stone. In general this is neglected, because oil gilding is in almost all cases intended to be viewed at a distance.

Preparation of oil size.

The surface, thus prepared, is ready to receive the fat oil size, by which the gold leaves are to be cemented upon it. This is prepared from linseed oil, exposed to the weather in a large flat pan, which is filled five or six inches deep with water, and the oil is poured upon the water about an inch deep. It should be placed where it will receive the action of the sun and rain for five or six weeks in summer. This will cause the oil to become thick like treacle, and some impurities will descend into the water. The oil is then to be taken off the water, well separated from it, and poured into a long phial, which is to be heated until the oil becomes perfectly fluid, by the settlement of the foul parts to the bottom. The clear oil size is then to be poured off, and strained through flannel. To render the oil fit for use, it is ground to a thin paint with yellow ochre. A coat of this paint or size is brushed over the surface which is to be gilt, but if found too thick to work well, it must be mixed up with drying oil.

Sizing the work.

Great care must be taken to cover every part, and to render this very certain, a second coat may be spread over the first, after it is dry. The gold leaves are applied upon this second size, when it is in such a state of dryness, that, on touching it with the finger, it feels strongly adhesive, but at the same time does not come off upon the finger.

Gilding.

The gold is applied by the same means as before described for burnished gilding, and after becoming dry is brushed over to remove the superfluous gold. If this operation produces any spots, they must be retouched with the size, and fragments of gold applied where it is requisite.

Leaf gilding on paper, &c.

Leaf Gilding, on paper or vellum.—This is extremely simple, as the surface requires no other preparation

By gum size.

than a wash of dilute gum water, or isinglass size. Upon this the leaves of gold are laid, when it is in a certain state of dryness, which must be known by practice: if it has become only a little too dry, it may be sufficiently damped by breathing on it. When the surface is covered with gold, it can be burnished with an agate, or dog's tooth.

Gilt letters.

Gilt Letters.—If it be required to gild manuscript writing, a strong size must be used for writing, instead of ink: it is made of gum ammoniac dissolved in

Writing size.

water previously impregnated with a little gum arabic, and some juice of garlick: this forms a fluid of a milky colour, which will flow very readily from a pen, or it can be laid on according to any design by a camel-hair pencil: it may be suffered to dry, and then, by breathing upon the paper, the size will be softened sufficiently to receive the gold, which is applied in leaves in the same manner as for any other kind of gilding. The superfluous gold being removed by a brush, the writing is found covered, in its finest strokes, with gold which may be burnished. Gold letters for shop fronts, &c. are painted in oil size, by the process of gilding in oil.

Printi[ng]

Printing in gold may be performed by beating up the white of eggs to a proper consistence, to mix with vermilion, and make a thick ink; with this the paper or vellum must be printed, and the gold applied in leaves, as before directed.

Gildi[ng let]ters b[y] gold.

A different method is sometimes employed to ornament paper with gilt letters. This is to use printing ink, composed of strong gum water; and the letters, after being printed with this, are sprinkled over with very fine powder of crystal or glass, so as to form when dry, a kind of sand or glass paper upon the form of letters. To gild these parts, it is only requisite to rub them over with a piece of solid gold, and the sharp angles of the crystal will cut off sufficient gold to gild the writing, which will be very brilliant from the reflexions of the crystal. It has been recommended to employ stamps for the printing, in which the letter shall be engraved or sunk, instead of being raised as in printing types. The sunk parts of these letters are to be filled up with an ink composed of gum, or whites of eggs, and the raised surface being kept clean, the stamps when applied upon the paper and pressed, will leave the mixture upon the paper in the form of the letters, engraved upon the face of the stamp, and considerably raised. The gilding is performed when the mixture is dry, by rubbing it with a piece of gold as before directed.

Gold on bo[oks].

Book-binders imprint gold letters on the backs of books, without any size, by means of brass types, which are cut the same as printing types; these are made hot in a charcoal fire, and are pressed upon the place where the letters are to be, over which a leaf of gold has been previously spread. The heat and pressure causes the gold to adhere to the leather, where the type was applied, but the gold brushes off from the other parts. Scrolls and all kinds of ornaments are impressed in the same manner; but when a length of bordering is required, the impression is engraved on the surface of a small roller, which is used hot, in the same manner as the types.

Gilt e[dges of] paper.

In order to gild the edges of the leaves of books, or writing paper, they must be strongly screwed in a press, after being cut as smooth as possible, and the edges sized with isinglass glue, mixed up with spirits of wine. The gold should be laid on when the size arrives at a proper degree of dryness.

The French workmen employ a ground of bole ammoniac, mixed up with powdered sugarcandy, by means of white of eggs. This is laid very thinly upon the edges, after isinglass size or gum has been applied. when the ground is dry, it is rubbed smooth with a wet rag, and this moistens it sufficiently to take the gold.

Japann[ers'] gildin[g].

Japanners' Gilding.—Gilding with gold powder is only used where the appearance of frosted gold is desired. The powder is sprinkled upon the article after the cement has been laid on. This method is not so durable as leaf-gilding, that is, it requires a greater proportion of gold to form an equally effectual covering by this means; for this reason it is generally covered with a coat of varnish, and is hence called *japanners' gilding.*

To reduce the gold to powder, two different means ilding.

reparation the pow- r by aqua gia,

may be employed; one by precipitation, and the other by grinding. For the first, any quantity of pure gold is put into a glass containing about eight times its weight of aqua regia, (nitro-muriatic acid). The gold will more readily dissolve, if it is either beat out into thin plates, or divided into small grains, by pouring it into water when melted. A gentle heat being applied, will facilitate the progress, and by occasionally stirring it with a glass rod, the gold will be wholly taken up. A solution of sulphate of iron or green vitriol, in about eight times its weight of water, is made at the same time, and if it leaves any sediment, it must be separated and rendered clear.

d sul- ate of in,

To precipitate the gold in a state of powder, a small quantity of the solution of sulphate of iron is poured into the glass containing the solution of gold, and a red powder immediately falls to the bottom from the nitro-muriatic acid, leaving the gold to unite with the iron of the vitriol, for which it has a greater affinity The fluid must be now poured off, and leaves the bright gold powder at the bottom of the glass, which is then to be filled with clean water, and the powder stirred up to wash it from any remains of acid. It will soon settle again, and the water must be poured off to leave the powder as dry as possible. The remaining water is evaporated, by exposing the powder in the air upon a piece of glass.

by mer- ry,

Another method of producing gold powder, is to form an amalgam of gold with mercury, by the same process as described for wash-gilding, namely, heating the gold to redness, and throwing it into mercury, heated nearly to its point of evaporation. The gold forms an amalgam with the mercury, and after being separated from the superfluous mercury, by passing through a piece of leather, the amalgam is put in a crucible or a glass, and exposed to a sufficient heat to evaporate the mercury, and this leaves the gold in a fine yellow powder. For this method, the mercury must be quite pure, and free from any admixture of lead, otherwise the powder will be found in lumps, and discoloured.

by grind- i.

Gold may be mechanically reduced to a powder by grinding leaves of gold with a muller upon a marble stone, and working it up with fine clear honey. The fragments brushed off by the leaf-gilders will answer this purpose, and the grinding must be continued until the gold forms a perfect yellow paste with the honey. This paste being thrown into water, the honey is taken up by it, and the gold settles in a fine powder. It must be repeatedly washed till the honey is quite separated, and then the powder is dried. This does not produce so brilliant a powder as the former means, because the particles of gold are bruised, and rendered dull by the action of the muller and stone.

Japanners'

The cement or size used for japanners' gilding is composed of linseed oil and gum. The oil is boiled, and whilst upon the fire, pieces of gun anime being put in, will be dissolved. The proportion of gum should be about one-fourth (by weight) of the oil; the mixture is boiled till it is reduced to the consistence of tar, and then strained through a cloth. When wanted for use, it must be ground with vermilion, adding as much oil of turpentine as will make it work with a brush. Some gilders add to the above composition asphaltum, red lead, and umber. These ingredients are pounded and mixed with the gum, before it is put into the oil. Such additions give the size a good colour, which is more necessary in gilding with powder than for leaf gilding, because the size appears in innumerable small specks, which will diminish the lustre of the gold unless the size is of a brilliant colour.

Gilding.

Operation.

The operation of gilding with powder, is nothing more than to paint the work over with the size, mixed up with oil of turpentine; and when the size is so far dried that it feels adhesive without coming off when touched with the finger, the gold powder is applied, by dipping a piece of soft wash leather into it, and daubing it upon the work. When the work is small, it is best to strew the powder upon it, and shake off the superfluous gold.

Gilding upon porcelain or glass.

by gold powder.

Gilding upon Porcelain or Glass.—The gold is reduced to a fine powder by any of the means described under japanners' gilding, and mixed with borax, adding as much gum water as will make it work with the pencil, with which it is to be laid upon the porcelain or glass; it must then be subjected to a sufficient heat to make the enamel soft, to which the borax contributes very much. This fixes the gold, and it can afterwards be burnished; or leaf-gold may be laid on with gum water, and fixed by burning. Borax is sometimes mixed with the gum.

or leaf-gold.

To gild upon glass without burning, a cement or size may be made of amber, melted in drying oil, and boiled to a strong consistence. It must be tempered for working with the pencil by oil of turpentine, and laid on the glass or porcelain, and the gold leaf spread over it. When perfectly dry, it will bear a careful burnishing, and is durable.

False or imitative gilding.

Dutch leaf

varnished.

False or Imitative Gilding.—Wash gilding cannot be imitated; it must, as we have before mentioned, be of pure gold. Leaf gilding may be done in Dutch leaf, which is made of copper covered with gold upon its surface, by the wash gilding process, and afterwards beat out in the same manner as the gold; but the leaves are much thicker, because there is little inducement to reduce them so far, and they are more easily laid on. When first done, this work has all the appearance of true gold, but soon tarnishes by the air, and any dampness will produce spots in it; if secured by a transparent varnish, it preserves its beauty as long as the varnish lasts, and in this case becomes a very good substitute. The proper varnishes are made of mastic sandarac, white resin, or copal, these alone being sufficiently white and transparent.

Silver or tin foil.

Silver leaf and tin-foil are made to represent gold, by covering them with a varnish or lacker of white resin, gum-sandarac, aloes, and red lead, mixed up and boiled with linseed oil. See *Gilding on Leather.*

False gilding upon leather.

For hangings.

False Gilding upon Leather. This is an art which was formerly practised very extensively for the hangings of apartments. At present it is scarcely known, but some very fine specimens which remain perfect, after being in use for a century, shew that it is a most durable kind of furniture for rich apartments. In the French *Collections des Arts et des Metiers*, the following account of this art is given. "The leather of calf skin is preferable to any other; the skins are softened in water, then beaten on a stone, and curried out to their greatest extent whilst wet; when dry they are cut square, and all reduced to the same size; after which, if any skins are defective, they are pieced with the fragments, which are joined by glue; the edges of the joints being pared away so as to make no increase of thickness. The grain side of the leather is now rubbed over with a piece of size, whilst in a state of jelly; and before this size dries, leaves of silver are laid on in the manner before described of the gold leaves for burnished gilding. When

Sizing the leather.

Silvering.

Gilding, Gilolo.

covered with silver, the skins are dried till they are in a proper state for burnishing, which is done by a large flint fixed in the middle of a wooden handle: the workman holds it with both hands, and forcibly rubs upon the silver till it becomes brilliantly burnished. The appearance of gold is now given to the silvered surface, by covering it with a yellow varnish or lacker, which is composed of white resin four pounds and a half, common resin the same quantity, gum sandarac two pounds and a half, and aloes two pounds. These ingredients are melted together in an earthen vessel, and after being well mixed by stirring, seven pints of linseed oil are poured in, and when the composition is sufficiently boiled to make a perfect union, and to have the consistence of syrup, half an ounce of red lead is added, and the liquor is passed through a flannel bag.

Burnishing.

Varnish.

To apply this varnish, the silvered skins are spread out upon a board, and fastened down by nails: These are exposed in the sun, and when thus warmed, the white of an egg is spread over the silver. After this is dry, the workman lays on the varnish, by spreading it with his hands till he covers the whole. The varnish will dry in the sun in a few hours, and is very durable. When the gold is desired to be laid according to any design, the varnish is printed upon the surface of the skin by a wooden block and a rolling press. By this means only the printed parts will appear to be gilt, the others remaining in silver as a ground, and are frequently painted in oil colours.

Printing.

False gilding for picture frames and other similar ornaments, may be performed with silver laid on in the manner described for burnished gilding, and the above varnish laid on after it is burnished: as the varnish preserves it, tin-foil answers almost as well, except that it will not bear too fine a burnish.

By tin-foil.

False Gold Powder, is made by melting tin, and pouring into it about half as much mercury. The amalgam thus produced must be pounded and mixed up with sal ammoniac and sulphur, each in weight about half the tin. The composition being calcined in a matrass, will form a bright-gold coloured powder, which answers very well for japanners, but will not keep its colour unless it is covered by a varnish. For farther particulars relative to this art, see *Handmaid to the Arts*; Lewis's *Commercium Philosophico Technicum*; and the *Circle of Mechanical Arts*. (J. F.)

False gold powder.

GILOLO, or Halmahera, one of the Spice Islands, is a large and singularly shaped island, which divides the Indian Ocean from the great South Sea to the east. It is composed of four peninsulas, separated from each other by deep bays. The equator passes through the island, and a meridian 126° east of Greenwich. Its average breadth is about 30 miles, and its length 220. The western side of the island is nearly straight, and the peninsulas extend towards the east.

The principal towns in the island, are Ossa, Maba, Patany and Weda; but they are little known, as they are seldom visited by Europeans. There is a fine watering place on the south side of the Bay of Ossa, where vessels may procure water and refreshments; and on some of the islands excellent timber for spars may be obtained.

Gilolo is naturally fertile. It abounds with bullocks, buffaloes, goats, deers, and wild hogs. The latter frequent the places where the sago trees have been cut, and get very fat upon the remains of it. The inhabitants subsist chiefly on the sago tree. It is a long tube of hard wood, about two inches in diameter, containing a pulp mixed with longitudinal fibres. The sago flower is procured from this pith, and large quantities of it may be obtained here at a very reasonable rate.

Gilsland.

The inhabitants carry on a considerable trade in their proas with Amboyna and the adjacent islands. They import cutlery, scarlet cloth, china ware, gold lace, iron in bars, opium, piece goods, and steel; and for these they exchange mats, nutmegs, mace, cloves, beech de mer, birds nests, pearl shells, seed pearl, and tortoise shell.

The Dutch were formerly masters of this island, but it is now in the possession of independent rajahs. See Forest's *Voyage*; Hamilton's *East India Gazetteer*; and Milburn's *Oriental Commerce*.

GILSLAND, is a watering-place in Cumberland, much resorted to in the summer season, chiefly on account of its sulphureous mineral waters. It is situated on a steep bank of the river Irthing, about two miles north of the road leading from Carlisle to Newcastle, and is about eighteen miles distant from the former place. The water issues out of a thin bed of argillaceous shiver, reposing on a stratum of indurated argil, through a small leaden pipe, at the rate of about two gallons and a half per minute. It exhales a strong sulphureous odour, which may often be distinctly perceived at the distance of forty or fifty yards. When first drawn from the spring, it is transparent and colourless, but becomes turbid on exposure to the air, and gradually loses its fœtid smell. As the properties of these waters were till late years but little known, Dr Garnet, formerly professor of natural philosophy and chemistry in the Royal Institution, undertook a series of experiments, of which the following were the principal results: A solution of acetite of lead, dropped into the water, produced a very copious brown precipitate, which afterwards changed to black. A similar change was produced in it by nitrate of silver. An infusion of litmus was converted into a red. Polished plates of silver or lead, immersed in the water, soon became tarnished, and lost their metallic lustre. Muriate of barytes, oxalic acid, and tincture of galls, produced no apparent change. When the gaseous products were expelled by boiling for about ten minutes, acetate of lead and nitrate of silver produced a white precipitate, but muriate of barytes and oxalic acid no effect. A wine gallon of this water evaporated slowly, yielded four grains of muriate of soda. From these experiments it is evident, that this water is impregnated with sulphuretted hydrogen, and carbonic acid gas in combination with muriate of soda. In respect of chemical composition, therefore, it has a striking resemblance to the sulphureous waters of Moffat. Besides these saline and gaseous ingredients, the Gilsland waters, like those of Buxton and Harrowgate, contain a considerable portion of nitrogen or azotic gas. A wine gallon, English measure, of the Gilsland waters, yielded four grains of solid matter, and twenty-five cubic inches of elastic fluids, viz.

Of muriate of soda four grains.

Of sulphuretted hydrogen gas	17	cubic inches.
Of azotic or nitrogen gas . .	4	
Of carbonic acid gas	4	
	25	

Gilsland has been long celebrated in the northern counties of England as a place of fashionable resort, and for the efficacy of its suphureous waters in the cure of certain nervous and bilious complaints, in diseases of the digestive organs, dyspræda, hypochondriasis, and also in scrofulous affections. Taken internally, in doses of from half a pint to two or three quarts (English measure) in the morning, it generally acts very powerfully as a diuretic, increases the cuticular discharge, and, from the moderate stimulus of the carbonic acid, increases the appetite, and promotes digestion. But these waters often produce a degree of constipation which ought to be carefully obviated, otherwise a disagreeable giddiness and head-ache comes on. Externally applied in the form of warm bath, it has been employed with considerable advantage in herpetic eruptions; and particularly in those morbid derangements of the dermoid texture, psoriasis, and lepra, which are referred by Dr Willan to the order Squamæ, in his admirable treatise on cutaneous diseases. Locally applied, it is also used to remove contractions and pains in the joints from strains or hard glandular tumours, and is a valuable remedy in chronic rheumatism. Though the sulphureous water is resorted to and chiefly drank at Gilsland, there is a fine chalybeate situated on a moor, at no great distance from the former spring. The water sparkles when poured into a glass, has a strong styptic taste, and deposits a copious yellow sediment. A wine gallon of this chalybeate, according to Dr Garnet, contains

Of iron	$2\frac{1}{2}$	grains.
Of muriate of soda	3	
Of carbonic acid	14	cubic inches.
Of azotic gas	5	

From this analysis, it would appear that this mineral water, if properly administered, might prove a useful remedy in all cases where chalybeates are indicated. (J. S.)

GINGEE, is a town and fortress in the Carnatic, and the capital of a district of the same name.

The fort is situated on a stupendous and almost impregnable rock, and has always been considered by the natives of India as the strongest in the Carnatic. The climate is very unhealthy; and the French are stated to have lost 1200 troops during the 10 years in which it was in their possession, although they never kept more than 100 Europeans. It is situated 82 miles south-west from Madras, and 37 north-west from Pondicherry. East Long. 79° 34′, and North Lat. 12° 15′.

GINGER, is the root of a plant which grows spontaneously in the East and West Indies, and in China. It flowers about August or September, and fades about the end of the year. When the stalks are withered, the roots are dug up, commonly in January and February, and are picked, cleansed, and gradually scalded in boiling water. They are then dried by exposure to the sun, and form what is called *black ginger*. White ginger is the very same root, but in order to produce it, the roots are not scalded, but are picked, scraped, separately washed, and dried very carefully. Ginger is generally sold in knotty, branched, and flattish pieces, and is of a pale colour and fibrous texture, when stripped of the outer bark. It should generally be chosen in large roots, new, and not easily broken; its colour should be of a light brownish green, and it should be resinous within, and of a pungent aromatic taste. The dark, soft, and fibrous kind, should be rejected. Sometimes it is imported green from Bengal. Preserved ginger is brought from the West Indies and China, but the former is preferred. It is brought home in large and somewhat transparent pieces, of a bright yellow colour. The jars which contain it should be carefully sealed up.

The following Table contains the quantities of ginger imported and sold by the East India Company, from 1804 to 1808. Sixteen cwt. of dry and 20 cwt. of green ginger are allowed to the ton. The permanent duty is 14s. 6d. per cwt. and the war duty, 4s. 10d.

Years.	March Sale.		Sept. Sale.		Total.		Average per cwt.		
	Cwt.	L.	Cwt.	L.	Cwt.	L.	*L.*	*s.*	*d.*
1804	..	..	111	268	111	265	2	7	9
1805	..	..	..	..	..	..		..	
1806	285	925	1001	2991	1286	3916	3	0	11
1807	570	1488	229	581	799	2069	2	11	9
1808	925	2182	1320	3447	2245	5629	2	10	2

See Lewis's *Materia Medica*, and Milburn's *Oriental Commerce*.

GINGOULPH, St, is a large village of Switzerland, situated on the extreme frontier of the Lower Vallais, upon the lake of Geneva, and at the foot of a rugged mountain, from whose summits, called the *Dents d'Oche*, about 5655 feet high, the environs of Geneva can be distinctly seen at the distance of ten leagues. The village is divided into two parts by a torrent, which issues from the valley of Oche, and forms the boundary between Savoy and the Vallais. The road from Evian to St Gingoulph, was formerly only a foot path, but the French government cut a magnificent road out of the rock, which has been open to all sorts of carriages since the 6th of December 1805. The lime of St Gingoulph is esteemed the best in this part of Switzerland. See Ebel's *Manuel du Voyageur en Suisse*.

GINSENG, is the name of a root which constitutes one of the principal medicines of the Chinese and Tartars. It grows chiefly in Chinese Tartary, and also in several parts of North America, from which it is sent to China. This trade to China was carried on by the French in 1750, and subsequently by the English; but since the Americans established their independence, they have carried it direct to China. The American root seldom exceeds the size of the little finger. It is frequently forked, and is of a horny texture, and a yellowish-white colour. The large roots, which are sound, fresh-coloured, and not very tough, are those which should be chosen for the Chinese market. In the year 1709, the Emperor of China sent an army of 10,000 Tartars in search of this root, on condition that each soldier should give him two catties of the best, and sell the rest for its weight in silver. By this means the Emperor gained 20,000 catties in one year.

GIORNICO, called *Irnis* by the Germans, is a town of Switzerland, situated on the Tesino, at the mouth of the Lower Levantine valley. It stands 1098 feet above the level of the sea, and 462 above that of the Lake Maggiore. The village, which is divided into two parts by the Tesino, is encircled with superb chesnut trees, some of which are more than thirty feet in circumference. Near the bridge are the remains of an old castle, which is supposed to have belonged to the ancient Gauls; and in the east are the ruins of a tower built in 940. This town is celebrated by the battle which 600 of the Swiss confederates, under Henry Troger, gained over 15,000 of the Milanese, under Borelli, in 1478. More than 1500 of the Milanese were killed, and most of their cannon, horses, and mules taken. Several of the cannon were kept at Giornico till 1798.

GIPSIES. See GYPSIES.

GIRGENTI, or AGRIGENTI, is a town of Sicily, Gironde || Gizah.

built on the spot which was formerly occupied by the citadel of Agrigentum. It is situated on a mountain on the river St Blaise, at the distance of about three miles from the sea. The streets, on account of their steepness, are impassable both for carriages and mules. The harbour of Girgenti is liable to be filled up by the south-east and north-west winds. The erection of two piers having failed to remedy this evil, the harbour is constantly clearing by galley slaves. The great magazines of the Caricatoria are large excavations in the solid rock, in which great quantities of corn are preserved without the least injury. There is constantly in these magazines 80,000 salmes of grain, a salme being that which is sufficient for the annual nourishment of one man. The magazines belong to the king, who is accountable for the corn lodged in the caverns. The proprietors pay a small sum for store-house rent. Foreign merchants come to Girgenti to purchase the surplus grain, when a sufficient quantity has been reserved for the home consumption. See AGRIGENTUM; and CIVIL ARCHITECTURE, p. 601, 602. (*j*)

GIRONDE, is a department in the south of France, bounded on the north by that of the Lower Charente, on the west by the sea, on the south by the department of the Landes, on the east by that of the Lot and Garonne, and by Dordogne. Its superficial extent is about 11,270 square kilometers, or 571 square leagues. It is watered by the rivers Dordogne and Garonne, and the Gironde, which is formed of the other two when united near Bec-d'Ambez, where they form a vast bason, or rather an arm of the sea, capable of receiving the largest ships. This department has more a commercial than an agricultural character. The districts of Blaye, Libourne, and Bazas, are very fertile in corn, while that of Bourdeaux produces the finest wines, of which 100,000 tons are annually exported, independently of what is consumed in France. One of the cantons of Esparse, near the sea, produces the celebrated wines of Medac. The best red wines are those of the Bordelais, Haut-Brion, and St Emelion; and the best white wines those of Sauterne, Langon, and Barzac. The other productions of the province are, brandy, wood, cork, turpentine, cattle, and fish. The following are the principal towns:

	Population.
Bourdeaux	112,844
Libourne	8,076
Bazas	4,215
La Reole	3,808
Blaye	3,580
Lespare	800

The forests occupy 100,000 hectares, or about 200,000 acres, of which three-fourths belong to individuals. The contributions in the year 1802 were 5,835,053 francs. Population 519,685.

GIRVAN. See AYRSHIRE.

GIZAH, DJEZA, GIZE, or JIZA, is a town of Egypt which stretches along the west bank of the Nile, and is supposed by Dr Shaw to occupy the site of the ancient Memphis. It is surrounded with walls of great extent, about ten feet high and three feet thick. They have only one gate, and six half moons, and are intended to resist the attacks of cavalry. Ismael Bey, who fortified the town, built a palace in the southern quarter of the city. There is here a cannon foundery established by Murad Bey, and a manufacture of sal ammoniac. Splendid country houses, with gardens, are built to the north-east of the city. The ground under the calcareous mountains, to the east, is filled with tombs. The town is surrounded with numerous date trees, which give it a fine appearance at a distance, when intermixed with the lofty turrets of the mosques. Gizah is the nearest town to the principal pyramids, which are called the Pyramids of Gizah. They are distant only about three leagues from the town. See Brown's *Travels in Africa*; Savary's *Letters*; and Sonini's *Travels in Egypt*. See also EGYPT and PYRAMID.

Glacier

GLACIERS, *Gletscher* in German, is a name given to extensive fields of ice and indurated snow, which occur in elevated mountainous districts, but particularly in the Alps of Switzerland and Savoy.

Position of the glaciers.

In all elevated countries, where the mountains rise above the line of perpetual congelation, their summits and flanks are covered with eternal snow. The snow which falls on these lofty regions at different seasons of the year, continues nearly in its original state, being converted into a substance of an intermediate character between snow and ice. On the sides of the mountainous declivities, there is more ice than on the summits; but still these fields of indurated, or of half-congealed snow, are by no means entitled to the name of glaciers, although they have been very improperly called the Upper Glaciers by an intelligent traveller.

The real glaciers are those accumulations of ice and snow which occupy the high vallies between individual mountains, generally far below the line of perpetual congelation, and extend themselves into the cultivated vallies which border upon the great chain. These glaciers are commonly encircled with lofty mountains; they stretch from north to south, and very few have an easterly or a westerly direction.

Description of a glacier.

The general character of a glacier depends upon the nature and state of the valley in which it lies. When the sides of the valley are smooth, and its inclination small, there is little variety in the appearance of the glacier. It presents a tolerably smooth surface, and is intersected with few rents or ravines. When the sides of the valley are rough and unequal, and its general inclination considerable, the surface is divided by deep chasms, and covered with numerous elevations, sometimes 50 or 100 feet high. If the declivity is more than 30° or 40°, the large cliffs and masses of ice are forced against each other with great violence, and are accumulated in the most varied and singular forms. These general remarks will be better understood from a particular description of the two celebrated glaciers of De Boisson and De Bois, in the valley of Chamouni, as they were seen by the writer of this article in the autumn of 1814.

Description of the Glacier de Boisson.

After crossing the Arve, above Servoz, by the wooden bridge of St Pelissier, and ascending a steep and rugged road, the sides of which are everywhere marked by the scoops and rents which Sir James Hall has observed on the whinstone and sandstone rocks in Scotland, we approach the village of Chavanon, and obtain a fine view of the different peaks of Montblanc. The village of Les Ouches is seen in front, and the Glacier de Boisson distinctly appears on the flank of Montblanc, stretching its frozen masses into the plain. We now leave the road, and after a little more than half an hour's walk through a fine meadow, and a gloomy forest of lofty pines, we reach the glacier. Its lower extremity and its lofty sides rise into high peaks and pyramids of ice, resembling regular crystals, and having their hollows and crevices of a bright azure blue, which forms a fine contrast with the broken sunbeams diverging in every direction from the numerous surfaces by

Glaciers.

which they are reflected. On ascending the hill, we reach the plateau or surface of the glacier, which does not present any thing remarkable. Its gently undulating surface is crossed with numerous chasms, and covered with enormuos masses of granite, which are gradually transported to a lower level, and accumulate in the plain below, forming what is called the *moraines des glaciers.* The Glacier de Boisson is bounded on the east side by lofty pines, many of which are crushed to pieces by the irresistible pressure of the walls of ice; and the ground in the neighbourhood is torn up, as if great convulsions were constantly accompanying the fall and descent of the icy cliffs. A few hundred yards only intervene between this region of sterility and desolation, and the rich and cultivated fields in the valley.

Glacier de Bois.

The Glacier de Bois has quite a different character from that of Boisson; and though it does not rise into such singular and varied shapes, yet its vast extent and its remarkable situation, and perhaps the difficulty of reaching it, render it a still more interesting object to the traveller. In order to examine this glacier, we left Chamouni about half past one o'clock upon mules; and after ascending a steep and rugged declivity, through a wood of firs, we reached, in 52 minutes, that part of the ascent where it was necessary to exchange our mules for long poles pointed with iron. The footpath crosses a deep ravine cut out by an avalanche; and at the end of other 43 minutes, we obtained a splendid view of the Aveyron, rushing out with great fury from below its icy covering, and throwing itself over a lofty precipice. At the end of two hours from our setting out, we reached the summit of Montanvert, which is 5724 feet above the level of the sea, and 2568 above that of the valley.

After resting half an hour in the temple erected for the accommodation of travellers, by M. Felix Desportes, the French resident at Geneva, we descended the hill till we reached the Mer de Glace. At first sight, this immense field of ice, about 6 miles long and 1½ wide, has the same appearance as if a tumultuous and highly agitated sea had been suddenly frozen; but upon examining it more narrowly, we found it intersected with numerous chasms and ravines, some of which are 100 feet deep. On the sides of these crevices the ice is most perfect, and has a fine blue colour; while on the surface, which is granular and porous, the congelation appears to have been less complete. By the assistance of our long poles we entered upon the Mer de Glace, and from our recollection of Saussure's description of the hazards which attend such a journey, we were not a little surprised at the apparent absence of all danger. The assistance of the guide was sometimes necessary to cross the yawning chasms; but in other respects, we experienced no difficulty. We passed a huge block of granite about 24 feet high, resting on the ice, and in the act of gradually descending to the valley; and we were now considerably advanced upon the glacier. Hitherto we had attended only to the objects below our feet, and were quite unaware of the magnificent situation in which we were placed. The whole of this frozen sea is surrounded with bare and lofty mountains. On the north-east, the red aiguille of Dreux rises like a huge obelisk to the height of 5832 feet above Montanvert, occasionally displaying its strongly illuminated summit from among masses of clouds that rolled about its base. On the south-west appeared the black peak of Charmoz; and on the south-east, where the glacier divides itself into two branches, called the Glacier of Lechaud, and the Glacier of Tacul, we discover the aiguilles of Lechaud, and the Great and Little Jorasse, the lofty peaks of the Giant and of Tacul. The black desolation which presented itself on every side; the dreary and unbroken silence which reigned around, and the sublimity and novelty with which every object was marked, gave to the present scene a peculiarly impressive character, of which it is impossible to form the least conception. The sound of the waters rushing below, at the depth of 80 or 100 feet, which is the general height of the glacier, and the crashing noise of large stones loosened by the melting of the ice and tumbling into the chasms, begin to remind the traveller that his situation is not without danger. A similar but louder noise arises during winter from the formation of the chasms, which sometimes shakes the whole mass with a noise like thunder, and which is the general harbinger of a change of weather. In many places there is something like a vertical stratification in the icy masses, stretching in the direction of the valley, and the surface of the ice has an appearance as if intersected by veins. Towards the edge of the Mer de Glace, the ice is covered with pounded granite, and huge masses of this rock mark the boundary between the glacier and the mountain. In those places where the ice is covered with sand, it appears completely black, like the darkest cairngorms, while in other places the perfect ice is green. Upon breaking this apparently black ice, however, we found it quite transparent, and remarkably pure and hard.

Mouth of the Aveyron.

We now descended Montanvert by another road, in order to see the extremity of the glacier, where it delivers the waters of the Aveyron. The whole of the glacier is supported on a granite base, which terminates towards the plain in a lofty precipice. The Aveyron formerly issued from below the glacier, through a frozen vault, where the rock had very little height; but it now discharges itself at a much higher point, producing a waterfall of great height and impetuosity. Sometimes it issues with dreadful force, and then abates, and over those parts of the rock where no water flows, huge masses of ice are constantly precipitating themselves, with a noise like that of the loudest artillery.

In ascending the valley, for the purpose of crossing the Col de Balme, we saw also the glaciers of Argentiere and Trient, which do not merit any particular description. The glacier of Argentiere lies at the foot of the lofty aiguille of the same name. It is covered at its extremity with blocks of granite, and almost blackened by a profusion of granite sand.

Subterraneous glacier of Beaume.

There is another species of glacier of a very interesting nature, but essentially different from those which we have described. One of them is in France near Beaume, and the other in the Carpathian mountains of Hungary. The first of these glaciers is near the village of Beaume, in a deep cave. The mouth of the cave is 45 feet wide, and after reaching by a long descent a hall 100 feet high, a ladder of about 40 feet long conducts to the glacier. About the beginning of the last century it was completely filled with ice, which was renewed every summer. The water, which descended on all sides from the surface, formed huge pyramids of solid ice, partly hanging from the rock, and partly shooting up from below. In winter, this cavern, which is 700 or 800 feet below ground, was filled with smoking water. The ground above it was formerly covered with huge trees, which kept off the sun's rays; but in 1724, a country-house having been erected on the place, the trees were cut, and the ice carried away for the use of the proprietor. The entrance of the cavern was covered up with a wall, and the ice has not formed so rapidly since that time. The glacier and cavern of Tselitz is in a very lofty rock in the Carpathian mountains. Its mouth is large, its width is 26 fathoms, and it penetrates to a depth of 50 fathoms, advancing still farther by a rough and winding passage. When the snow, which clothes the mountain in winter, begins to melt in spring, it filters through the rocks, and falls in drops, which are instantly frozen, and which form pyramids of ice both in the roof and on the floor of the cavern. The cavern is thus lined with ice, sparkling like the most brilliant crystals. M. Bel informs us, that six hundred carts would not be able to carry off this ice in a week. At the approach of autumn the ice begins to melt; and at the beginning of winter the air is mild, the earth dry, and not a vestige of ice is to be seen.

Subterraneous glacier of Tselitz.

Origin and formation of the glaciers.

It was long the opinion of the vulgar, and even of some intelligent writers, that the glaciers increased from below; and M. Altmann was the first who maintained their true origin, although he erroneously supposed that the pyramids of ice rose from the glacier itself. In order to explain the origin of glaciers, let us suppose that all the lofty mountains and peaks which surround the Glacier de Bois have been covered with snow during winter. At the approach of spring, the snow at low altitudes, and at the place where the glacier itself exists, is completely melted by the influence of the sun and the rains. At a greater altitude, varying with the latitude of the place, and with local circumstances, the snow is only partly melted, and having, therefore, imbibed a great quantity of water, it is frozen into a mass of imperfect ice during the succeeding winter. A fresh fall of snow covers these frozen spaces, and is in its turn converted into imperfect ice. In this way, the ice is accumulated during every succeeding winter, till the equilibrium of the mass is destroyed, either by its own magnitude, or by other causes, and the whole is precipitated in the form of an avalanche into the valley below. The snow which falls in still higher regions, lies in tranquillity on the level summits, or the hollow cavities of the mountain; but that which falls upon the declivities is easily loosened by any sudden thaw, and falling down, it adds either to the accumulated ice below, or passes directly to the bed of the glacier. The ice thus collected from the surrounding heights, will experience particular changes in its new situation. It is now subject to the action of the sun and the rain, which will wear down the high and angular masses into pyramidal and other shapes; and the water will fall down the chasms, and give a particular transparency to their sides. At the lower extremity of the glacier towards the plain, the greatest changes will take place. The fall of the exterior masses will be followed by the advance of those behind them, and a movement will thus be propagated throughout the whole glacier.

Progressive descent of the glaciers.

From these causes, the glaciers will progressively descend to the plains below; and the rapidity of their motion will depend upon the inclination of the bed on which they rest, and on the magnitude and velocity of the reinforcements which they receive from fresh avalanches. The stream which flows from the extremity of the glacier, forms in general a vault of ice above, which gradually widens as the ice melts, and when it can no longer sustain the superincumbent mass, it is crushed by its own weight, and gives place to the masses behind it. This progressive motion of the glaciers, is rendered visible by the variation in the position of large stones on the surface, or of trees frozen in the ice. In the glacier of Chamouni, the progressive motion has been observed to be 14 feet in the year; and on those of Grindelwald, 150 feet in six years, or 25 feet in the year.

On the increase or diminution of the glaciers.

It has been a question keenly agitated among naturalists, whether the glaciers are in a state of increase or diminution, and each party has succeeded in proving the truth of his opinion. We may necessarily infer, therefore, that they sometimes increase and sometimes diminish. The lower extremity which projects into the plain, sometimes continues to diminish for a series of years, as the quantity which is annually dissolved is not replaced by the superjacent masses. At other times, when they are copiously supplied by fresh avalanches, they advance more rapidly than they dissolve, and therefore encroach upon the cultivated plains. Their augmentation commonly takes place in spring, and when they have made great inroads upon the lower ground, they are generally found to diminish for some years afterwards.

On the heaps of stones on the surface and at the foot of the glaciers.

We have already had occasion to mention both the masses of granite rock, which lie upon the surface of the glacier, and the heaps of enormous stones, called the *Moraine*, or *Murren*, which are accumulated at its lower extremity. These stones sometimes are totally different from those in the valley where they now lie, and must have been detached from rocks often six or eight leagues distant. These stones are frequently accumulated in separate mounds like hillocks or graves, and arranged in parallel lines of a considerable height and width. These are generally called Gouffrelynes, and appear on a great scale in the glacier of Rosboden on the Simplon. Sometimes a large regular pyramid of ice is seen, with a huge stone upon its summit. The heaps of stones which we have mentioned, contain in general specimens of the rocks in the higher regions of the mountains.

On the texture of the ice of the glaciers.

It has been already stated, that the glaciers are composed of different kinds of ice. Some of it is granulated and imperfectly frozen, other parts have a transparent green colour, as in the chasms and crevices, while that which is near the heaps of gravel, is of a bluish black colour. The only exception to the generality of this remark occurs in the glacier of Rosboden, the whole of which consists of ice, hard, firm, and compact, and of a blackish blue colour.

Vaults of ice.

The vaults of ice are always formed at the exit of the little stream which runs below the glacier. In winter, all these openings are closed up by ice, but the heat of spring speedily dissolves it, and vaults sometimes 100 feet long, and 50 or 60 wide, are formed. The figure and magnitude of these suffer constant changes. That of the Aveyron, once so much admired, is no longer in existence.

On the number and extent of the glaciers.

In the extensive alpine chain from Montblanc to the borders of the Tyrol, there are no fewer than 400 glaciers, the greater part of which are six or seven leagues long, by one half or three quarters of a league wide, and from 100 to 600 feet thick. A very few of these are so small as a league in length. M. Ebel has calculated, as nearly as can be done, their general extent, and has found that those between Switzerland and Montblanc, and on the frontiers of the Tyrol, would form a single glacier of 130 square leagues.

For farther information on this subject, we must refer the reader to the article Alps, where he will find an account of the glacier of Furca, the glacier of the Aar, and the glaciers of Grindelwald and Lauterbrunnen. See also Grouner's *Histoire Naturelle des Glaciers de Suissè*, translated by Keralio; Saussure *Voyages* diators, Iorgan-hire. *dans les Alpes*; Ebel's *Manuel du Voyageur en Suisse*; Lambert's *Voyage Pittoresque en Suisse*.

GLADIATORS is the name given to persons usually slaves, or condemned criminals, who were brought out to fight one another for the amusement of the Roman people. See ROME.

GLAMORGANSHIRE, a maritime county in South Wales, is bounded on the north by Caermarthenshire and Brecknockshire; on the south by Merionethshire; on the east by Monmouthshire, from which it is separated by the river Rumsey; and on the south and west by the Bristol Channel. The greater part of its sea-coast swells into a semicircular sweep; but the west extremity is formed into a narrow beak, between the open channel and an arm running round the coast of Caermarthen. The county measures from east to west 48 miles; from north to south, at the broadest part, 26 miles: its circumference is 125 miles. It contains 822 square miles, or 526,680 acres. There is in it one city, Landaff; one county town, Cardiff; ten hundreds, viz. Caerfilly, Cowbridge, Dinas Powis, Kibber, Langwelack, Miskin, Neath, Newcastle, Ogmore, and Swansea; eight market towns, and 118 parishes. It returns two members to parliament, one for the county, and one for Cardiff, and is in the province of Canterbury; three parts of it are in the diocese of Landaff, the remaining part in the diocese of St David's. There are in it two deaneries, Landaff and Cowbridge; and it pays one part of the land-tax. The north part of the county is very mountainous and barren; thinly inhabited, and serving chiefly for the feeding of cattle and sheep. In this part various rivers take their rise, which run to the south through vales, gradually enlarging; thus forming a middle district tolerably adapted for cultivation, and at last terminating in the great level or vale of Glamorgan. This is a tract extending along the sea-coast to the distance of eight or ten miles inland, the most fertile part in Wales, rich in corn and pasture, and well furnished with coals, lead, iron, and limestone: it is open, but not a dead flat: it has an undulated surface, on a dry substratum of limestone. The land is inclosed with good hedges, mostly hawthorn. To the north and north-east, the vale is well sheltered by mountains. To the south, it has the dry, rocky shores of the Bristol channel, without any fens. Another district of Glamorganshire deserving particular notice, is what is termed Gowerland: it is a tract of country bounded by the Neath and Loughor rivers. Its circuit is between 40 and 50 miles; in point of landscape, it is inferior to most other parts of the county; but the origin and habits of the people, and its antiquities and curiosities, render it highly worthy of attentive examination. It abounds in many places with deep pits. The east side is remarkably fruitful and well cultivated. The south-west is inhabited by the successors of a colony of Flemings, probably planted there at the same period that the Flemings were settled in Pembrokeshire. They do not understand the Welsh language; but are distinguished by their dialect and provincial dress, and rarely intermarry with the Welsh. They wear what is called a *whittle*, made of fine wool, dyed scarlet, nearly a yard square, with a fringe at bottom. This garment is thrown across the shoulders, and fastened with a pin or broach; anciently it was fastened with the prickle of the black thorn, which is still used by some of the old women.

The climate of the higher parts of Glamorganshire is of course rather severe; but in the lower districts it is uncommonly mild, so that myrtles, magnolias, and other tender exotics, grow luxuriantly in the open air.

Rivers. The principal rivers are the Lower Taafe, which rises in the mountains that separate Glamorganshire from Brecknockshire, and traversing a wild district towards the south, falls into the Bay of Glamorgan, near Swansea. The Neath, a much more considerable river than the former, rises in the same mountains, more to the eastward; descending from these with great rapidity, it forms a deep valley, through which it flows to the south-west to Neath, where it meets the tide; and after several windings in the marsh below that town, falls into the Bay of Swansea. The Avon, the Ogmore, and the Ewenny, are three small rivers which cross the vale of Glamorgan, each falling successively into Glamorgan Bay. The Taafe rises within the limits of Brecknockshire, considerably to the eastward of the source of the Neath; soon after passing Merthyr Tydvil, it precipitates itself into the deep abyss of a vale, forcing its way with great fury between mountains and woods, till, not far from Caerfilly, it is crossed by the wonderful structure of the Pont-y-Pryd—a stone bridge of a single arch, supposed one of the widest, constructed of masonry, in the world: this bridge springs from rock to rock, with indescribable lightness and beauty. Several miles lower, the Taafe emerges into a spacious and well-inhabited plain, in which Landaff and Cardiff are situated: flowing through their bridges, it meets the tide, and traverses a broad marsh to fall into the sea, opposite to the high rock of Pennarth.

Woods. The level and more cultivated parts of Glamorganshire are rather destitute of wood; but its eastern and western extremities are well wooded. The magnificently clothed hills of Margam, Bagland, Briton Ferry, and the vale of Neath, unite the beauties of cultivation with the luxuriance of forest scenery. The wood, which rises immediately from the church of Margam, covers the breast of a mountain 800 feet in height, and more than a mile in circumference; the value of the oak timber has been estimated at L. 60,000.

Agriculture. The agriculture of this county presents little that is interesting; it is behind many other counties in Wales, although the vale of Glamorgan offers many facilities to the husbandman. It is naturally fertile, and lime is every where to be found in abundance, and with ease. On the mountains, a breed of sheep, somewhat similar to those on the Cotswold hills, is kept. The cattle of this county, which resemble those of Normandy, are in high repute for draught.

Mineral productions. But it is its mineral productions, and its manufactures depending upon them, which distinguish and enrich Glamorganshire. It abounds in limestone, iron, and coal. With respect to that most extensive bed of limestone, of which nearly the whole of Glamorganshire forms only a part, it commences with the eastern extremity of the county, and, taking a direction due west, runs in a straight line to Swansea Bay, appearing again in Gowerland, and, having passed under Caermarthen Bay, is seen to occupy the greatest part of the south and west of Pembrokeshire. The neighbourhood of Merthyr Tydvil abounds with excellent coal, iron ore, mill-stones, and limestone rocks. Excellent flag-stone for paving, and a very good kind of slate, are found in this neighbourhood, and, indeed, throughout the mountainous district of Glamorgan. On the left of the road about Pentyrch are very extensive coaleries, and abundance of iron ore. In some respects this county is interesting to the geologist. On the top

Glamorganshire.

of Curn Bryn, one of the highest mountains in South Wales, is a huge cromlech, consisting principally of an immense stone of lapis molaris. The lake of Config is esteemed a singular geological curiosity. The water is contained in a depression of an irregular form, in the midst of sands; and, though lying within a very short distance of the sea at flood tides, invariably retains its freshness pure and untainted. At a short distance from Newton Noltage is the well mentioned by Camden, which ebbs and flows reversely with the tide of the sea. The only mineral spring in the county of Glamorgan is at Swansea. This spring has an acid, styptic taste, like alum, though the predominant salt in it is the sulphate of iron. It turns blue with vinegar, but will not curdle with milk.

Manufactures.

The principal manufactures of iron, copper, &c. are at Swansea, Merthyr Tydvil, and Neath. In 1720, Swansea was noted for the manufacture of straw hats; in 1730, the first copper work was established, on the east side of the river; since that period they have gradually increased, as well as the iron works, to an extent equalled in few parts of the kingdom. Lead is also smelted here. The copper is brought from Anglesey, Cornwall, and Devon. Merthyr Tydvil was a very inconsiderable village till 1755, when the iron and coal mines in its vicinity first attracted attention; and a Mr Bacon obtained the lease of a district abounding in them, eight miles long and four wide, for £200 per annum. About 10 years ago, about 190 tons of iron were, on an average, sent weekly, from one person's works only, to Cardiff. The number of smelting houses is sixteen. About the year 1800, an overshot wheel was constructed, upwards of 50 feet in diameter, and six in breadth; the gudgeons, on which it turns, are supposed to be the largest in the kingdom. The quantity of iron sent from Penydarran works by the canal, averages annually about 7000 tons; the Dowlas works produce annually about 5000 tons; and the Plymouth works about 4000 tons. In the neighbourhood of Neath are very extensive works for the manufacture of iron and copper. Two immense blast furnaces produce 30 tons of pig-iron every week. A copper foundery, and manufactory on a very extensive plan, is carried on near the village of Margam, the works of which consume 70 tons of coal daily. The tin works of Melin Gryffyd, four miles to the north of Cardiff, are, perhaps, the largest in the kingdom; producing not less than 13,000 boxes of tin plates, each containing 225 plates, in one year.

Canals.

The internal commerce and manufactures of this county are much facilitated by its canals. The canal for the carriage of the coal to the Neath river, was the first work of the kind attempted in Wales. There is a bog of two miles, between the colliery and the river, the spongy nature of which, for some time, baffled the skill of the engineers. The length of the canal is little more than three miles; it was executed entirely at the expence of a private individual. The canal from Merthyr Tydvil to Cardiff was completed in 1798; it is navigable for barges of 100 tons. In some places it skirts precipitous mountains, at the height of 300 feet above the river Taafe, which it accompanies. The space it passes is 26 miles; in which there are 40 locks, and as many bridges. The new iron rail-way runs nearly by its side. The fall of the canal is nearly 600 feet. The head of the Swansea canal in Brecknockshire is 372 feet above the level of the Tawy at Swansea bar; there are 36 locks upon it in the space of 16 miles, and several aqueducts.

Glamorganshire ‖ Glaris.

Antiquities.

As connected with the antiquities of this county, the ancient buildings, called Church-houses, may be mentioned. There are at least fifty of them still remaining in this district. Their origin and use are not accurately known; but most probably they were the halls in which the courts of legislation and of justice were held for the respective petty lordships of the great lordship of Glamorgan, every one of whom exercised *jura regalia*. The Roman stations, forts, and camps in this county, are generally understood to be at Cardiff, Caerfilly, and Caera. The great Roman road runs over Newton Down, through Kenfig, Margam, Aberavon, and Neath. But the most celebrated monument of antiquity is Caerfilly castle, now in ruins, said to have been the largest in the kingdom, next to that of Windsor. The wall of the celebrated leaning tower of this castle is still between 70 and 80 feet high, and of a prodigious thickness. It hangs 11½ feet out of the perpendicular.

Customs.

It is a very common practice in this county to plant the graves with flowers, or with sweet-scented herbs. No person ever plucks them up; but a relation or a friend will gather a little, and wear it in remembrance of the deceased. When a young couple are to be married, their way to church is strewed with sweet-scented flowers and evergreens. About two miles from Cowbridge is a place famous for the meeting of the Welsh bards: it took place annually on the 28th of May, under the immemorial patronage of the Hensolt family, at whose expence they were entertained. The last meeting was held in 1720; and in consequence of the death of Richard Jenkins, the last of the family, it was discontinued.

Bards.

In the time of the Romans, Glamorganshire was inhabited by the Silures: it was, in succeeding ages, an independent principality, which was overrun and divided by some of William's Norman nobles in the year 1088.

Population.

By the population returns, there were, in 1811, 8217 families in this county, principally employed in agriculture, and 7915 in manufactures, &c. (W. S.)

GLANDS. See Physiology.

GLANDERS. See Veterinary Medicine.

GLARIS, or Glarus, is a town of Switzerland, and the chief place of a canton of the same name. The town is very gloomily situated upon the river Linth, and is large and populous. The town-house is a good building, and contains, in one of the antichambers, the huge horns of the Bouquetin, an animal which was destroyed in the canton about the end of the 16th century, and also a bear which was killed in the Alps in 1716. There is here a good public library, founded by a society in 1758. India stuffs and drabs are manufactured at Glaris; and there are mills in which is prepared the famous green cheese, known by the name of Schabzigher. There is an agreeable promenade to Enneda, a thriving little town, inhabited by about 150 families. The inhabitants of Glaris are principally merchants, who wander through the whole of Europe, from Lisbon to Moscow.

GLARIS, Canton of, is one of the Swiss cantons, extending about 15 leagues in length and 7 in breadth. It contains 21¼ square geographical miles, only two of which are arable. This canton consists of a great valley, and three lateral vallies enclosed on all sides except the north-east by lofty mountains, rising to the height of from 5000 to 11037 feet. The vallies of this canton are watered by the Linth, the Sernft, and the Lontsch; and its principal lakes are those of Wallenstadt and

Glaris.

Clonthal, and some smaller ones among the mountains. Some corn and grapes, and much fruit, are raised in the canton. In summer, about 7000 or 8000 cattle are pastured on the mountains; but, in winter, they do not exceed 4000 or 5000. The milk is principally employed in making butter and the celebrated Schabzigher cheese, which is exported in great quantities. The blue melilot, one of its principal ingredients, is carefully cultivated by the inhabitants. Goats are so numerous, that every commune has about 300 or 400. Since the year 1802, the Merino sheep have been introduced, and the wool of the country has been thus ameliorated. The inhabitants are distinguished by habits of active industry. England was supplied with writing slates from the valley of Sernft, till the opening of the Caernarvonshire quarries. At the beginning of the 18th century, a manufactory for linen cloth was established. The spinning of cotton was introduced in 1714, and from 1755 to 1760 muslins were fabricated. Since that time, India stuffs, pocket handkerchiefs, stockings, and muslin shawls, have been manufactured. Paper is also made in the canton, and muslin embroidered. The climate is very mild in the vallies. The spring is early, and strawberries are ripe in the middle of April, and cherries about the end of May. In 1803, the population of the canton was 24,000.

GLASGOW,

Glasgow.

GLASGOW is a great commercial and manufacturing city of Lanarkshire in Scotland, situated on the north bank of the river Clyde, in West Long. 4° 15′ 51″, and North Lat. 55° 52′ 10″.*

There is no authentic record by which the origin of the city can be ascertained. Its name, in the Gaelic language, signifies a *grey smith*. It has since been inferred, that a person of this description, eminent in his profession, had taken up his residence in the place, and that, in compliment to him, it had received this name.

[Bi]shopric of [Gl]asgow [fo]unded in [56]0.

In the year 560, it is said, a bishopric was founded here by St Mungo, or Kentigern, and to this circumstance the origin of the place has been attributed; it being probable that the sanctity of the residence of this holy man, and the observance of miracles which would in all probability take place, would naturally draw those to the spot who were religiously inclined.

From this period, and for the space of more than 500 years, history has declined to record any thing worthy of notice respecting this place. Prior to 1100, it would appear, the Bishop's Church was a mean building, chiefly constructed of timber, and had gone into decay.

[Ca]thedral [b]uilt in [11]23.

In the year 1123, John Achaius, nominated bishop by David I. finished and decorated a considerable part of the present cathedral, and solemnly consecrated it in presence of the king, who immediately bestowed on the church the lands of Perdeye, now Partic, &c. This prelate divided the diocese into two archdeaneries of Glasgow and Tiviotdale, established the offices of dean, sub-dean, chancellor, treasurer, sacrist, chanter, and successor, and settled a prebendary on each of them, out of the donations he received from the king.

In 1174, Joceline, abbot of Melrose, was elected bishop of Glasgow, and made an addition to the cathedral, which had been so far carried on by John Achaius. He also procured a charter from William, King of Scotland, surnamed the Lion, in 1180, erecting Glasgow into a royal burgh, and likewise a charter to hold a fair for eight days annually.

[Gl]asgow [er]ected into [r]oyal [bu]rgh.

In 1387, during the time that Matthew Glendoning was bishop, the great spire of the cathedral, which had hitherto been formed of timber, was consumed by lightning. In 1408, his successor, William Lauder, built the great tower of stone as far as the first battlement: he also laid the foundation of the vestry of the cathedral. The great tower of the Episcopal palace was founded about the year 1437, and carried on by the exertions of Bishop Cameron.

[Spi]re of the [ca]thedral [des]troyed by [lig]htning, [13]87.

In 1450, Bishop Turnbull obtained from King James II. a charter, erecting the town and the patrimonies of the bishopric into a regality. He also procured a bull from Pope Nicholas V. for erecting a university within the city, which he endowed, and on which he bestowed many privileges.

Erected a regality, and the university founded.

The establishment of this seat of literature contributed, more than any thing that had formerly been done, towards the enlargement of the town, which, before this period, was so inconsiderable as not to contain more than 1500 inhabitants. In the year 1488, the bishopric of Glasgow was erected by act of Parliament into a metropolitan see, and the temporalities and liberties of the church were after this confirmed by a charter of James VI.

Inhabitants reside near the cathedral.

Prior to the year 1400, it would appear that the inhabitants chiefly resided in the vicinity of the cathedral, and in that part of the High Street which is bounded by the cathedral and the convent of the Black Friars, (now the College Church.) On the establishment of the university, the number of buildings gradually increased downwards to where the Cross now is, and from thence eastwards on the Gallowsgate (now Gallowgate.) Some time after this period, the citizens founded a collegiate church in the Trongate, which they dedicated to the Blessed Virgin; and this circumstance naturally induced the citizens to continue their buildings as far west as this place of worship, which now bears the name of the Tron Church. It then became necessary for the inhabitants to form the Saltmarket Street, so as to procure an easy approach to the Clyde. As many of the citizens supported themselves by fishing in the river, they were incorporated into a society; and in order that they might be at hand to prosecute their business, they built a considerable part of the Fishersgate Street, which has since gone under the name of Bridgegate Street.

Inferiority of Glasgow in 1556.

Notwithstanding this apparent extension, Glasgow at this time held but an inferior rank among the towns of Scotland; for it appears that, even in 1556, at Queen Mary's taxation, it held only the eleventh place. This inferiority has been attempted to be explained in various ways; among others it has been remarked, that in proportion as the reformed religion preponderated, the money which had been expended in the town by the bishop, and the other dignitaries of the church, would be directed into other channels; and as the early reformers undervalued human learning, if they did not entirely despise it, the influence of the college was for a time suspended; it may be also remarked, that Glasgow suffered severely during the civil wars, and afterwards experienced the miseries of famine and pestilence. In 1652 a great fire

* This is the position of the New Glasgow Observatory, as determined by the observations of Mr Cross. ED.

Glasgow.

Great fire in 1652.

broke out, which destroyed a considerable number of the houses in the Saltmarket, Trongate, and High Streets, which at that time were formed of timber. By this calamity, the habitations of nearly one thousand families were completely destroyed, and their fortunes nearly ruined; so that they were under the necessity of applying to other towns for relief. Notwithstanding these discouraging circumstances, we find that Glasgow had so far recovered from her disasters, that in 1695, at the assessment of the burghs, she was rated as the second in Scotland in point of wealth.

From the year 1450, when the town and the patrimony of the bishops were incorporated, down to the Reformation, the bishops, or certain lay lords in their right, nominated the magistrates. Although the parliament, in 1633, declared the burgh to be royal, with freedom of election, we find it afterwards disturbed by Cromwell and the Privy Council.

Glasgow declared free by William and Mary.

In 1690, the town was again declared free by a charter of William and Mary, which was confirmed by an act of Parliament in the same year, to the effect that the town council should have power to elect their own magistrates, as fully and freely in all respects as the city of Edinburgh, or any other royal burgh within the kingdom. This freedom of election has continued ever since.

Glasgow sea port.

Prior to the union between England and Scotland, the river was not in a state to bring up vessels of burthen to the city; the magistrates, therefore, purchased eleven acres of ground near the village of Newark, to enable them to form a sea-port town. In 1710, we find that wharfs, docks, and storehouses, had been erected, a bailie appointed, and the town, which was now called Port-Glasgow, formed into a separate parish, with right of patronage.

Armorial bearing.

The armorial bearing of the city is on a field parti. p. fess. argent and gules, an oak tree surmounted with a bird in chief, a salmon with a gold stoned ring in its mouth in base, and on a branch on the sinister side, a bell languid or, all proper. The motto, "Let Glasgow flourish." In former times, "through the preaching of the word," was added to the motto.

Situation of the town.

The situation of this city commands the attention of strangers: It lies on the north bank of the Clyde, is bounded on the west by the village of Anderston, on the east by the Calton and Bridgeton, on the north by the Barony or Landward Parish, and on the south by the river.

Climate.

The air, though generally healthy, is somewhat moist. The average of rain which has fallen for 30 years previous to 1790, is 29 $\frac{65}{100}$ inches. The greatest quantity in any year during that period was in 1775, which was 43 $\frac{9}{10}$ inches, and the least, which was in the year 1788, was 19 $\frac{43}{100}$ inches.

The following Table shews the quantity of rain that fell at the Macfarlane observatory from 1810 to 1814, as measured by an excellent rain-gage by Crichton of Glasgow:

	Inches.		Inches.		Inches.
1810	25.132	1812	22. 81	1814	19.522
1811	27.801	1813	18.368		

In 1712, the river was swoln to a height never before remembered. On the 12th March 1782, it rose 18 inches higher than in 1712, so that boats were floated in the streets of the under part of the town.

The soil around the city being very various, is so improven by an abundant supply of manure, as to produce heavy crops of every description. Coal, freestone, whinstone, and clay of excellent quality, are to be found in almost every direction.

The greater part of the buildings are erected on ground having a gentle ascent from the river; the ancient part of the town being separated from the more modern by a considerable acclivity, commencing near the College. The public park, or green, on the banks of the river, adjoining the south-east side of the town, contains upwards of 108 acres of grass, and 3 miles 6 furlongs and 12 poles of gravel walks. This park is of great use to the inhabitants, and contributes much to the general appearance of this part of the town.

The length and breadth of the city is ascertained by two main streets, which cross each other nearly at right angles. The principal street running nearly east and west, bears the several names of Westergate, Argyle Street, Trongate, and Gallowgate, and is one mile and a half, one furlong, fifteen poles, and two yards long; 83 feet broad at King Street, and 77 feet at Queen Street. The street which runs south and north takes the names of the Saltmarket, High Street, Kirk Street, and Castle Street, and is three-fourths of a mile thirty-four poles and three yards long; 54 feet wide at Bell Street, and 47 feet at George's Street. The greater part of the streets are 60 feet wide; the average width is between 56 and 57 feet. They are all causewayed with very durable whin-stones, and skirted with hewn stone pavements of various breadths, conformable to the police act. Common sewers, large enough to admit persons to clean them, extending four miles seven furlongs and ten poles, are formed in the streets.

Common sewers.

Of the three squares in the city, St Andrew's, St Enoch's, and St George's, the latter is the most spacious: the centre of it is reserved for an equestrian statue of his Majesty. Public buildings, and the tenements fronting streets, are built with hewn stone, and covered with slates. The greater part of the private buildings, particularly in the ancient part of the town, are built in what is called flats; by which two or more families are accommodated under the same roof. In the more modern part, however, the tenements are so formed, that one family possesses the whole.

Building ground, r disposed

The building ground here is not disposed of by the lineal foot of front, as is the case in the other great towns in the island; it is sold or feued by square measure. A yard of nine square feet will bring from one to eighteen guineas, according to the situation. The general rate of ground, however, for dwelling houses fronting a street, not in a very centrical situation for business, is from two to four guineas per yard.

Since the erection of the village of Glasgow into a burgh, in 1180, its constitution has undergone several alterations. In 1268, it appears that the town was governed by a provost and bailies, and that the corporation was duly organised. In 1636, a royal charter was obtained, appointing a water-bailie, and empowering him to exercise a maritime, civil, and criminal jurisdiction, from the bridge to the Clough, at the mouth of the river, 26 miles below the town.

Office o water b first appointed 163(.

By the constitution of the burgh, three distinct bodies are recognised, viz. the magistrates and town council, and the merchants and trades houses. The set, or constitution, having undergone some slight alterations by the convention of royal burghs in 1801, is now declared to be as follows: The affairs of the burgh shall be governed by a provost, and three bailies of the merchant rank, and two bailies of the trades rank; twelve councillors of the merchant, and eleven of the trades rank; a master of works, who must be of the merchant rank; and a treasurer of the merchant and trades rank alternately. These two officers are councillors *ex officio*. The offices of the Gorbals bailie, and the bailie and depute bailie of the river, do not add to the number of

Set or c stitution the bur

councillors, and, like the treasurer, are chosen from each of the ranks alternately. The dean of guild and convener of the trades' house, are councillors *ex officio* during the first year they are in office, after which they must be elected ordinary councillors. The lord provost (who from courtesy is stiled honourable) and the five bailies are charged with the executive, while the magistrates and council conduct the other public affairs of the community.

The provost, two senior merchant bailies, the senior trades bailie, the dean of guild, and the convener, are justices of the peace for the county; the junior merchant and trades bailies exercise similar powers within the burgh. In 1720, the lord provost first began to wear a velvet court dress; and in 1767, the provost and bailies, magistrates, dean of guild, and convener, first began to wear gold chains; the bailies of the river and barony of Gorbals have also latterly worn gold chains. It is to be regretted, that the funds of this respectable corporation are not in a situation to warrant its managers to appropriate a sum to support the dignity of the chief magistrate, without affecting the progress of public improvements, which have been carried on for a number of years past with a spirit which does honour to the managers of the city. This burgh, of itself, does not return any representative to Parliament. The magistrates and council of the burghs of Glasgow, Rutherglen, Dumbarton, and Renfrew, elect one member among them: In the event of equality, each burgh takes the casting vote in rotation. Although the population of either of these conjoined burghs do not exceed one-fortieth part of Glasgow, they are equal in their political franchises.

[agistrates ...st began ... wear gold ...ains in ...67.]

The revenue of the burgh arises from various sources, but chiefly from what is called the common good. The following may be considered as the most productive, viz. an impost of two pennies Scots on the Scots pint of all ale or beer, brewed or sold within the city. This impost, which was first laid on in 1693, extended only over the burgh, has since been made to comprehend the barony of Gorbals, and the town of Port Glasgow. (For the history of these, see LANARKSHIRE and PORT *Glasgow.*) Ladles and multers, these are certain dues paid on grain, meal, and fruit, &c. brought into the burgh; dues on cattle killed within the burgh; dues from the public washing house and tron; rents of markets, church seats, houses, mills, and mill lands, burgess entries, feus of land, and ground annuals, &c. amounting in whole in the year ending 31st December 1813, to £13,604, 11s. 8d. The following may be considered as the particulars of the expenditure, viz. burgh assessment, criminal prosecutions, alimenting criminal prisoners, general expence of the prison and bridewell, expence of church and civil establishment, ministers stipends and officers salaries, police establishment, repairs of heritable property, and general improvements; the amount of all which, for some years past, has exceeded the revenue. This excess may be accounted for, by the extension of public improvements of late years, which have necessarily required an anticipation of the funds.

[...venue ...d expen...ure of the ...rgh.]

Exclusive of the above, which may be considered as the revenue and expenditure *proper* of the community, the magistrates and council are entrusted, in whole or in part, with the administration of the following funds, the particulars being elsewhere narrated:

[...er trusts ...mitted ...the ma...rates ...council.]

Navigation of the river Clyde;
Assessment for the maintenance of the poor;
Statute labour conversion fund;
Pontage of the bridges; and
Police establishment.

It appears from ancient records, that those persons who bought and sold merchandise of any description in this burgh, considered themselves as a distinct class of citizens from those who manufactured the articles, and the claim of precedence often gave rise to dissensions among the burgesses. In the year 1604, when both parties became anxious for an amicable adjustment of their political differences, they submitted their claims to the final decision of Sir George Elphinstone, who was then Provost, and to two of the ministers of the city. The arbiters, to use their own words, declare, that after great pains, long travailing, and mature deliberation, they, on the 6th of February 1605, pronounced their decreet, containing fifty-four articles, which is the letter of guildry. This decreet was immediately confirmed by the magistrates and council, and in 1612 by an act of parliament, and has been, after a few slight alterations, acted upon ever since. By the letter of guildry, the Dean of Guild is president of his house, and from courtesy is stiled Lord Dean of Guild. He takes precedence of the convener of the trades house in all places, and of the provost and bailies at every meeting of his house.

[Merchants and trades ranks.]

The merchants' house consists of all the merchant burgesses who have matriculated, that is, who have paid a fee, now fixed at ten guineas, to the funds of the house. These members, however, have only the privilege of attending one meeting in the course of the year, and of electing 24 members of the Dean of Guild's council, which is made up as follows: the Dean names 12 members, who may be either foreign or home traders; he then puts the whole of the remanent members into 24 lists or leets, whereof 12 must be foreign, and 12 home traders. The qualified members, at the meeting, elect one person from each leet, who, together with the dean, the provost, three merchant bailies, the collector, and the 12 persons nominated by the dean, compose the council, to whom the administration of the whole affairs of the house is entrusted throughout the year. The funds of this public body arise chiefly from rents, feus, ground annuals, interest, matriculation, and burgess entry money, donations, and mortifications.

[Merchants' house.]

The convener is president of the trades house, and takes precedence of the trades bailies, at all meetings of the house. The members consist of the present and late convener, two trades bailies, the present and late collector, the present and late deacons of the 14 incorporations, and 26 assistants, nominated as follows: the deacons of the hammermen, tailors, cordiners, and maltmen, nominate four of the members of their incorporation; the weavers two; the bakers, skinners, wrights, coopers, fleshers, masons, gardeners, and barbers, one each; the dyers do not nominate any. These members constitute the trades house, and to them its whole civil and political concerns are entrusted.

[Trades' house.]

The affairs of finance are placed under the exclusive management of the convener and deacons, and extraordinary members of the house; the latter are the trades bailies, collector, and members who have passed the chair, or have been at any time in the magistracy. The funds of this public body, like the merchants house, arise chiefly from rents, ground annuals, and feus from the lands of trades-town, interest, burgess entries, donations and mortifications.

A circuit court of justiciary, (anciently termed justice in Ayre,) is held here in the months of April and September yearly, wherein all criminal cases, high treason excepted, are tried by a jury of 15 persons. The jurisdiction of the circuit extends over the counties of Lanark, Renfrew, and Dumbarton. It has been custo-

[Court of justiciary.]

Glasgow.

mary for two of the judges to be on this circuit attended by the sheriffs of the three counties, and the Lord Provost and magistrates of the burgh. Formerly it was necessary for the jury to retire from the court, and make up a written verdict. In 1814, an act of parliament was passed, empowering juries, when they were unanimous as to the verdict, to return it, *viva voce*, without leaving the box. Forty-five jurymen are summoned on each circuit, whereof 25 are from Lanarkshire, and 10 from each of the other two counties. This court also gives judgment in appeals from inferior courts, in civil matters, where the sum at issue is not under £15. An elegant hall, or court room, was fitted up in the public offices in 1810, for the accommodation of this court, which contains more than 300 persons.

Sheriff's court.

The sheriff's court has jurisdiction in civil as well as in criminal matters within the county. The civil court, for ordinary procedure, is held every Wednesday, at eleven o'clock, in the circuit court room, during the sitting of the court of session; and during the vacancy, the court is held at such intervals as the judge may think expedient. In cases of a summary nature, there is access to him every lawful day. All crimes competent to be tried before the sheriff, which infer capital or corporeal punishment, or banishment from the county, must be tried by a jury of 15 persons; the forms of the justiciary court being strictly adhered to, with this difference, that, in all cases, the objections to witnesses and other steps of procedure must be taken down in writing. No capital sentence can be inflicted in less than 40 days after the passing of the sentence, nor corporeal punishment in less than 12 days. The sentence of this court, whether of a civil or criminal nature, are, like other inferior courts, subject to the revisal of the supreme courts.

Commissarial court.

The commissariat court was formerly the bishop's court. The jurisdiction of the commissariat of Glasgow, Hamilton, and Campsie, is very extensive, comprehending a great part of the counties of Lanark, Renfrew, Stirling, Dumbarton, and Air. It takes cognizance of all testamentary affairs, and matters of scandal. Civil actions for debt may also be tried in it, to the extent of 40 pounds Scots. The term of this court is similar to the sheriff's, and is held in the same hall on Thursdays at 11 o'clock; in former times, it was held in the consistory house, adjoining the cathedral.

Town court.

The town court is the principal civil court of the burgh. It seems to have been instituted about the same time that the burgh was erected. The provost and bailies are the judges. The procedure is conducted in writing, by procurators, under the superintendance of a legal assessor, who is a member of the faculty of advocates. In ordinary cases, the court is held in the burgh-hall every Friday at 11 o'clock during the session, and at least once a month during the vacation of the Court of Session; but in cases which require extraordinary dispatch, the court is open every lawful day. Its jurisdiction is limited to the burgh, and is competent to decide questions of personal obligation to pay or perform to any extent; no claim, however, can be enforced in this court, unless it exceeds 30s. The court is also competent to judge in questions of property, pledge, hypothec and retension, of exclusive privilege of count and reckoning, service of heirs, &c.

Inferior civil court.

The inferior civil court, commonly called the conscience court, from the matters at issue being often left to the oath of parties, was instituted for the determination of small civil claims, not below five, nor exceeding forty shillings. Each of the magistrates, in rotation, officiates as judge; an assessor attends, to give legal advice, if it should be found necessary, and to minute the verbal debate, procurators not being admitted. This court is held in the hall of the town court every Monday at 11 o'clock.

Daily court.

The daily court is held every lawful day at two o'clock, in the burgh court hall. The bailies officiate in rotation, without the assistance of assessors; the procedure is not taken down in writing, no claim being competent above ten shillings.

Criminal court of the burgh.

In the criminal court of the burgh, as is the case in the principal civil court, the magistrates officiate as judges; the procedure is conducted in writing, under the superintendance of legal assessors; and is held every lawful day in the police office at 10 o'clock, and thereafter in the clerk's chamber at 12 o'clock. This court grants warrants for the arrest and commitment of offenders of every description, so that they may be brought to trial either in the supreme court of justiciary, or in this court. In particular, it takes cognisance of those inferior offences, which, by the law of Scotland, do not require a trial by jury; to the effect of inflicting punishment by fine, banishment from the burgh, exposure to public contempt, imprisonment in jail, solitary confinement in bridewell, subjection to hard labour, or even to the effect of inflicting a slight corporeal punishment.

Dean of guild court.

The dean of guild court takes cognisance of all matters within the burgh, wherein the heritable rights of the citizens are involved. It consists of the dean of guild, who is president, four members from the trades-house, and four from the merchants-house, chosen annually, who are termed the Dean of Guild's Brethren. This court determines in all matters of dispute between conterminous proprietors, encroachments on the streets, insufficiency of buildings, and the adjustment of weights and measures, &c. The procedure is conducted in writing by procurators, under the superintendance of a legal assessor. This court is held on Thursdays at 11 o'clock in the burgh-hall. The trades rank, conformable to ancient usage, sits on the right of the president.

Justice of peace court.

The judges in this court are those gentlemen in the commission of the peace, who act for the under ward of Lanarkshire; the jurisdiction being confined to that district. The court meets in the circuit court hall, on the first Monday of every month, at 11 o'clock A. M. two justices forming a quorum. They decide in all matters of debt, which do not exceed five pounds; and determine on fines and penalties to any amount that may have been incurred in consequence of illegal traffic, infringement on the game laws, &c. in determining disputes between master and servant, whether as to aliment or rate of wages. Procurators are not admitted in this court, nor is the procedure taken down in writing.

Public buildings for the purposes of religion.

The Cathedral or High Church, is perhaps the most splendid edifice, and entire specimen of our ancient architecture, that is in Scotland. It was founded, as has been before mentioned, in the year 1123, by John Achaius, Bishop of Glasgow, and was dedicated to St Mungo, or Kentigern, during the reign of David I.

Cathedral.

This venerable pile is placed on the west bank of the Molindinar Burn, on an elevated part of the north quarter of the town, declining considerably to the eastward; and is seen at a very great distance in almost every direction, the floor of the choir being 104 feet above the level of the river at the foot of Saltmarket street, at low water mark.

Although we have not been able to ascertain the name

Cathedral.

of the architect from any record or inscription on the building, it seems to have been John Murdo, from an inscription on Melrose Abbey, of the date 1146. It appears, that he intended the cathedral to assume the form of a cross, from the circumstance of his having formed the south transept; although, for reasons not known to us, that part of the building has been carried no higher than the first tier of arches. The greatest internal length of the cathedral from east to west is 319 feet, the breadth 63 feet; the height of the choir, 90 feet; and of the nave 85 feet. The building is 1090 feet in circumference, measuring round the walls and abutments. The edifice is supported by 147 pillars, and is lighted by 157 windows of various dimensions, many of which are of exquisite workmanship.

The south and north fronts are divided into compartments by square projections, which display two tier of pointed windows with various decorations. The first or undermost range having completed its ornaments, the wall terminates in a battlement, from which the lower roof springs to meet the inner wall, raised so high above this roof as to form space for the second range of windows; this wall then terminates in a battlement similar to the under one, and receives the main roof, which is covered with lead. The succession of windows on the right and left of the transept being interrupted, windows have been formed under the great tower, on each side of the building, 40 feet by 20 feet, divided by mullions and tracery of curious workmanship. About the centre of the building, a square tower rises nearly 30 feet above the roof, supported by four massy pillars, each 29 feet 6 inches in circumference: from this rises a tapering octangular spire, with diminishing battlements. The spaces between the battlements are enlivened by pointed windows, and relieved by mouldings and small spires, the whole terminating in a ball and weather-cock at the height of 225 feet above the floor of the choir. Another square tower, somewhat less ornamented, rises on the west end of the church to a level with the first battlement of the tower above described, and is surmounted with a pyramidal roof covered with lead, and terminated by a ball and vane: this tower contains the bell and clock. The groined arches which support the stone floor of this tower, are of singular workmanship, the middle part of the floor being finished with a circular opening, so large as to admit of a stair going up through it. Prior to the Reformation, and when the rites of the Roman Catholic religion were performed in the cathedral, the grand entrance was by the west end of the building, 17 feet high and 11 feet wide, surmounted by a great window. These openings are formed with beautiful mouldings, terminating in pointed arches. The space which is now occupied as the outer High Church, constituted part of the choir, so that this department of the cathedral extended 152 feet, from the west end of the building to the four steps leading up to the organ gallery and screen of the nave, which was ornamented by a large window and figures of curious workmanship. The nave was what is now used as the inner High Church; the space behind contained the altar: the arched roof of this part of the building, is supported by five massy pillars, over which was a terrace-walk adjoining the large window, in the east wall of the nave.

The vestry, on the north side of the altar, forms a cube of 28 feet: its vaulted ceiling is supported by a pillar 20 feet high. The chapter-house was in the north cross of the cathedral, and had a communication with the nave. The consistory house, in which the bishops held their ecclesiastical courts, projects from the south-west corner of the building, and does not by any means contribute to the general harmony. This court-room is still occasionally used by the commissary of the district: it is 25 feet by 23 feet, and is fitted up with a bench and seats, which evidently bear the marks of antiquity; the royal arms over the bench has the letters C R. II. Immediately above the court-room is a repository for certain official documents connected with the court. The cemetery is of the same dimensions, and is placed immediately under the nave, having entries by a flight of steps, descending on the right and left of that which leads up to the nave at the east end of the choir. The space underneath where the altar stood, is said to have been a repository for relicts, and a cemetery for the bishops. The monument of St Mungo is shewn in this place, in a tolerable state of preservation.

The craftsmen protect the cathedral.

Having thus given a description of the cathedral during the time the rites of the Roman Catholic religion were performed in it, we have now briefly to enumerate the alterations which took place in the buildings when the reformed religion was established. Before entering on this, however, it may be proper to inform our readers, that in 1579, when the fury of fanaticism had nearly reached its height, and while it was thought meritorious to destroy every edifice which had been consecrated for the service of the Roman Catholic religion, the magistrates, at the instigation of certain clerical and lay zealots, determined to raze the cathedral to the ground, and for this purpose had engaged a numerous band of workmen to pull down the stately fabric. When these workmen were assembled by beat of drum, and with their unhallowed hands were about to pull down the carved work, the craftsmen of the city, to their immortal honour, assembled, and swore, that the first man who should pull down one stone of the building should be buried under it; nor would they retire, till they had an assurance from the magistrates that no damage should be done to the fabric. Having thus weathered the storm, the cathedral was altered to contain three places of worship, the choir was divided into two by a stone partition, the west division being formed into a place of worship, under the name of the Outer High Church. The nave of the cathedral was fitted up, and termed the Inner High Church; and the cemetery, although low in the ceiling, when compared with the others, was fitted up into a place of worship for the barony, or Landward parish. In the internal formation of these places of worship, it does not appear that much attention had been paid to taste or ornament; on the contrary, when we observe the great windows and doors, and other admirable decorations then rudely blocked up, we are led to believe, that our early reformers disliked every appearance of show or grandeur in their places of worship.

When it was resolved to fit up the interior of what is called the Inner High Church, in a style which might in some degree correspond with the magnificent external architecture of the cathedral, the magistrates entrusted the arrangements to the late Mr William Stark.

At that time, the entrance from the choir was by small side doors: the centre of the church was entirely filled with pews; the galleries were deep and heavy; the pulpit placed on one side; and the great east window built with stone. The appearance is now completely changed: the entrance is in the centre of the west end; a passage leads from it to the pulpit near the other extremity. The galleries, which were indispensible for accommodation, are placed behind the axis of the pillars of the church; and the east window is opened, and filled with stained glass.

Glasgow. Cathedral.

In repairing the capitals of the pillars, the work is executed so much in the manner of the old carving, that the difference cannot be perceived; and in the small vestibule, the fronts of the galleries, the pulpit, and indeed all the modern parts, the Gothic style is perfectly preserved. The whole is painted of a grey colour, which appears sufficiently neat and clean, without the least glare or tawdriness; and the sober imposing effect of the church is worthy the memory of the architect, who, by the pure and classical taste of his public buildings, has done so much to ornament this city.

About the same time leave was given to a society of sacred music to erect an organ in what is commonly called the choir; and this was executed by Mr David Hamilton, architect, in a manner creditable to his taste.

In 1811, the seats in the outer High Church were completely removed, and the whole of the interior renewed in a manner well suited to the magnificence of the place; the pulpit has been removed from the south side to the west end of the church; and in 1812, the great western window, immediately over the original grand entrance, was opened at an expence upwards of £ 500. This window is 44 feet 6 inches high by 23 feet 6 inches wide.

The heritors of the Barony parish, taking into consideration, the ruinous condition of the seating of their church, and finding the space not large enough for the increased population of the parish, agreed to abandon it as a place of worship. Accordingly, in the year 1801, the seats were removed, and it was again converted into a burying-place, such as it had originally been. This repository for the dead, contains 65 pillars, with capitals of curious workmanship, supporting the groined arches, underneath the stone floor of the Inner High Church; the whole is rendered visible by a glimmering light passing through small apertures retained from the former windows. When a stranger enters this place and examines the monuments of art, and those erected to the memory of departed worth, he is insensibly struck with veneration and awe.

The entrance to the choir is now by the south front. It is 74 feet 6 inches long, 63 feet wide, and 90 feet high, and has a grand imposing effect, the pillars being more than 80, and the windows 40 feet high.

The south transept has long been used as a burying-place for the clergymen of the city: the style and execution of the work in this aisle is much admired. Immediately over this, a flower garden was placed; but in 1812, it was removed, and a stone pavement, concealed by a parapet, substituted in its place. The north transept, formerly the Chapter House, has been fitted up as a private burying-place.

Bishop's palace.

The Bishop's Palace or Castle, erected in 1430, stood somewhat to the south-west of the cathedral, nearly in front of where the Royal Infirmary now stands: it was inclosed with a strong wall of hewn stone by Archbishop Beaton: the ruins of the castle were removed in 1789, to make way for the erection of the Infirmary.

College Church.

The College church is situated on the east side of the High Street, a little below the College. It is a plain building, partaking of the Gothic, with a small steeple in front, containing a clock and bell. It was built in 1699, on the site of a venerable Gothic pile, termed the church of the Black Friars, which was unfortunately destroyed in 1666 during a violent storm. At the Reformation this church was made over to the College, but was some time afterwards conveyed to the community under certain restrictions.

Tron or Laigh Church.

The Tron church, situated on the south side of the Trongate, a little to the eastward of King Street, was founded and endowed by the community in 1484, and dedicated to the Virgin Mary. Prior to the Reformation, a number of chaplainries were founded in it, by pious and wealthy citizens. In the year 1592, this place of worship underwent a thorough repair; and on the 8th February 1793, it was destroyed by fire. The steeple belonging to this church, which is of mixed ancient architecture, projects into the Trongate, and forms a striking feature in that street: it was built in 1637; is 126 feet high, and has a clock and two bells in it. The under part of the steeple being formerly used as a tron, gave to it its present name. In 1794, this church was rebuilt on the site of the old one, from designs by Mr James Adam. It is a plain modern building surmounted by a spacious cupola.

North-west Church.

The north-west church situated in Canon Street, fronting Candleriggs Street, was erected by the community in 1721. Its form is oblong, lying east and west, with a transverse aisle. A steeple 140 feet high, having a clock and bell in it, is placed at the south front of the church. The steeple displays less taste than might have been expected from the period in which it was built.

St Andrew's Church.

St Andrew's church is situated in the centre of St Andrew's Square. It was founded in 1739, but not finished till 1756. It is nearly a copy of St Martin's in the Fields, Westminster, and is allowed to be as complete a specimen of the composite order of architecture as is to be found in Scotland. On the west front a grand portico is formed; the arms of the city are displayed in the pediment in basso relievo; a lofty spire, with a clock and bell in it, is placed at this front of the building: its form and proportions, however, are by no means in unison with the church.

St Enoch's Church.

St Enoch's church, situated on the south side of St Enoch's Square, fronting Buchanan Street, and founded in 1780, is of an oblong form; a portico of the Doric order, is placed at the north end; a lofty and handsome steeple, having a bell and clock in it, is formed at that end of the church.

St George's Church.

The Wynd church, which had been built by a party of Presbyterians during the time of Episcopacy in 1687, was found to be unsuitable for the congregation of the venerable Dr Porteous. Accordingly in 1807, the presbytery, with concurrence of the magistrates, translated the congregation to St George's church, erected on the west side of Buchanan Street, fronting George's Street.

Few things are more difficult than to place a steeple or spire on a modern building, without destroying its effect. A Gothic church is usually proportioned in elevation to its tower; but modern churches, built more for convenience than grandeur, are for the most part so low in their walls, that the spire must either be insignificant in its own dimensions, or appear to crush the building to which it is merely attached, but with which it never seems to be connected. Aware of this, Mr Stark, who gave the plan of this edifice, resolved that the tower should be the principal object of attention, to which the rest of the façade might be considered as an accompaniment. In this view, he was desirous of projecting it from the front of the church, over the side pavement of the street; but this being thought objectionable, the idea was abandoned, and the tower carried back to the line of the front.

The tower itself, both in its general form, and in the variety as well as the proportion of its parts, is uncommonly beautiful; and probably its termination, had the colossal statues intended by the architect been placed on its angles, would have been equally rich and graceful; but many difficulties arose in getting well composed statues for so unusual a situation, without incurring an expence which the magistrates would have thought unjustifiable. Mr Stark accordingly agreed, with reluctance, to substitute obelisks, which it must be confessed appear meagre terminations to the angles of the tower, and scarcely accord with the beautiful little temple which rises from its centre.

ony rch.

The place of worship for the Barony, or Landward parish, in the cathedral, having become insufficient for the purpose, the heritors, in 1798, built a church adjoining, and in complete view of the cathedral and Royal Infirmary, from a design of Mr Adam's. The architecture is of a mixed style, varying from the adjoining specimens of Gothic and Grecian architecture. The outline of the west front of this church has an imposing effect: it is to be regretted, however, that the execution of the whole of the exterior, is so much inferior to that of the adjoining buildings, to which it was intended to assimilate. This extensive parish has chapels of ease, at Shettleston, Calton, and Anderston.

iscopal pel.

The Episcopal chapel is situated to the north of the public green, and immediately behind St Andrew's Square. It is a handsome oblong building, erected by subscription in 1751. The altar, orchestra, and organ gallery, are placed on the east end of the chapel. The whole of the interior is fitted up with great taste, and the window over the altar is beautifully ornamented with scriptural devices.

ian Ca- c Cha- e

A very magnificent Roman Catholic chapel, in chaste Gothic, is at present erecting on the north side of West Clyde Street, from designs by Mr James Gillespie. The towers and pinnacles, the embrazures, the grand entrance, and the magnificent window done up with mullions and tracery, surmounted by a colossal statue of St Andrew on the principal front, are well calculated to gratify the admirers of this venerable style of architecture. The buttresses, embrazures, and ornaments, of the other fronts, which are all executed in polished ashlar, harmonize with the general order. The nave and aisles of the interior are to be fitted up in strict conformity with the style of the exterior. A valuable organ, now building, is to be placed in a gallery over the grand entrance, the altar being at the opposite end of the chapel. This place of worship, which does great credit to the taste of the architect, is to contain 2200 persons, and is calculated to cost about L 13,000, the greater part of which is to be raised by small weekly contributions, from those persons who profess the Roman Catholic religion in this city and neighbourhood.

iges.

Prior to the year 1340, a timber bridge, which had been thrown across the Clyde somewhere to the west of the Saltmarket Street, went into decay; on which William Rae, bishop of Glasgow, in 1345, built a stone bridge across the Clyde, at the foot of what is now called the Stockwell Street, communicating with the barony of Gorbals. This bridge, plain, without even an affectation of ornament, was originally constructed with eight arches. Two of these, on the north side, were built up, when it became necessary to narrow the river, and thereby protect the adjoining houses from the effects of floods. This bridge continued for more than 300 years, without requiring (so far as we have been able to learn) any material repair. In the year 1671, the southmost arch fell at noon of the day on which Glasgow fair is held; and although the concourse of people passing and repassing at the time must have been very great, it is recorded, that no person received injury. This arch was rebuilt with all convenient speed; and the bridge received frequent repairs till the year 1777, when an addition of 10 feet was made to its breadth on the east side, by which the fabric is strengthened, and the passage rendered more convenient for carriages. The bridge, as it now stands, is 415 feet long, by 22 feet wide, within the parapets. The pious and public-spirited Lady Lochow is said to have prevailed on Bishop Rae to allow her to pay the expence of the centre arch.

Jamaica Street Bridge.

In 1768, the foundation of a stone bridge, across the Clyde, was laid at the foot of Jamaica Street, for the more easy communication to the west coast. It has seven arches, is 500 feet long, and 30 feet broad within the parapets. Its general appearance is such, as to combine the idea of strength with elegant simplicity. The plan was given by Mr Milne, the architect who designed Blackfriars bridge, London. The pontage arising from these two bridges, in 1814, was £1529 : 5 : 9, which goes to discharge the existing debt, and keep them in repair.

In the year 1794, the foundation of a stone bridge, to be thrown across the Clyde at the foot of the Saltmarket Street, was laid. During the subsequent year the work was carried on, and so far completed, that the arches were thrown across, and the parapets nearly finished, when, on the 18th November, 1795, the lower part of the city was subjected to an alarming inundation of the river, which, at four o'clock P.M., swept away the northmost arch of the bridge, and, in two hours afterwards, the whole arches gave way. This bridge, which was named Hutchison's, consisted of five arches, was 410 feet long, and 26 feet broad within the parapets.

In 1803, a timber bridge, for foot passengers, justly admired for the simplicity of its construction and light appearance, was thrown across the Clyde at the bottom of the Saltmarket Street, a little eastward of the site of Hutchison's bridge. Its outline is one grand sweep of 340 feet, having eight supports and breakwaters. The breadth within the parapets, which are formed of upright spars, with diagonal braces, is seven feet four inches, the expence of erecting it was £1200. An act of Parliament was procured, authorising certain trustees to levy a halfpenny from every person who passes and repasses the bridge on one day of the week only. The nett pontage, which, in 1814, was £81, goes to discharge the debt incurred in building the bridge, and in keeping it in repair. The design was by Mr Peter Nicholson, architect, author of *The Principles of Architecture, Carpentry, &c.*

Hutchison's Bridge, intended to be rebuilt.

In 1814, the magistrates and council of the city, and others interested in Hutchison's town, obtained an act of Parliament for building a bridge across the Clyde, near the site of the bridge that fell in 1795. They have also procured designs from Mr John Rennie, and are on the eve of contracting for its immediate erection. The cost is supposed to be from £18,000 to £19,000.

College.

The college buildings, and the houses for the accommodation of the professors, are situated on the east side of the High Street, near the Blackfriars church. They are very extensive, having a front of 305 feet to the High Street, and 282 feet from east to west. These buildings, and the four courts, three of which form quadrangles, occupy a space equal to 9556 square yards. The buildings are generally three stories high, of ashlar work, diversified with turrets and appropriate ornaments. There are three entrances in the principal front. The centre gate is ornamented with a species of demi-rusticated work; the royal arms in basso relievo, gilt, are placed over the gate, and consols, supporting a broad balcony, are formed at each side. The entire of the façade, which has a fine effect, is terminated, on the

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Glasgow.

south, by the principal's house, and, on the north, by that occupied by the professor of oriental languages. At the centre of the east side of the west court, a lofty tower, plain, without any gaudy show of ornament, rises to a considerable height, and terminates in a ballustrade, and semi-curvated roof. The eastmost range of buildings, erected more than 200 years ago, having become unfit for the purposes for which they were intended, were taken down in 1811, and a magnificent range, from designs by Mr Peter Nicholson, erected on their site. The east front is divided into three compartments, the centre projects, and is ornamented with chamfered work, supporting four massy Doric columns, with entablature and pediment; the receding divisions exhibit a range of pannelled pilasters, cornice and ballustrade. This new erection, which is 160 feet long, and 50 feet deep, contains the anatomical theatre; the common hall, 73 feet long; and rooms for the humanity, Greek, logic, chemistry: medical, and mathematical classes. The library is a handsome insulated building, on the south-east extremity, the faculty hall fronting the High Street, is a very spacious room, handsomely wainscoated. The chapel, in which the professors and students attend divine service, is fitted up in a suitable manner. There are some valuable historical pictures, and portraits of eminent literary characters, hung round the walls of several of the apartments. The adjoining ground, on the east of the college, commonly called the college garden, consists of several acres, inclosed by a high stone wall, laid out in walks and shrubberies, for the use of the professors and students: The Macfarlane observatory is erected near the east end of it.

Town-hall and buildings connected with it.

The town-hall buildings, situated on the north side, and at the east end of the Trongate Street, were finished in the year 1636. The basement was originally formed into an arcade, with a rusticated front; the upper part of the building displays the complete range of the Ionic order. The town-hall is fitted up in an elegant manner. The walls are decorated with portraits of the kings and queens of Scotland and Great Britain. Ramsay's Archibald Duke of Argyle, in his robes as Lord Justice-General, is admired as a very valuable picture. The bust of his present Majesty is placed over the mantle-piece; and the statue of his immortal premier, William Pitt, by Flaxman, at the east end of the hall. In 1781, a subscription, by way of tontine, was opened, for building a coffee-room and hotel, in 107 shares, at £50 each. Mr William Hamilton, architect, gave the design, and displayed great professional skill in throwing the arcade of the town-hall into an extensive piazza, retaining the upper part of the cross walls of the superior structure. The coffee-room, on the ground floor, is 74 feet long, of proportional width and height, and is very handsomely fitted up. There are at present 1146 annual subscribers to the room, at 32s. each. It is supplied with Scotch, English, Irish, and Continental newspapers, magazines, reviews, and other periodical publications. In this coffee-room strangers are freely admitted without introduction, and may enjoy all the privileges of subscribers for four weeks without subscription,—a liberality, we believe, not equalled in any of the other great towns in the island.

Prior to 1812, the jail stood contiguous, and at the east end of the town-hall. The jail, from the increased population of the city, having become too small, was taken down in 1812, and an elegant building substituted in its place; the upper part being ornamented with turrets and embrazures, so as to preserve a similarity to the old tower of the prison, which is still preserved. This tower, which is 126 feet high, projects on the High Street, and is only remarkable for its terminating in the shape of an imperial crown. It is furnished with a clock and bell, and a set of musical chimes, so arranged as to play a separate tune at the end of every two hours. A skilful musician performs favourite airs on the musical bells, during Change hours, every lawful day, Saturday excepted.

Merchants or Guild Hall.

The merchant's hall is situated on the south side of the Bridge-gate Street, a little to the east of the Stockwell Street. It was rebuilt in 1659, by Sir Patrick Bell, the then Dean of Guild; it is 80 feet long, and of a proportional width and height. Donation and inscription boards are hung round the walls, containing the names of the Deans of Guild. The building consists of two stories of ashlar work, with little decoration, the basement being fitted up for shops. This building, from its situation and present condition, is by no means suited to the wealth and respectability of Glasgow merchants. The steeple, however, adjoining the south-front of the hall, is considered one of the handsomest in the city; it is 164 feet high; after rising 85 feet in the form of a square tower, a ballustrade is formed, within which a tower of smaller dimensions is again formed, terminating in a ballustrade; this arrangement being repeated, a pyramidal spire is terminated by a gilt ball and ship in full sail.

Town Hospital.

The buildings of the town hospital, which were erected from donations and subscriptions of public bodies and individuals, were so far finished, that the poor were admitted in 1733. The buildings form a quadrangle, the large court in the centre being used as airing ground. The principal front is to Clyde Street; it consists of a centre and two projecting wings of three stories. This range contains the great hall, where the inmates assemble for worship, and other apartments for the use of the charity. The buildings on the other sides of the quadrangle are chiefly fitted up for offices, and the accommodation of sick and fatuous persons, the insane having been removed, in 1814, to the Lunatic Asylum.

Royal Infirmary.

The royal infirmary is situated in the north quarter of the city, partly on the site of the archbishop's palace, near the cathedral. The designs for this building were from Messrs Robert and James Adam; and the general form of it is so imposing, as to command universal approbation. The design partakes of the parallelogram form, with bold projections at each end, having a pediment in the centre, supported by pillars of the Corinthian order, and the royal arms, in alto relievo, cut in the tympan of the pediment. A spacious dome, with vertical lights covering the operation hall, terminates the building, which consists of four stories. The foundation stone of this edifice was laid in 1792; the interior arrangements are well fitted for the purposes of the hospital. Although the Infirmary is calculated to contain 150 patients, it has latterly been found inadequate for the accommodation of increasing applicants; accordingly the managers are at this time making an addition at the back of the buildings, which, without injuring the general appearance, will give more than one third additional accommodation. This addition, which will cost £4000, has been raised by special subscription.

Trades-hall Buildings.

The trades-hall buildings, situated on the west side of Glassford Street, fronting Garthland Street, were erected in 1791, from designs by Mr Robert Adam. The front consists of a centre building, and two wings, the former of two stories, supported by a rusticated basement, with a projection at its centre, on which there are four Doric columns, supporting an entablature. The front is relieved with various mouldings, ornamented with griffins in basso relievo, and terminated in a ballustrade, in the centre of which the city arms are cut in alto relievo, supported by two female figures in a recumbent posture. A dome rising through the roof, terminating in a lantern, gives a happy effect to the whole. The hall, 70 feet long, 35 feet wide, and 24 feet high, exclusive of a magnificent dome, is fitted up with appropriate decorations. Portraits of persons of the trades rank, who had made donations to the house, and the arms of the 14 incorporated bodies, are hung round the walls. Tablets with the names and designations of the conveners of the Trades House, from 1605 down to the present day, are also placed on the walls; the other parts of the building are fitted up as committee rooms, &c. The hall of the Trades House free school adjoins this edifice, which, for extent, light, and ventilation, is justly admired. From a remote period, down to the year 1791, the Trades House and incorporations met in their hall near the cathedral, known by the name of the Alms House, from their chaplain distributing alms to decayed out-door members. This building being found incommodious, and by no means suited to the increasing respectability of the trades rank, has been appropriated to another use.

Assembly rooms. The assembly rooms, erected in 1796 by a tontine subscription of £ 20 shares, are situated on the north side of Ingram Street. From a rusticated basement story, a bold projection is formed at the centre of the building, which supports four Ionic columns, pilastres, and entablature. Various appropriate ornaments are introduced on the front, which terminate in a ballustrade. The interior consists of the assembly-room, card, supper, and retiring rooms, and apartments for the housekeeper, public kitchen, &c. The principal room, 80 feet long, 35 feet wide, and 27 feet high, is finished and fitted up with every requisite, in the most elegant manner. Mr James Adam gave the design of the principal or centre building. The wings, which are separated from the main building by a colonnade wall, were built in 1807, from designs by Mr Henry Holland.

Grammar school. In 1788, the grammar school buildings, in Grey Friars Wynd, were found to be insufficient for the purpose; accordingly a new set were erected on the north side of George's Street in 1789. The front, which has a light cheerful appearance, consists of three compartments, the centre receding from the wings, in which large Venetian windows are formed. The interior is subdivided into a common hall, 70 feet long, and seven large well-aired rooms for the accommodation of the classes. At the back of the building, more than half an acre of ground is enclosed for the use of the students.

Surgeon's hall buildings. In 1791, the Faculty of physicians and surgeons finding that their hall in the Trongate was not sufficiently commodious, erected buildings on the east side of St Enoch's Square. The front consists of two stories; a rusticated basement supports a range of pilasters, entablature, and ballustrade. The interior consists of the faculty-hall, library, committee-rooms, offices, &c.

Barracks. In 1795, government erected very spacious barracks on the north side, and near the east end of the Gallowgate. Exclusive of the guard-house, suttlery, infirmary, and magazine, there are three large buildings for the accommodation of the military: The centre is for officers: it is a handsome building, four stories high, having the royal arms in demi-relief, displayed in the tympan of the pediment. The other two buildings, placed at right angles from the centre one, are for the accommodation of the soldiers; they contain 72 apartments, fitted for 14 men each, exclusive of 24 kitchens. The whole is enclosed with a high wall, forming an extensive parade.

City guardhouse. In 1810, the city guardhouse was removed from Candleriggs Street to the east side of Montrose-street. Its front is formed with arched compartments, surmounted by a cornice and blocking. The interior contains ample accommodation for the officers and soldiers, and the piazza is sufficiently spacious for the relief.

Bridewell. In 1789, a plain building, 106 feet long, 30 feet wide, and 6 stories high, was erected on the north side of Duke-street, for the purposes of a bridewell; it contain 126 cells, 8 feet by 7 feet, exclusive of a chapel and a large work-room. On each side of the bridewell, spacious wings are formed at right angles, which contain the infirmary, public kitchen, keepers' lodgings, and rooms for raw materials for the manufactory, &c. The whole is enclosed within a wall.

Markets and Weigh-house. The principal beef, mutton, and fish markets, are situated in King Street. The former occupies a space of 112 feet by 67 feet, and the latter 173 feet by 46 feet, subdivided around the area into stalls. The courts are paved with free stone, and the fronts formed of ashlar work, with rusticated entries; the beef-market in Bell Street being fitted up in a plainer style. The vegetable market is also done up into stalls, and is so spacious as to occupy the whole site of the former Wynd Church, having its principal entry from King Street. The butter, cheese, and poultry markets, are placed in Montrose Street. The tron, or weigh-house, is a large building, situated at the east end of Ingram Street, and is used for the general purposes of a tron and store-house. Prior to the late erection of markets in the city of Newcastle, the markets in King Street were considered the best in the island. Each stall in the fish-market has a water-pipe in it, and the other markets have a plentiful supply of water.

Slaughter house. The slaughter house, situated a little to the south of the Bridgegate Street, was erected in 1810, and is the largest and most commodious in the island: it contains 77 killing rooms, two cattle-yards and alleys, and accommodation for the searchers and scavengers: it covers 4736 square yards of ground, which is all paved with square stones. Water pipes are placed along the whole of the killing rooms, and extensive sewers carry off every thing which would become offensive.

Theatre. The theatre in Dunlop Street being found inconvenient, and too small for the accommodation of the public, a magnificent one was erected on the west side of Queen Street, in 1804, on the principle of transferable shares, of £25 each. The building is 158 feet long, and 70 feet wide, being considerably larger than any of the provincial theatres. On the east front there are columns of the Ionic order, 30 feet high, with corresponding entablatures, and appropriate devices. The interior is elegantly fitted up with every suitable convenience, to accommodate 1500 persons, from designs by Mr David Hamilton. The building and scenery cost upwards of £18,500.

Hutchison's Hospital. The buildings of Hutchison's Hospital being removed from the Trongate, to make way for Hutchison Street, the patrons, in 1803, erected a hall and offices in Ingram Street, suitable for their accommodation. This building, and the spire of 150 feet high, which rises from the north front, is a great ornament to this part of the town. The great hall and committee rooms are

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fitted up in an elegant manner, from designs by Mr David Hamilton.

Lord Nelson's monument.

The citizens of Glasgow were the first to erect a monument to the memory of the immortal Nelson. Immediately after the hero's fall, a subscription was opened, and on the first of August 1806, the foundation of a solid ashlar obelisk, 142 feet six inches high, of chaste proportions, was laid at the west end of the high green, with great masonic solemnity: the subscription at that time amounted to £2075. On the 5th of August 1810, the upper part of the obelisk was completely shattered, and the greater part of its shaft rent during a violent storm of thunder and lightning. It is very remarkable, that although the ashlars of the upper part were thrown out of their beds, and so suspended that a passenger could see through the obelisk, yet at the present moment, after a lapse of five years, they seem to be still in the same situation.

Hunterian Museum.

The Hunterian museum was erected in 1804, and is situated at the west end of the college garden, in front of the common hall. This was the first public building erected by Mr Stark, who must be considered as singularly fortunate at the commencement of his professional career, in having such an opportunity of displaying his talents and his taste. He was no less fortunate also in being employed by a society, which, from full confidence in his abilities, avoided every interference with his arrangements.

Mr Stark chose the Roman Doric for the portico, as the gravest and most imposing order that could be employed in so confined a situation; and he made its parts as simple and large as that order could properly admit. Behind the portico he formed a recess, divided from it by a second row of columns, like the pronaos of an ancient temple. By this arrangement, securing great depth of shade, without projecting his columns too far into the narrow court, he produced a very rich effect in the angular view, and to so small a portico giving wonderful dignity on a near approach.

The merit of this building, however, is not confined to the portico; its general proportion, the simplicity of its parts, and the elegance of its form, render many views of it from the garden, little if at all inferior to that of the principal front. The interior, likewise, corresponds in a remarkable degree with the exterior appearance. There are, throughout, the same simplicity, the same elegance, and the same attention to picturesque effect. The saloon for paintings, is particularly beautiful in its form, proportions, and decorations, while it is at the same time well contrived for exhibiting to advantage the collection which it contains. With the exception of the staircase, which is too small and too plain, a man of taste will discover, in this elegant building, a unity and consistency rarely to be met with in modern works: no part is neglected, and no part charged.

Gaol and court houses.

The gaol and court houses, situated on the west end of the Green, were built in 1810. The magistrates having resolved to erect a new gaol and court house, applied to several architects, and from their designs, all of which were too expensive, they made a selection and arrangement according to their own ideas. Mr Stark was then desired to adapt his elevation and court hall to the new design. The former has been executed exactly from his drawings; but in the latter, some deviations were afterwards made by order of the committee. Every consideration pointed out the Grecian Doric, as the proper order for such a building, and particularly in so open a situation. But architects have seldom succeeded in adapting this order to a front, in part of which the columns are to give place to a simple wall. Either they have reduced the massiveness of the entablature, on which the magnificence of the order entirely depends, or the cornice, which is admirably proportioned to the immense columns by which it is carried, has appeared heavy and even overwhelming in those parts where it is deprived of their support. This difficulty Mr Stark, by the general simplicity of the arrangement, and the size of the window dressings, has, in as far as possible, overcome; and though in this design there may be somewhat wanting of that unity and symmetry which charm in his other works, the magnificence of the portico rivets the attention, and diverts the mind from what may be less perfect in the other divisions of the facade.

The portico exhibits very nearly the proportions of the Parthenon, and may serve to give some idea of that celebrated temple, divested indeed of the magnificence it derived from the most exquisite sculpture of ancient times. As in the Parthenon, the columns are placed on colossal steps, the dignity of which cannot be conceived without having been seen; and there is a recess divided from the portico by a screen of columns, like the pronaos of the temple, which adds greatly to the richness and grandeur of the effect. It was subject of regret to the architect, that the portico could not be projected farther from the side wall of the building, and the screen of the pronaos. But such a projection would have destroyed all affinity between the centre and the wings, in which porticos, on account of their expense, were inadmissible.

In so flat a situation, it may also be regretted that greater elevation could not be given to the building, consistently with the employment of the Grecian Doric. This defect would probably, however, have passed unnoticed, had it not been rendered much more observable by a parapet and rail, which have been carried along the front since Mr Stark's death, and which, while they sink the building, conceal the colossal steps on which the grandeur of the portico so much depended. Were this obstruction to the view removed, there can be no doubt that the want of elevation in the general form would be far less conspicuous; though to have avoided it entirely was perhaps impossible.

A Grecian Doric portico of six columns is necessarily long in proportion to its height; and to have shortened the compartments, by which the centre is connected with the wings, would have crowded the façade, and destroyed all affinity among the forms and proportions of its several parts.

In contemplating so magnificent a portico, small defects pass unnoticed; and if they could not be remedied without adopting a less imposing order, the most fastidious taste will applaud the architect, for having submitted to what was unavoidable, for the purpose of producing so sublime an effect.

These buildings contain halls for the several courts, and ample accommodation for the civil and criminal establishments. The entry to the gaol is by the west front. This department consists of two spacious courts, 74 fire-rooms, 58 cells, and 2 apartments for prisoners under sentence of death, so completely cased with iron, that it is not necessary to subject the criminals to personal irons, as is done in almost every other jail. There are also a chapel, a military guard-house, and apartments for the keeper of the gaol's family. Four cast-iron cisterns, calculated to contain 14,776 gallons of water, are placed on the top of the prisons, from which the several apartments and water-closets are supplied. Prisoners are received from the counties of

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Lanark, Renfrew, and Dumbarton: They amounted, in 1814, to 1172 persons, viz. 367 debtors, 525 male criminals, 239 female criminals, and 41 deserters: The whole expence of these buildings, viz. £34,811, has been defrayed from the funds of the corporation.

Lunatic Asylum.

The foundation-stone of the Lunatic Asylum, situated between the Royal Infirmary and the Glasgow Observatory, was laid with great masonic solemnity, in 1810. Modern architects seem very generally to have aimed at reputation, rather by the invention than the proportions of their designs. Little aware of the dignity arising from the graceful diminution of columns, from inter-columnations rather narrow than wide, from harmony in the details, and from congruity in all the parts, in reference to each other and to the whole, they must be astonished at Palladio's fame, and unable to comprehend how his buildings, which are for the most part small in their dimensions, and without any pretensions to novelty or singularity in their forms, should so long have charmed the world, and at every repeated inspection afforded increased delight.

In this respect more perhaps than any other, Mr Stark bore a nearer resemblance to an architect of ancient than of modern times. By constant and respectful study of their works, he seemed to have imbibed the spirit of the Greeks, while, by the powers of his genius, he adapted their principles to the wants, manners, and opinions of his countrymen. In the lunatic asylum, he had less opportunity than usual of pleasing, by the proportions of the mouldings, or the richness of the details; for every costly ornament would have been improper, and the situation of the building rendered its effect from a distance much more important, than its beauty on a near approach. Yet even here, he studied the details with the utmost care, convinced that the grandeur of the general form is never independent of a due proportion in the minuter parts.

On considering the interior arrangements of a lunatic asylum, it appeared to him that wards, projected diagonally from a central building, would afford every facility, both for the superintendance and classification of the patients. Such a form had been little attempted, and never executed with a pleasing effect. The difficulties presented by it, Mr Stark has admirably surmounted. By a just proportion of the diagonal wards to the central buildings, by raising over the latter a circular attic, and crowning the whole with a noble dome, he has given the asylum a character of blended elegance and dignity, which perhaps sets it above all his other designs, and, simple and unadorned as it is, entitles it to a most eminent place among the works of art. So noble indeed is this design, that the managers could scarcely persuade the public, that, on erecting it, an extravagant sum of money had not been squandered on external decorations. Its effect is now a little injured by the garden walls, having been raised higher than the architect intended, and still more by a recent building, which interrupts its finest point of view; but wherever it is seen, it must excite feelings of the highest admiration; and even if in course of time all views of it as a whole should be intercepted by the extension of the town, the dome will always remain one of the greatest ornaments of the city.

The asylum and airing grounds cover about three acres and a half. In the distribution, care has been taken to class the higher and lower ranks of both sexes according to the frantic, ordinary, or convalescent state of the disease. The buildings contain 136 apartments for the use of the patients, exclusive of those appropriated for the housekeeper, apothecary, superintendant, physician, and committee; and the whole range of store-rooms, servants' apartments, kitchens, baths, &c. Each class of patients has separate entries to the subdivided airing grounds, which are laid out in gravel walks, flower-plots, and shrubberies. The eating-rooms, parlours, and bed-rooms, for the higher ranks of patients, are spacious and genteelly furnished: the close rooms for that class are 11 feet 6 inches long, 8 feet wide, and 10 feet 6 inches high; and for the paupers, 11 feet 6 inches long, 6 feet 6 inches wide, and 10 feet 6 inches high; each ward having a gallery 70 feet long by 7 feet 6 inches wide, for exercise in bad weather. The several apartments of the asylum are rendered comfortable by the introduction of rarefied air, generated in the sunk storey, and communicated by concealed flues.

Glasgow observatory.

In 1810, the foundation stone of the Glasgow observatory was laid on the south side of Garnet Hill, situated a little to the north-west of George's Square. The funds for this institution were raised by subscription of £20, transferable shares. The building is divided into three compartments: the first contains the instruments for scientific observations; the second those for popular observations; the third is fitted up for the accommodation of the subscribers, where they have the use of astronomical instruments, and treatises connected with the science.

In the Glasgow observatory, there are a great variety of valuable astronomical and meteorological instruments. The most remarkable are, a fourteen and a ten feet telescope by Herschel; a mural, azimuth, and altitude circle, by Troughton; a sidereal and mean time clock by Hardy; and a chronometer by Arnold.

Lyceum.

The Lyceum is situated on the east side of South Albion Street. The saloon is 54 by 33 feet, and the adjoining library 33 by 22 feet, the whole being elegantly fitted up. The saloon is amply supplied with newspapers and periodical publications; and the library is stored with a well-chosen collection of books. Strangers are not admitted to the Lyceum, without being introduced by a subscriber.

Riding school.

The riding-school, which was erected by subscription, is situated on the west side of York Street. It contains two circles of 40 feet each, stables, and a gallery for spectators.

Anderson's Institution Buildings.

The buildings for Anderson's institution are situated on the west side of John Street. The ashlar front is relieved with mouldings, terminating in a ballustrade and pediment: the roof being formed into a dome, has a very fine effect. The great hall is of a spherical form, and seated for 500 persons. The library, laboratory, committee, and apparatus apartments, are fitted up with every convenience.

Post office.

The post office, situated on the east side of South Albion Street, has an ashlar front, relieved in the centre, and terminating in a pediment. At one end of the building there is a covered way, and at the other a spacious lobby, for the accommodation of the public. A range of windows are so placed in the lobby, that persons having boxes in the office, can see if they have letters before the delivery commences.

Magdalene Asylum.

The Magdalene Asylum for the reception of females, who are desirous to return to the paths of virtue, is situated a little to the east of the Lunatic Asylum: It was erected in 1812, and is supported by voluntary contribution. The building consists of three stories; the front is divided into three compartments, the end ones terminating in pediments. This establishment is completed with every suitable accommodation, for the matron, the committee, and 34 penitents. The chapel, exclusive

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of the gallery, contains 150 persons. The managers being aware that the objects of this institution could not be obtained amid the bustle of active life, have inclosed above an acre of ground by a high wall, within which all the buildings for industry and accommodation are placed. As washing and dressing clothes for families form a prominent part of the economy of this establishment, the inclosed ground which is laid down in grass, is well adapted for bleaching, being supplied with pipes from the water companies.

Lock Hospital.

The buildings for the Lock Hospital, situated on the south side of the Rotten-row, are plain, and so completely inclosed, that the patients can only see into the spacious court-yards. Convenient apartments are fitted up for the committee, the housekeeper, and the surgeon.

Charitable institutions.

The public institutions and benefit societies which are established in this city for the relief of the necessitous, are so various and complicated in their nature, that we are under the necessity of briefly mentioning a few of the principal ones, with the sums expended in the year ending December 1814.

The merchants and trades houses, granted annuities to decayed members or their families to the amount of £1620, exclusive of a number of bursaries and apprentice fees, which are placed at their disposal. The 14 incorporations, and the Faculties of Physicians and Surgeons, and Procurators, gave to their poor £3800, exclusive of annuities to widows. Hutchison's and St Nicholas hospital, distributed to outdoor pensioners £1910. The sum raised for the maintenance of the Town's Hospital is £10,273. The ordinary expence of the Royal Infirmary is £3200, and that of the general session £2832. These sums, and what are annually expended for the purposes of the Highland and Humane Societies, Lunatic and Magdalene Asylums, the Lock Hospital, Buchanan and Graham's societies, and those institutions which have for their object the distribution of the scriptures, the education of youth, or the support of old age, amounts to upwards of £35,000 per annum, exclusive of private charities, which are very great. The writer of this article had a recent opportunity of receiving these particulars from the respective secretaries.

Glasgow regiment.

On the breaking out of the war with the United States of America in 1775, the public bodies and spirited individuals of this city raised a battalion of 1000 men, which was named the Glasgow Regiment. The subscription in a few days amounted to £10,000.

In 1795, and at subsequent periods, when government found it necessary to embody volunteer corps, the citizens of Glasgow enrolled themselves into the following corps. The 1st and 2d regiments, the light horse, the sharp-shooters, the armed association, the trades house battalion, the Highland regiment, the grocers' corps, and the Anderston and the canal suburbs corps. The greater part of these regiments found their own uniforms, and served without pay. When the volunteer system gave place to the local militia, this city completed, and has at this time, five regiments in the service of government.

Banks.

In 1695, the Bank of Scotland was established in Edinburgh by charter, with a stock of £100,000; and in 1696, a branch was sent to Glasgow, but recalled in 1697. In the year 1731, a branch was re-established, and again recalled in 1733. In the year 1749, the first Glasgow bank was opened, under the firm of the Ship Banking Company. In 1761, the Thistle Bank commenced business, and some time afterwards, the Glasgow Arms, and Glasgow Merchant Banking companies were formed. In 1729, the Royal Bank of Scotland was constituted by charter, a branch of which was established here in 1783. And in 1809, a company commenced business under the firm of the Glasgow Banking Company.

Exclusive of the above, which are all carrying on business to a very considerable extent, (excepting the Glasgow Arms, and Merchant Bank companies, which have retired,) branches from the following banks have been established, viz. Bank of Scotland, British Linen Company, Paisley and Paisley Union, Greenock, Renfrewshire, Commercial Bank of Scotland, Aberdeen, Air, Stirling, Falkirk, Leith, Perth, Kilmarnock, Fife, and Dundee, &c.

Provident bank.

In 1815, a provident or savings bank was established here for the benefit of the lower orders of the community, wherein deposits of one shilling and upwards are received, bearing interest at the rate of four per cent. when the sum shall amount to 12s. 6d. and have lain one month in the bank. When a contributor's deposit amounts to £10, it is transferred in his or her name to any bank they may desire, and the receipt delivered to them, and they may again pay in their savings, and draw out all, or any part of them, in sums of not less than six shillings. This institution is placed under the management of a governor, deputy-governor, and 28 directors, who all act gratuitously. The necessary charges are defrayed from a subscription fund of upwards of £7,000, and from one per cent. on the deposits, the Royal Bank generously allowing the provident bank five per cent. for money lodged with them, while the contributors only receive four per cent. Although it is little more than four months since the bank commenced business, there have been 785 accounts opened. During the first three months there were 590 accounts, amounting in whole to £2407 : 9 : 6, of which Royal Bank receipts for £750 were given out to contributors, £1550 : 13 : 3 retained in the Royal Bank at the credit of the Provident Bank, and the residue repaid.

Insurance offices against fire.

The Glasgow friendly fire insurance company having been on the decline for a number of years past, was dissolved in 1805. In 1803, a company was formed under the designation of the Glasgow Fire Insurance Company, with a capital of £100,000 divided into 400 shares. This concern, not answering the expectation of the proprietors, was given up in favour of the Phœnix office in 1811. Although there is now no fire insurance office belonging to the town, there are no less than 22 branches of the London and provincial offices established in it. It is worthy of remark, that although the local offices above alluded to have not succeeded, that the annual increase of duty in four years, ending 1814, paid by 15 of the London offices, amounted to £61,175.

Statue of King William.

In 1735, Mr James Macrae, a citizen of Glasgow, and late governor of the presidency of Madras, presented to the town a metallic equestrian statue of King William III. The statue is placed on a pedestal at the cross, bearing an appropriate inscription, and is inclosed by an iron rail.

Mr Pitt.

In 1812, a full length statue in marble of that great minister, who conducted the affairs of Britain during an eventful period of 26 years, was erected in the town hall, by subscriptions from the citizens of Glasgow. This statue, which is executed in parliamentary robes, from the chissel of Mr John Flaxman, London, cost upwards of £1300, and has the following inscription, *Gulielmo Pitt Cives Glasguenses posuerunt* A. D. MDCCCXII.

Sir John Moore.

In 1809, this city lost one of her bravest sons, by the death of Sir John Moore, who, at the head of the British army in Spain, fell gloriously in the arms of victory, on the plains of Corunna, and was buried in the citadel of that town. When the accounts of his victory and death reached his native town, a subscription, amounting to upwards of £4000, was immediately completed, and a bronzed pedestrian statue ordered to be erected to his memory in some conspicuous part of the city, under the direction of Mr John Flaxman, London.

History of the university and other institutions.

The university was founded, as before mentioned, in 1450, in virtue of a bull obtained from Pope Nicholas V. by the solicitation of James II. and William Turnbull, Bishop of Glasgow. This institution, while in its infancy, consisted of a chancellor, rector, dean of faculty, a principal, who taught theology, and three professors of philosophy. At the Reformation, this seminary suffered very materially; and it was not till after James VI. had granted a new charter of erection, and bestowed on it the teinds of the parish of Govan, that it recovered from the shock which it had received. In 1617, the teinds of the parishes of Renfrew and Kilbride were annexed and ultimately conferred on it. In 1630, the temporalities of the bishopric of Galloway were added; and in 1670, the teinds of Cadder, of Old and New Monkland, were conveyed to the college, by charter from Charles II. In 1693, after the Revolution, the sum of £300 per annum was granted to each of the Scottish universities, out of the property of the abolished bishoprics of Scotland; and the better to insure the payment of this sum, this university obtained from the crown a lease for 19 years of the teinds of the archbishopric, which has been periodically renewed ever since. These teinds, and the annual returns from heritable property, and donations received from individuals at various times, constitute the fund from which the professors' salaries, and certain stipends are paid, the college buildings supported, and the other concerns of the university maintained. From its erection down to the present time, the number of professorships have been increased. At present, the establishment consists of a lord chancellor, lord rector, dean of faculty, a reverend principal, a reverend professor of divinity, professors of church history, oriental languages, natural philosophy, mathematics, moral philosophy, logic, Greek, humanity, civil law, medicine, anatomy, practical astronomy, and the regius professors of natural history, surgery, and midwifery. The crown presents to the following chairs, viz. the principality, church history, civil law, medicine, anatomy, astronomy, natural history, surgery, and midwifery. The college elects the chancellor, the dean of faculty, and the professors of divinity, oriental languages, natural philosophy, mathematics, moral philosophy, logic, Greek, and humanity. The rector and dean of faculty are chosen annually. In choosing the former, the mode of election is materially different from that of the other office-bearers. He is elected by what is called the Comitia, that is, a court consisting of the office-bearers and professors, and all the students who have matriculated, by enrolling their names, and stating the place where they were born, and the name of their father and his designation, &c. This court consists nearly of 1000 members, is divided into what is called the four nations, viz. the Glottiana, Transforthana, Loudoniana, and Rothsaiana. The majority of the members of each nation constituting one vote, in case of an equality, the rector has the casting vote. It has been usual to re-elect the rector for one year only. The regius professors have no vote in the faculty, except for the dean; they, however, vote in the Comitia, in common with the matriculated members.

The college has a number of bursaries in its gift. Among others, there are ten for Baliol college, on Mr Snell's mortification, at £70 each, arising from an estate in Warwickshire. This distinguished seminary has produced, at various times, some of the most eminent literary characters of the age in which they lived. Among others, may be ranked the names of the celebrated poet and historian George Buchanan, Archbishop Spottiswood, Principal Leechman, Adam Smith, Hutchison, Reid, Cullen, and Hunter.

Andersonian Institution.

The late celebrated Mr John Anderson, professor of natural philosophy in the university of this city, by his last will, disponed and conveyed his valuable apparatus, museum, and library, and his other effects, to 81 trustees, whereof nine were to be tradesmen, nine agriculturists, nine artists, nine manufacturers, nine physicians and surgeons, nine lawyers, nine divines, nine natural philosophers, and nine kinsmen or namesakes, for the purposes of establishing a college in this city, for the arts, medicine, law, and theology. At the professor's decease, his trustees were incorporated by charter in 1796. Pecuniary and other considerations have hitherto limited the plan to physical science, comprehending natural philosophy, chemistry, materia medica and pharmacy, mathematics, and geography. Popular and scientific lectures, from its commencement, were continued to be delivered to both sexes, in this institution, by Dr Garnet, with great approbation, till in 1799 he received an appointment in the royal institution of London, which had been formed on the model of this primary institution. Dr Garnet was succeeded by Dr Birkbeck, who, in addition to the branches taught by his predecessor, introduced a familiar system of philosophical and mechanical information, to 500 operative mechanics, free of all expence, exclusive of the exhibition of an extensive apparatus; particular models illustrative of the arts, were introduced. A subscription library for the use of this class, has been productive of beneficial effects.

Hunterian Museum.

The late celebrated Dr William Hunter of London, was born in 1718, at East Kilbride, a village about 8 miles south-east from this city, and was educated at this university. By his last will, he left his splendid and very valuable museum in trust to the professors of the college of Glasgow, to be received by them a certain number of years after his death, which happened in 1783. This collection was brought to Glasgow in 1808. It consists of minerals and fossils, plants, shells, fishes, beasts, birds, insects and reptiles, books, rare and valuable manuscripts, anatomical preparations, antiquities, original pictures from the most eminent masters, and many other productions of nature and art. The coins and medals are of the first consideration; the whole is estimated at £150,000. This collection is placed in a building erected in the college garden for the express purpose; and is shewn to the public on application to the trustees.

Royal Infirmary.

The royal infirmary is a noble institution, supported by voluntary contribution. By its charter, the management is placed in the lord-provost, who is, *ex officio*, president; the member of parliament; the dean of guild; the convener of the trades-house; the professors of medicine and anatomy; the president of the faculty of physicians and surgeons; one member from the town-council, merchants and trades-houses, and college; three from the faculty of physicians and surgeons; and ten from the general court of contributors. From 31st December, 1813, to 31st December, 1814, there have been admitted to the hospital 1267 patients, of whom 855 were medical, and 412 surgical; 666 of the gross number were men, and 601 women. Of 104 distinct diseases, with which the patients were afflicted, there were 154 cases of fever, and 52 operations performed; 758 patients were cured, 100 relieved, 102 died, 132 remained in the hospital, and the remainder were either convalescent, improper, or incurable. Since the opening of the infirmary in 1794, there have been admitted 15,036 patients; of which number 10,325 have been cured, and a considerable number of the remainder relieved. During the above period, advice has been given at the infirmary to nearly 40,000 out patients. The subscriptions for 1814 amounted to £1901. 11s. 5d.; contributions, £152 : 11 : 6; legacies, £522, 6s. 9d.; and the fees from medical students for leave to attend the hospital, £597 : 15 : 1.

Town hospital. This institution is supported by fixed contributions from the town council, merchants, and trades houses, and general session; but chiefly from an assessment on the inhabitants, laid on by 15 persons not connected with the town council. The mode is, to assess every person, in proportion to his property and business, within the burgh, who is supposed to be worth £300. In 1814, there were 484 persons in the hospital; 795 out pensioners, who received nursery wages for their children; 738 out pensioners, who received meal from the hospital; making a total of 2017 on the funds. The average cost of each person in the hospital, in 1814, is £9 : 15s. per annum; the quantity of meal used in 1814, is 2302 bolls. The rate of assessment on every £100 of supposed property in the burgh, 3s. 6d.; valuation, £5,830,700; amount of assessment, £10,273.

Lunatic asylum. This institution was opened on the 12th December, 1814, when 23 male and 18 female patients were admitted. Since the opening, a period of only 11 months, 112 patients have been admitted; of whom 24 have been cured, six relieved, one died, six discharged being idiots, and 75 remained in the asylum. The rates for the support of paupers belonging to Glasgow, or those parishes who have contributed £50 for every 1500 persons in the parish, is 8s.; and for those who have no claim, 10s. 6d. per week. The rates for boarders are from 13s. upwards. Although there are at present no boarders in the asylum whose rates are higher than 31s. 6d. per week, every suitable accommodation is provided for the higher ranks.

Magdalene asylum. As a few months have only passed since this institution was opened, no distinct statement of its affairs can be given. There are at present 14 penitents in the asylum, whose conduct gives the managers the happiest presage of future usefulness.

Lock hospital. The affairs of this asylum, for the reception and cure of unfortunate females, are, by its charter, placed under the management of one member from the town council; one from the merchants and trades houses; one from the clergymen; two from the faculty of physicians and surgeons; and eight from the court of contributors. From 31st December, 1813, to 31st December, 1814, there were 128 patients admitted, whereof 118 were cured, one died, and nine remained in the hospital. The expenditure of 1814 was £447 : 14 : 1½. Although no proper patient was refused admittance, the number has this year happily diminished nearly in the proportion of one-third from former years.

Libraries and newspapers. Although it will not be expected that, in a manufacturing and commercial town like Glasgow, there would be libraries on a very extensive scale, there are nevertheless to be found in the collection of the college, the Hunterian museum, the faculties of physicians, and surgeons, and procurators, books of the utmost value and consideration, in every branch of literature. The books in the public subscription and circulating libraries are on a scale suited to the extent of the place. In 1810, the following newspapers were published here:—the Courier, Herald, Journal, Chronicle, Western Star, Clyde Commercial List, and Centinel. The two last, which were weekly papers, are now discontinued.

Water Companies. Prior to 1806, the citizens had no other supply of water than from 28 pump-wells in the streets. As some of these were very limited, and the water often of a bad quality, a number of the inhabitants, in 1806, procured an act of Parliament incorporating them into a company for supplying the city and suburbs with water, under the name of the Glasgow Water Works Company. **Glasgow company.** Accordingly, this corporate body purchased lands at Dalmarnock, on the banks of the Clyde, about three miles above the city, where they erected steam-engines, filtering pits, and reservoirs, &c. and now send river water, in a pure state, in iron pipes, through the streets and lanes of the city and suburbs, for the accommodation of all those who choose to purchase it. The expenditure of the company up to April 1815 is £81,194, 9s. 7d. The produce of water rents for one year, ending at same period, is £5971 : 8 : 7, which is raised in advance from the following rates, viz.—persons occupying a dwelling-house rented under £4, pay 5s. per annum; £4, and under £6, 6s. per annum; £6, and under £8, 7s. 6d. per annum; £8 and upwards five per cent. per annum. Bakers pay 5s. per annum for each man or boy employed in the bakehouse. The keepers of horses and cows, 4s. for each. Counting-houses, shops, and warehouses, pays from 5s. to 10s.; and public works according to the quantity of water used. The cast iron pipes, belonging to the company, laid in the streets and lanes within the royalty, exclusive of the main from Dalmarnock, and pipes in the suburbs of Gorbals, Calton, Bridgetown, &c. amount to seventeen miles, four furlongs, and three poles.

Cranston Hill Company. In 1808, a number of persons, connected with the suburbs, obtained an act of Parliament, incorporating them into a company for supplying the city of Glasgow and its suburbs with water, under the name of the Cranston Hill Water Company. Accordingly, they purchased lands at Cranston Hill, and on the banks of the river, about a mile below the city, and erected steam-engines, filtering beds, reservoirs, &c. and now send river water, in a pure state, in iron pipes, through a number of the streets and lanes of the city and suburbs. The expenditure of the company is £52,000. The water rates are nearly the same as the Glasgow company. The cast-iron pipes belonging to this company, laid in the streets and lanes within the royalty, exclusive of the main from Cranston Hill, and the pipes in the suburbs of Anderston, Gorbals, Calton, and Bridgetown, &c. amount to nine miles, four furlongs, and eleven poles. The total length of pipes within the royalty, belonging to both companies, is 27 miles, and fourteen poles.

Clyde Navigation. The affairs of the river Clyde are placed, by act of parliament, under the management of the magistrates and council. The revenue arising from tonnage, cranage, and harbour dues, collected at the Broomielaw, amounted, in 1814, to £5,920, 2s. 8d. Those dues are kept distinct from the corporation's funds, and are laid out in deepening and improving the river and harbour, and in discharging the debt of the trust.

Police Establishment. Prior to 1800, the police of the city was under the sole management of the magistrates and council, and supported from the corporation funds. In 1800, an act of parliament was obtained, vesting the management in the lord provost, magistrates, dean of guild, convener, and 24 commissioners, to be chosen by the inhabitants.

Glasgow. The commissioners are authorised to assess the inhabitants of houses, shops, and warehouses, &c. for the purposes of the act. The executive power is vested in the magistrates, and the administration of all its other affairs in the magistrates and ward commissioners. The commissioners hold stated weekly and quarterly boards, and numerous committees watch over the particular concerns of every department. This act being in force for seven years, gave the inhabitants an opportunity of observing its beneficial consequences; accordingly, in 1807, a new act was obtained, without requiring any material alteration, other than that the rate of assessment was increased on rents of £4, and under £6, from 4d. to 5d. in the pound; £6, and under £10, from 6d. to 7½d.; £10, and under £15, from 9d. to 11¼d; £15, and upwards, from 1s. to 1s. 3d. The commissioners, under this act, have merited and received the general approbation of the citizens, who have rarely been called on for the maximum rates.

Abstract Statement of the Receipts and Disbursements for the year ending 25th July 1814.

Sum contributed by the city of Glasgow	£800	0	0
Amount of assessment	6734	2	2
Dung of the streets	652	2	9
Amount of fines	157	0	9
Disbursements.	£8343	5	8
Salaries to the master, clerk, collector, treasurer and surveyor	£640	0	0
Wages to 19 officers	793	10	5
78 watchmen, at 11s. per week	2230	16	0
8 patrole, at 2s. per day	249	12	0
15 scavengers, at 11s. per week	429	0	0
1 ditto, 15s. ditto	39	0	0
Carting dung from the streets	455	8	8
Lighting 1264 lamps, from 20th August to 5th May	2569	16	0
10 ditto part of the season,	12	6	10
Oil for watchmen's lamps, clothes to officers and watchmen, rent of office, fire-engines, and secret service money,	923	15	9
	£8343	5	8

Statute labour. In 1807, a renewal of an act of Parliament was obtained, appointing the magistrates and council trustees of statute labour conversion within the city, and authorising them to assess the inhabitants of dwelling-houses, whose rents are under £5, in 2s. yearly; £5, and under £10, 3s. yearly; £10, and upwards, 5s. yearly; horses, 15s. each; and each ploughgate of land, (60 acres,) at 60s.: the following persons being always exempted,—clergymen, parochial schoolmasters, militia men enlisted under the act of 1779 and 1782, and paupers. The nett proceeds of 1814 are £1445, which is all expended on the streets and common sewers.

Education of youth. This city has long been conspicuous for the number and excellence of its seminaries. In 1814, there were more than 1400 students attending the university. Of this number 800 were enrolled as students of philosophy, and of the Greek and Latin languages, . . 1400

In the Andersonian institution there are 280 students instructed in natural philosophy, chemistry, materia medica, and mathematics, . . 280

The principles of natural philosophy and mechanics are explained to 490 operatives, at a moderate fee, ... 490

In the private lecture rooms instruction is given to 210 medical students, ... 210

In the public grammar-school there are four teachers of the Latin, and a rector, who gives instructions in the Greek and Latin languages, and in geography. The number of students in this seminary are 520

Amount, where a full fee is paid, ... 2900

The following are benevolent foundations, in which all the children receive a substantial education, and some of them clothing and money annually:

In Hutchison's school there are	84	boys.
— Trades-house school,	108	
— Wilson's school,	60	
— Town's hospital, with addition of maintenance,	90	boys and girls.
— Miller's school,	60	girls.
The Highland Society educate and put out to apprenticeships,	80	boys.
The Highland Society also educates 60 boys and girls belonging to Highlanders,	60	
In Lennox's school,	52	girls.
— Fleshers school,	55	boys and girls.
— Peddie's school,	45	girls.
— Routledge's school 70 girls, employed at the public works, are taught, in the evenings, to read, sew, knit, and spin,	70	
In the six schools under the patronage of the kirk-sessions, there are 450 boys and girls taught to read and spell,	450	
On benevolent foundations, where no fee is paid,	1214	
In the Lancasterian schools a small fee is exacted,	560	
In the Sunday schools, under the inspection of a committee from the town council and general session, 800 boys and girls are taught to read the Bible, and repeat the Shorter Catechism, gratuitously,	800	
In the Sunday schools, under the joint management of members of session and dissenters, 1740 boys and girls are taught to read the Scriptures gratuitously,	1740	
In 1799, the presbytery of Glasgow ascertained, that there were 60 private schools in the city, wherein the various branches of elementary education are taught, at various rates; in addition to such as are above described. If we suppose, that, during the course of 16 years, the number of these schools have increased to 75, and that each school averages 45 children, the total will be	3375	
Total of persons educated within the city,	10,589	

A number of these schools have juvenile libraries attached to them.

Ecclesiastical state. This city is the chief seat of the synod of Glasgow and Ayr, and of the presbytery of Glasgow. The members of the latter are the ministers of the city, of the

Glasgow. Ecclesiastical state.

barony, Gorbals, Rutherglen, Cumbernauld, Carmunnock, Calder, Campsie, Govan, Kirkintilloch, Kilsyth, Cathcart, and Eaglesham, and their elders. The synod is composed of seven presbyteries, viz. Glasgow, Ayr, Irvine, Paisley, Hamilton, Lanark, and Dumbarton.

At the Reformation, one minister, who was superintendant of the western district of Scotland, officiated in Glasgow, and had the pastoral charge of all its inhabitants: in 1583, the session of Glasgow was regularly constituted, of 1 minister, 35 elders, and 26 deacons. In 1590, although the lay members of session were numerous, we find the minister had summoned an inquest from the neighbourhood, to assist him in judging of matters of scandal. Soon after this period, public worship was performed in three churches: during subsequent periods, commencing about the time of the Revolution, the town has been divided into eight separate parishes. The patronage of the original one is vested in the crown, the town-council electing all the other clergymen.

The places of worship within the city are now as follows:—nine parish churches, including the barony, four chapels connected with the establishment: one covenanted presbyterian, one antiburgher, three burgher and three relief meeting-houses; two tabernacles; one English and one Scotch Episcopalian chapel; one independent, two baptist, and two methodist meeting-houses; one Roman Catholic and one unitarian chapel. The Glassites, Bereans, universalists, &c. have all places of worship. The number of sittings in the whole are 35,550.

Steam Boats.

In the summer of 1811, Mr Henry Bell, an ingenious engineer of this city, constructed and plied between Glasgow and Greenock, the steam boat Comet, performing a voyage of 22 miles in three hours and a half, by means of an engine of three horse power. This vessel was the first which was impelled by steam on a navigable river in Britain. Since the above period, the following vessels have been built by various persons, and are now plying on the river, viz. the Glasgow, the Clyde, the Dumbarton Castle, the Britannia, the Caledonia, the Argyle, the Greenock, the Duke of Wellington, the Prince of Orange, the Princess of Wales, the Trusty, and Industry, the two last mentioned being constructed chiefly for trade, carry each 70 tons of merchandise; the Prince of Orange, and the Princess of Wales, boats, have accommodation for 120, and the others for 220 passengers. These vessels are worked by engines of from 10 to 32 horse power; the average time of performing a passage of 22 miles is reduced to three hours; when the wind and tide are both favourable, the voyage can be completed in little more than two hours; but when adverse, it is prolonged to three and a half, or even four hours: the present fare for the cabin is 4s. and for the forecastle 2s. 6d. Exclusive of the vessels which are at present plying on the Clyde, the Duke of Argyle and Margery steam boats, carrying each 220 passengers, are now on the Thames, they were carried round by the Forth and Clyde navigation, a distance of more than 500 miles; one of these boats encountered and weathered a very heavy sea. Steam boats from the Clyde are also plying on the Mersey and Forth.

Baths.

Some years ago an extensive range of hot and cold baths were erected in Bath Street, a short distance from George's Square. A model has been approved of for floating baths, intended to be erected on the Clyde during the ensuing summer.

Commerce and manufactures.

The situation of Glasgow is singularly favourable for carrying on manufactures and commerce. Placed on the border of one of the richest coal and mineral fields in the island, with which it communicates by the Monkland Canal, while for carrying off its commodities, and receiving returns, the Atlantic is open to it on the one hand, through the river Clyde, and the German and North Sea on the other, through the Forth and Clyde canal and river Forth.

Before the year 1707, there had been different branches of manufacture begun at Glasgow, particularly the manufacture of coarse linens; and a considerable trade had been carried on with Holland. The union of the kingdoms at this period having opened the colonies to the Scotch, the merchants of Glasgow availed themselves of the circumstance, and entering extensively into a trade with Virginia, soon made their city the great mart for tobacco, and Glasgow became the chief medium through which the Farmers General of France received their supplies of that article. To so great a height was this branch of commerce carried, that for several years before the war, which ended in American independence, the annual imports of tobacco into the Clyde were from 35,000 to 45,000 hogsheads; and in the year immediately preceding that event, 57,143 hogsheads were imported. Only from 1200 to 1300 hogsheads of these were sold for home consumption.

The trade, while it continued, engrossed almost the whole capital and commercial enterprise of Glasgow; very little other foreign trade was attempted, and any manufactures that were carried on, were chiefly of articles adapted to the demands of the Virginia market. Supplying that state with European goods, and taking of the produce of its soil in return, became, in a great degree, a monopoly in the hands of the Glasgow merchants.

There had, as early as the year 1732, been a beginning made in a trade with the West India Islands, but up to the year 1775, the business was confined to a few houses, and had not been very beneficial. The imports of West India produce into the Clyde in the year 1775, were as follows: Sugar, 4621 hogsheads and 691 tierces; rum, 1154 puncheons and 193 hogsheads; cotton, 503 bags.

The interruption of the intercourse with America, now forced the traders of Glasgow to turn to other objects, the enterprise and capital which the commerce with that country had nearly wholly engrossed. They began more generally to direct their attention to manufactures; and the discovery then just made by Mr Arkwright, of the improved process of spinning cotton wool, a few years after this period, led to attempts in the different manufacturing towns to bring the manufacture of muslins into this country. The cambric and lawn manufacturers of Glasgow embarked in the undertaking, and, aided by the facility which a similarity of the fabrics afforded, were successful beyond their most sanguine expectation. The progress of the cotton manufacture at Glasgow after this was rapid, a number of spinning works were established, and most of the different fabrics of cotton cloth were executed. Dyeing and printing of linen and cotton cloths, a branch of manufacture which had been going on for some time on a limited scale, was now greatly extended, and furnished employment to a large amount of capital. A number of other manufactures of linen, woollen, iron, and pottery, and of the other articles subsidiary to more important branches, were prosecuted on a smaller or greater scale, and continued to extend as the general commerce of the city advanced. The manufacturers of

...gow.

...mmerce al manu-...tures.

Glasgow, who, till this period, had principally looked for a vent for their goods to the demands of their own export merchants, now began to open a more extensive sale to London and other parts of England, and going over to the continent, formed connections with almost every country of Europe.

...tton ...ls.

The number of cotton mills belonging to Glasgow, situated in the town and different parts of the country, is 52. The spindles in these are calculated at 511,200; and the capital employed in the buildings, machinery, and in carrying on the manufacture, at about £1,000,000. Two of these mills, not yet finished, and now filling with machinery (1816), will cost £50,000 each.

S...nning ...ks.

The first spinning works were established at a distance from town, for the convenience of water for the machinery; as the Badindalloch and Down mills, which are in Stirlingshire, the Catrine mills in Ayrshire, the Lanark mills, and the Rothsay mills in the island of Bute, all the property of houses in Glasgow.

No positive estimate of the amount of the cotton manufacture, in all its branches, can be given; but some facts may be mentioned, from which an idea of its extent will be derived.

...aving ...power.

Belonging to Glasgow there are eighteen works for weaving by power, which contain 2800 looms, producing about 8400 pieces of cloth weekly. The number of hand looms employed by the manufacturers of Glasgow, at this date, appear, upon a pretty careful investigation, to be about 32,000.

...ico ...nting.

There are eighteen calico printing works belonging to Glasgow; and there has lately been added to this branch, an extensive manufacture of Bandana handkerchiefs, introduced by Messrs Henry Monteith, Bogle and Company, the cloth for which, being dyed a fine turkey red, the pattern is afterwards produced, by discharging the colour of the figure by a chemical process.

...endering ...ses.

There are 17 calendering houses in Glasgow, containing 39 calenders moved by steam, which execute more than four times the quantity of work performed by the same machinery when moved by horses. One of these houses employs 119 hands in calendering and folding the goods; and the whole of these establishments are able to calender in a day 118,000 yards, besides dressing 116,000 not calendered, and glazing 30,000.

...foun-...es.

There are nine iron founderies in Glasgow, and several extensive works for making steam engines, with the machines and machinery required for the different processes of manufacturing. It was not before the year 1778 or 1779 that the power of the steam engine, in consequence of Mr Watt's inestimable improvements, was found to be applicable to manufacturing operations; and it was many years after that period, before it was brought into general use. There are now 73 steam engines in Glasgow, and the immediate suburbs, of a power of from four to fifty horses employed in the different processes of manufactures.

...rts of ...t India ...uce.

The war of 1793 having for a time brought into our possession the West India colonies of the other European states, the West India merchants of Glasgow obtained a large share of the trade which this circumstance threw into the hands of this country. The connection with Demerara in particular, which it gave them the means of forming, proved valuable, and is now likely to be lasting. The imports of West India produce into the Clyde, for the three last years, have been as follows.

		1812.	1813.	1814.
Sugars	Hogsheads	28862	36037	40004
	Tierces	2543	4038	3712
	Barrels	5868	7248	5282
	Boxes	100	2660	8703

Glasgow.

Commerce and manufactures.

			1812.	1813.	1814.
Rum	Jamaica	Puncheons	2346	5265	4033
		Hogsheads	53	141	150
	Leeward Islands	Puncheons	4690	7567	7410
		Hogsheads	44	23	69
Coffee	Casks		5025	12325	16251
	Barrels		928	5384	8107
	Bags		7927	35823	53237

The removal of the royal family of Portugal to America, having opened the trade of the Brazils to foreigners, the merchants of Glasgow immediately formed establishments there, and have continued since to have a profitable intercourse with that country. Establishments were also made at Buenos Ayres and the Caraccas, as soon as these parts of America began to assert their independence; but the commerce with these states has hitherto been fluctuating and hazardous, from the situation in which their affairs have been kept.

Trade with America.

Upon the conclusion of the peace of 1783, an intercourse was opened by the merchants of Glasgow with the different states of the American Union; and the introduction of the cultivation of cotton wool, a few years after, into the southern states, furnished the means for a great increase of this trade. Indeed, without this new field to supply the quantity of the article which the growing demands of the manufacturers required, and of the qualities suited to the different fabrics to be made, this important branch of industry never could have reached that high state at which it has arrived. The bringing home this article for the manufactures of Glasgow, and sending out the returns, became a great trade, and led to the formation of establishments for carrying on this part of the business at Charlestown and New Orleans. The imports of cotton-wool into the Clyde, for the last four years, have been as follows.

Imports of cotton wool into the Clyde.

	1812. Bags	1813. Bags.	1814. Bags.	1815. Bags.
Charlestown and Savannah	5358	..	..	9014
New Orleans	2586	..	..	2224
Other American ports	1971	8234	1859	2737
Brazil	5099	7367	3168	1345
Demerara	7316	5627	6957	8764
West Indies	7475	11212	9786	2057
Continent of Europe	..	..	435	504
Coastwise	8246	7194	16302	4786

Besides the trade with these parts of America which have been mentioned, the merchants of Glasgow have large dealings with Canada and Nova Scotia.

The rapid progress making in the use of mechanical power in manufactures, is particularly favourable to the growing prosperity of Glasgow, from the inexhaustible supply of coal it possesses for working machinery. This, with the advantage of water communication in every direction, renders it, almost more than any other place, fitted for carrying on manufactures of a heavy or bulky nature, and must have the effect to bring many new branches of industry of this description to be added to those which it already has. This city, then, producing thus a great variety of articles for exportation, and carrying on, at the same time, a very extensive foreign trade, seems to combine all the requisites to raise it to the highest commercial eminence. The revenue of the post-office at Glasgow, in the year 1781, was £4344 : 5 : 8; in 1814 it was £34,000.

Chamber of Commerce.

Connected with the commerce of Glasgow is the institution of its Chamber of Commerce and Manufactures, the first establishment of the kind made in the island. This association was incorporated by a royal

Glasgow.

charter in the year 1783, and owes its origin to Dr Patrick Colquhoun, author of the *State of the Police of London*, and other works, and at that time a merchant in Glasgow, and one of its most enlightened and public-spirited citizens.

The chamber consists of the merchants and manufacturers of Glasgow and the neighbourhood, who may become members upon paying five guineas at admission, and 10s. 6d. yearly. The management is vested in thirty directors, six of whom are renewed annually; and their duty is to keep a watchful eye on whatever may be supposed to affect the commercial interests of Glasgow and its neighbourhood, and, at the same time, to serve as the organ of communication between the manufacturing and commercial body of the district, either acting generally or separately, and the legislature or any of the departments of the state.

Population of the city and suburbs.

In 1780, the number was	42,832	In 1791,	66,578
In 1785,	45,889	In 1801,	83,769

Census of 1811.

North parish	11,159	South-west	8193
North-west	9940	St Andrew's	5250
West	4190	St Enoch's	7715
East	6159	Govan	8081
South	5758	Barony or Landward parish	38,216
Gorbals	5799		
Total population			110,460.

In 1815, the number of families in the 24 police wards, who paid taxes on rents under £5 per annum,

was	7455
Do. on rents of £5 and upwards	5272
Number of families in the 24 wards	12,727

On the principle of there being an average of five souls in each family, the number of inhabitants in the 24 wards of the royalty would be 63,635; being an increase of 5271 during the period of four years. If to this number the population of the Gorbals, Govan, and Barony be added, as taken in 1811, the amount will be 115,731; and if we suppose the increase of these suburbs for four years to be 4269, the grand total in 1815 will be 120,000.

Mortality bills.

In 1814, there were interred in the burying-grounds within the royalty, and in the immediate suburbs, 3254

In the year 1813,	2704
Increase of burials in 1814	570

(C. J.)

GLASS.

Glass.

GLASS is the name of an artificial substance, formed by the igneous fusion of siliceous earth with various salts and metallic oxides, and possessing a high degree of transparency, equalled only by the more perfect crystals of the mineral kingdom, and other physical properties, which render it one of the most useful and ornamental substances which the arts have received from the ingenuity of man.

The word glass is of uncertain etymology. It has been derived by some from the word *glessum*, the name which the ancient Gauls and Germans gave to amber, and from which has arisen the German word *gleisser*, "to shine," and the English word *glisten*; while others have traced it to the word *glastum*, the Latin term for woad, either because the ashes of this plant were used in the manufacture of glass, or because glass had commonly that blue tinge which the Britons communicated to their bodies by the use of the woad. Its derivation from the Latin word *glacies*, signifying ice, is not less probable than those which we have mentioned.

Origin and history.

It would be a task as irksome to ourselves, as it would be unprofitable to our readers, to detail the unfounded speculations which have been accumulated respecting the origin of this remarkable substance.

There is some reason to believe that glass was made by the Phenicians, the Tyrians, and the Egyptians. Paw and other antiquarians maintain, that the first glasshouse was constructed at Diospolis, the ancient capital of the Thebais; but it appears from the writings of the ancients, that the Phenicians had made considerable progress in the manufacture of glass; and Pliny informs us that the Phenician colony of Sidon obtained, for some hundred years, the chief ingredients of their glass from the Phenician town Acco, now St John D'Acre, near the place where the small river Belus throws itself into the Mediterranean.

The account of the origin of glass, which Pliny has handed down to us, is extremely plausible. A merchant vessel laden with nitre or fossil alkali, having been driven ashore on the coast of Palestine, near the river Belus, the crew went in search of provisions, and accidentally supported the kettles on which they dressed them upon pieces of fossil alkali. The river sand, above which this operation was performed, was vitrified by its union with the alkali, and thus produced glass. The important hint which was thus accidentally obtained, was soon adopted, and the art of making glass was gradually improved. *

In the time of Pliny, glass was manufactured out of the fine sand which was collected at the mouth of the river Vulturnus. After being ground to powder, it was mixed with three parts of nitrous fossil alkali, or soda, and after fusion it was taken to another furnace, where it was formed into a mass called *ammonitrum*, and converted into a pure glass. A similar method of making glass was used in Spain and Gaul.

Pliny informs us, that in the reign of Tiberius an artist had his house demolished for making glass malleable, while Petronius Arbiter asserts that he was beheaded by the emperor. About the commencement of the Christian era, drinking vessels were commonly made of glass, and glass bottles for holding wine and flowers were in common use. The company at Rome which was engaged in the manufacture of glass, had a particular street assigned to them near the Porta Capena. Alexander Severus imposed a tax upon this company in A. D. 220, which was continued in the time of Aurelian.

The art of making coloured glass seems to have been coeval with the invention of glass itself. Many of the Egyptian mummies, one of which is in the British Museum, are ornamented with beads of variously coloured glass, which could not have been executed without a chemical knowledge of the properties of the metallic oxides. By what processes these coloured glasses were formed, it is not easy to discover, as the ancients were not acquainted with the mineral acids which are now usually employed in the preparation of metallic oxides. Strabo

* "Fama est, adpulsa nave mercatorum nitri, cum sparsi per littus epulas pararent, nec esset cortinis attollendis lapidum occasio, glebas nitri e nave subdidisse. Quibus accensis permixta arena littoris, translucentes novi liquoris fluxisse rivos, et hanc fuisse originem vitri." *Plin.* lib. xxxvi. cap. 65.

story.

was told by the workmen of Alexandria, that their country produced an ingredient for making coloured glass; and Seneca informs us, that Democritus introduced into Europe the art of making coloured glass, and of thus imitating the precious stones. But from whatever source this curious art was derived, it was brought to a high degree of perfection among the Greeks and Romans; and many of the gems were so admirably counterfeited, as to deceive even those who were intimately acquainted with the study of minerals.

ls used mosaic.

In the time of Augustus, the Roman architects made use of glass in their mosaic decorations; and several specimens of this glass have been found among the ruins of the villa of the Emperor Tiberius, in the island of Capri. Some of these specimens have been examined and analysed by Klaproth. They consist of pieces of red, green, and blue glass.

proth's ysis of ent red green

The first of these is of a lively copper red colour, perfectly opaque, and very bright at the place of recent fracture. The green glass has a light verdigris colour, is opaque, and has a scoriaceous shining fracture. Two hundred grains consisted of

	Red Glass.	Green Glass.
Silex	142 . . .	130 grains.
Oxide of lead . .	28 . . .	15
Oxide of copper .	15 . . .	20
Oxide of iron . .	2 . . .	7
Alumine	5 . . .	11
Lime	3 . . .	13
	196	196

The blue glass had a sapphire colour, verging towards that of smelt, and was transparent at the edges only. Some of the plates of it are not coloured throughout the whole of their mass, but only through about two-thirds of their thickness. Each of the strata is so distinct as to give the appearance of a blue and a colourless plate adhering at their broad surfaces.

of forming pictures n colour- d ass.

A still more singular art of forming pictures with coloured glass was known and practised by the ancients. It consists of variously coloured glass fibres, fitted with the utmost exactness, so that a section across the fibres represents the object to be painted. These fibres, when properly joined together, are afterwards cemented by fusion into a homogeneous and solid mass. Specimens of this art seem to have been first discovered about the middle of the last century. Count Caylus first describes them in his *Collection of Antiquities*, and Winkelman in his *Annotations on the History of the Art among the Ancients*, under the name of pictures made of glass tubes. Sulzer, in his *Theory of the Polite Arts*, describes, in the article Mosaic, specimens which he had seen at Dresden; and Klaproth has given drawings of one which he has in his own possession. The following description of two pieces of this kind of glass, which were brought to Rome in 1765, is given by Winkelman:

"Each of them is not quite one inch long, and one-third of an inch broad. One plate exhibits, on a dark ground of variegated colours, a bird representing a duck of various very lively colours, more suitable to the Chinese arbitrary taste, than adapted to shew the true tints of nature. The outlines are well decided and sharp, the colours beautiful and pure, and have a very striking and brilliant effect; because the artist, according to the nature of the parts, has in some employed an opaque, and in others a transparent glass. The most delicate pencil of the miniature painter could not have traced more accurately and distinctly, either the circle of the pupil of the eye, or the apparently scaly feathers on the breast and wings, behind the beginning of which this piece had been broken. But the admiration of the beholder is at the highest pitch, when, by turning the glass, he sees the same bird on the reverse, without perceiving any difference in the smallest points; whence we could not but conclude, that this picture is continued through the whole thickness of the specimen; and that, if the glass were cut transversely, the same picture of the duck would be found repeated in the several slabs; a conclusion which was still farther confirmed by the transparent places of some beautiful colours upon the eye and breast that were observed. The painting has on both sides a granular appearance, and seems to have been formed, in the manner of mosaic works, of single pieces; but so accurately united, that a powerful magnifying-glass was unable to discover any junctures. This circumstance, and the continuation of the picture throughout the whole substance, rendered it extremely difficult to form any direct notion of the process or manner of performing such a work. And the conception of it might have long continued enigmatical, were it not that, on the section of the fracture mentioned, lines are observable, of the same colours which appear on the upper surface, that pervade the whole mass from one side to the other; whence it became a rational conclusion, that this kind of painting must have been executed by joining variously coloured filaments of glass, and subsequently fusing the same into one coherent body. The other specimen is about the same size, and made in the same manner. It exhibits ornamental drawings of green, white, and yellow colours, which are traced on a blue ground, and represent volutes, beads, and flowers, resting on pyramidally converging lines. All these are very distinct and separate, but so extremely small that even a keen eye finds it difficult to pursue the subtle endings, those in particular in which the volutes terminate. Notwithstanding which, these ornaments pass uninterruptedly through the whole thickness of the piece."

History. Art of forming pictures with coloured glass.

Plate CCLXXV. Fig. 4.

One of the two specimens which we have mentionsented as in the possession of M. Klaproth, is represented in Plate CCLXXV. Fig. 4. Both the pieces have a heart-shaped form, their principal front being flat, and the reverse convex. The length of one of them is one inch, its breadth four-fifths, and its thickness, two-fifths. The other specimen is two-thirds of the size of the first; but they are both nearly alike in the colouring and manner of drawing. The principal mass of the large specimen is a dark and perfectly opaque, but the smaller one, which is in some places transparent, has a sapphire blue colour. The blue ground is ornamented with voluted stellular, minute flowers, on such a small scale as to be scarcely imitable by the miniature painter. Their colours are red, green, brown, sky-blue, and white, and are all pure and lively. The delineations pervade the whole mass; and it is obvious from examining a fracture, that those minute ornaments are formed of parallel glassy fibres of various hues, agglutinated by fusion.

Glass used for windows.

About the end of the 3d century, as appears from a passage in Lactantius,* glass was used for windows; and there is reason to believe, from the glass plates

* "Manifestius est, mentem esse, quæ per oculos ea, quæ sunt opposita transpiciat, quasi per fenestras lucente vitro, aut speculari lapide obductas." *De Opificio Dei*, cap. 5.

History.

Glass used for windows.

found in Herculaneum, that window glass had been introduced at a much earlier period. St Jerome, A. D. 422, Paulus Silentiarus, A. D. 534, Gregory of Tours, A.D. 571, and Johannes Philoponus, A. D. 630,* all speak in the most distinct manner of the use of glass in the formation of windows.

Italy was the first modern nation that employed glass in windows. The custom was afterwards introduced into France; and though the art of making glass was brought into England in A. D. 674, by foreign artists sent for by the Abbot Benedict, who glazed the church and monastery of Weremouth in Durham, yet this great invention was so much neglected, that private houses were not lighted through glass till the end of the 10th century. The windows of houses, and even of cathedral churches, were covered with fine linen cloths.

Painting of church windows.

The application of painted glass to the decoration of church windows, was made before the commencement of the 9th century, as we are informed by Anastasius, librarian to Pope Leo III. that painted glass was used in his time. This art made rapid advances to perfection; and all the ingenuity of the art was exhausted in the production of those splendid windows which at present adorn the Gothic cathedrals of Europe. The art of staining glass, though still known and practised, is, however, to a certain extent lost; and we admire, without being able to imitate, some of the rich productions of the middle ages. We have had occasion to see a specimen of glass, brought home by Dr Brewster from the abbey of Konigsfeld, in Switzerland, which consists of *six* different layers of green and purple glass placed alternately. The thickness of the plate is only about the 7th part of an inch; and the different layers have an equality of thickness, and a parallelism, which is truly surprising. The compound colour is a light purple. A section of this plate is shewn in Plate CCLXXV. Fig. 5, the dark layer representing the purple, and the light one the green glass.

Glass made at Venice.

The art of making plate glass by blowing, was carried on to a great extent at the village of Murano, near Venice; and Europe was long supplied from this quarter with the finest and largest mirrors.

In England and France.

We are indebted, however, to the French, for the art of casting large plates of glass, which was introduced in 1688 by Abraham Thevenart. An account of this establishment, and of the glass manufactories in England, will be found in our articles England, vol. ix. p. 10, and France, vol. ix. p. 718.

In Scotland.

Glass appears to have been first made in Scotland in the reign of James VI. and the exclusive right of manufacturing it within the kingdom, was given to Lord George Hay for 31 years, from 1610. This right was transferred in 1627 for a considerable sum, to Thomas Robinson, merchant-tailor in London, who again transferred it for £250 to Sir Robert Mansell, vice-admiral of England. A manufactory of glass was carried on for some time in a cave at Wemyss, in Fifeshire. Regular glass works were afterwards established at Prestonpans; but the principal places where glass is now made in Scotland, are Leith,† Glasgow, and Dumbarton.

Sect. I. *On Glasshouses, Pots, &c.*

Glass-houses.

The glasshouses now in use are commonly large cones, from 60 to 100 feet high, and from 50 to 80 feet in diameter at the base. *The furnace* is erected in the centre, over a large vault, that extends from one side of the cone to the other. The vault or cave is generally made of a sufficient height and width to allow the workmen to wheel a barrow with rubbish out and in. This, however, is not the only purpose of this cave, as it is made to communicate with the furnace by an aperture in the top of it, of such a size as the furnace above may require. Over this aperture a grating of strong iron is placed, so as to be in the centre of the furnace, and upon that grating the fuel is laid and ignition is maintained by the air that issues into it through the caves or vaults underneath.

Crucibles or pots.

The crucibles or pots are the most important article about a glasswork. The clay obtained at Stourbridge is found to answer the purpose better than any other. After carefully picking and brushing the clay, it is ground in a mill, and sifted through a sieve of about 20 passes in an inch: it is then wet with warm water, and well tramped in a large cistern, until it is brought to the consistence of a thick paste. Some manufacturers make up a very large quantity of this paste, and keep it in that state for many months: others, again, work it immediately into pots or crucibles. It is also common to take old crucibles and grind them down to a fine powder, which they add to the crude clay in quantities seldom exceeding a fourth part, from an idea that the burnt clay renders the crucible more refractory, and of course more likely to resist the combined action of the fire and alkali required in the composition for glass. This mixture contracts less than if the pots were made entirely of crude clay, and of course is less liable to break while drying.

Various methods have been tried for working the clay into pots, by using moulds, &c.; but the method that has been most generally practised, is to knead the clay, while in the state of a paste, till it is nearly as tough as the putty used by glaziers. It is then made into rolls, and wrought one layer upon another, and pressed together with the greatest care, so as to make a compact body, quite free of any vacuity, and generally into the shape of an inverted cone, or into a cylindrical form.

The pots used for bottles and window glass are generally made about 40 inches diameter at top by 30 at bottom, and about 40 inches deep, and are termed open pots. Those for flint glass are covered over, and termed capt pots; they are made of various sizes and shapes. Bottle and crown house pots are made from three to four inches thick; and flint house pots from two to three inches thick. After the pots are made, it requires a good deal of attention to bring them to that state of dryness requisite for their being taken to the annealing furnace. Before pots are set into the furnace, they are heated up with the greatest caution, in an arch or vault built for the purpose, to a perfect white heat. This operation requires four or five days, or longer if they are not very dry previous to their being used; and when they are completely annealed, as it is termed, they are carried with the utmost expedition from the annealing arch, and set into the working furnace. The setting of pots is deemed the severest labour about a glass-house, from the great heat attending it; and is described as follows by M. Blancourt. He observes, that the roughest work in this art, is the changing the pots when they are worn out or cracked. In this case, the great working hole must be uncovered, the faulty pot

* Philoponus informs us that the glass was fastened in with plaster.

† The Editor has been indebted to Mr James Geddes, of Leith, for the principal information respecting the manufacture of bottle, crown, and flint glass, contained in Sects. I. II. IV. and V.

must be taken out with iron hooks and forks, and a new one must be speedily put in its place through the flames, by the hands only. For this work, the man guards himself with a garment made of skins, in the shape of a pantaloon, that covers him all but his eyes, and is made as wet as possible. The eyes should be defended with a very thick plate of glass.

Sect. II. *On Bottle Glass.*

Bottle glass. Plate CCLXXV. Fig. 1.

The bottle-house furnace, represented in Plate CCLXXV. Fig. 1, (see description of Plates,) is generally an oblong square chamber, arched over with the same material. Some give it a very flat *crown*, as it is called; and others raise it high and of a barrel shape. This furnace is erected in the centre of the building, on the top of the cave or vault, and is divided into three spaces in the inside by the grate, and on each side of that is the site for the pots or crucibles, which is a bank of the same material as the furnace, generally about a foot high, and three broad.

In this furnace there is a hole about a foot diameter for each pot, called working holes, at which the workmen put in the materials, and take out the liquid glass. At each angle of the furnace there is also a hole about the same size, which communicates with the calcining furnace; and the flame that issues from the main furnace, which otherwise would be lost, reverberates on the materials in this furnace, and calcines them. There are generally eight other furnaces or arches in a bottle-house. Six are used for annealing the bottles after they are made, and two for annealing the pots, previous to setting them into the main furnace.

Materials.

The materials used for bottle glass are of the coarsest kinds. Government will not allow any but the commonest sea or river sand, mixed with soap boiler's waste, which is done in the proportion of three of soap waste to one of sand, according to the quality of the soap-waste: this soap-waste is generally calcined in two of the arches used for that purpose, and termed the coarse arches, which are kept at a red heat from 24 to 30 hours, the time required to melt the materials and work them into glass, which is called a journey; after that the soap-waste, now termed ashes, are taken out and bruised and mixed with the sand in the proportions already mentioned. The mixture is then put into the fine arch, where it is again calcined during the working journey, which is generally 10 or 12 hours more. When the working journey is over, the pots are again filled with the red hot materials out of the fine calcining arch. In about six hours it is melted; the pots are again filled up, and this second filling requires about four hours to melt.

Fusion.

By continuing the heat to as great a degree as possible, in the course of 12, 15, or 18 hours, these materials become a perfect glass fit for making wine bottles. The furnace is then reduced to a working heat, by shutting the cave doors, and excluding the air from the grating. The metal, as it cools in the pots, becomes more dense; and all the heterogeneous matter that was contained in the ashes, and not melted into glass, floats on the top and is skimmed off. The furnace is then filled with coal, in such a way that it will retain what is termed a working heat, for four or five hours, when it is again filled so as to preserve that degree of heat till the working journey is finished. It is impossible to give any correct idea of the process of blowing to a person that never saw glass manufactured. There are six people employed in the making of one bottle, independent of all the men employed in preparing the materials, each person forming a distinct part; and by that division of labour, they are enabled to make a very large quantity in a journey; and although ten men and boys are busily working with long hot irons, and red hot glass metal in a liquid state, in a space not exceeding four square yards, yet such is their regularity in passing one another, and handing back and forward their work, which never fails to strike a stranger with terror, that it is very rarely any of them meet with an accident.

Method of making bottles.

One workman, called a gatherer, dips the end of a tube, heated red hot, and about five feet long, into the pot containing the metal, to which it readily adheres; and after it is cooled a little, he again immerses the end of the tube so as to cover the metal; and, by giving it a turn in his hand, he is enabled to bring out of the pot as much as is required for a common wine bottle. He then hands it to the blower, and prepares another; while the blower, by rolling the metal on a stone or plate, brings it to the end of the pipe or tube: he then holds it in a brass or cast-iron mould, and, by blowing down through the tube, makes the glass, which is now getting cold, retain the shape given to it, which is that of a common wine bottle. It is then handed to the finisher, who, by means of a cold piece of iron with which he touches the neck while still red hot, but cold enough to retain its shape, cuts it off from the blow-pipe, as completely as if done by a diamond.

Sect. III. *Broad or Inferior Window Glass.*

Broad glass.

This species of glass consists of different ingredients, and is manufactured in a different manner from crown window glass. Its ingredients are, soap boiler's waste 6 bushels; kelp 3 do.; sand 4 do.

When these materials have been calcined for from 20 to 30 hours, they are removed with iron shovels, while red hot, to the melting furnance, when the pots are filled with it. By exposure to the heat from 12 or 15 hours, the whole is reduced to a fluid state. It is then taken out upon tubes in the manner described under Sect. IV. and blown into globes of nearly a foot in diameter. These globes being carried to the mouth of the oven, a longitudinal and nearly rectilineal crack is produced, by touching it with a cold iron dipped in water. The globe is then opened on a smooth iron plate at the mouth of the furnace, and then forms a circular sheet of thin transparent window glass. See Parke's *Essays*.

Sect. IV. *Crown Glass.*

Crown glass. Plate CCLXXV. Fig. 2.

The furnace for crown glass, represented in Plate CCLXXV. Fig. 2. (see description of Plates,) is generally constructed for four or six pots of such a size as will contain from 16 to 20 cwts. of glass. There are also several other furnaces required in this manufacture: A reverberatory furnace for calcining the materials; flashing furnace, and bottoming hole, used for the purpose of heating the glass, in order to continue its flexibility till it acquires from the workman the desired shape, with several others called arches, which are used for the purpose of annealing the glass after it is made, and the pots previous to their being set into the furnace. The materials for crown glass, that is the best window glass, are two parts of kelp to one of fine white sand; these are the usual proportions; but the quality of even the best kelp is extremely various, some vitrifying more and some less sand. From six to eight cwt. of these materials, after they are well mixed, are put into a reverberatory furnace, of about six feet

Crown Glass.

square, having an arch thrown over it of about two feet in height. On the one side is a grating to contain the fire, with an ash-pit beneath. The bottom of this furnace is raised about 3½ feet high, so as to be more convenient for the workmen to turn the materials. As the neutral salt contained in the kelp when heated is extremely penetrating, and readily goes through common or even fire bricks, carrying along with it a considerable quantity of alkali, and thereby very much injuring the quality of the glass, various plans have been tried to prevent it, some by making large bricks of fire clay, and others by placing a plate of iron so far under the floor of the furnace, as not to be much affected by the heat, from an idea that when the iron tub or pan is filled with the neutral salt, no more will be lost. Another plan is to have flues for admitting a stream of cold air below the floor of the furnace, which cools it, and keeps the salt from running off. But it would undoubtedly be a much better plan to separate the alkali from all heterogeneous matter previous to mixing it with the sand.

The operation of calcining, or burning *frit*, requires much care. After the materials are put into the furnace, they are stirred frequently, until all the earthy matter in the kelp is burnt away, which generally requires about three hours; the heat is then raised to such a degree, as to bring the materials almost into a state of fusion, which must be prevented by constant stirring, otherwise it would get into what is termed *catches*, or small knots that contain more sand than the rest of the batch, occasioned by the alkali being dissipated, from an excess of heat. If it is continued at that high temperature for about two hours, it will be sufficiently calcined. It is then taken out of the furnace, and spread, while warm, upon a plate, and divided into large cakes; this must be done before it cools, otherwise it would be one hard lump. It is the opinion of many, that frit cannot be too old. All the opulent manufacturers, therefore, lay up great quantities, and seldom use any till it is six months old.

Crown glass is made by filling the pots on the melting furnace with frit, adding about one-eighth part of broken glass. The furnace is then raised to as high a degree of heat as possible, and in about ten or twelve hours the frit is melted. The pots are again filled up in the same manner. The heat is then continued, and if possible increased, till the metal, as it is now called, is completely fine, that is pure liquid glass fit to be made into window glass, altogether requiring from 30 to 36 hours of intense heat.

After the metal is completely fine, the founder, that is the workman who manages the metal making, allows the fire to slacken for about two hours, until it arrives at what is termed a working heat; this is called settling the furnace, and on the proper settling of the furnace the working of the metal in a great measure depends.

Blowing or flashing of crown glass.

For blowing or *flashing* crown glass few tools are required. The principal instrument is an iron tube, the end of which being heated, is dipped into the pot of melted glass, and turned round to collect some glass upon it. This portion of glass is distributed equally upon all sides of the end of the tube, by rolling it upon a flat table of iron. It is then heated, and again dipped into the melted glass, to take up an additional quantity. In this state, by blowing slightly through the tube, the glass is made hollow within; and the workman judges, from the manner in which it enlarges when he blows, if the glass is so arranged round the end of the tube, that it may be afterwards blown out and extend itself equally on all sides, to form a large globe, or hollow vessel of any other circular figure, of a regular thickness. If he perceives any side to be too thin, he corrects this, by rolling it on the marble. This operation is repeated three or four times. He then heats it well in the fire, and rolls the glass with great care, to form it circularly upon the end of the tube, and lengthen it out in the manner represented by Fig. 1. Plate CCLXXVI. Then, by blowing through the tube, he distends the glass into the form of a long hollow pear, resting it all the while upon the iron table, and rolling it round, that it may preserve a correct circular figure, and distend itself equally. To lengthen out the neck of the pear, he rolls it, as it may require, over a smooth iron rod, fixed up horizontally, as in Fig. 2. and the pressure thus caused will lengthen the neck. He then blows again through the tube, supporting the glass, by resting the extreme end of the pear upon the iron rod, and rolling it round at the same time: The pressure upon the iron rod raises a small point or eminence upon the globe, opposite the end of the blowing iron. The blowing being dexterously managed, and assisted by the pressure of the rolling, the glass is enlarged to the form of a sphere, Fig. 3, which remains attached to the tube by a neck.

Plate CCLXXVI. Fig. 1. Fig. 2. Fig. 3.

By the time the workman has proceeded so far, and produced a globe, Fig. 3. of a very regular thickness, the glass is generally so far cooled as to grow firm; and though it will readily yield to a pressure, it will not alter its figure by its own weight. To proceed in the operation, it must be heated again. For this purpose, it is carried to a particular furnace, called the *bottoming hole*, to be exposed to the heat of the flames. A slight wall is erected before one-half of this mouth, to screen the workman from the heat; and the screen is at a sufficient distance from the wall of the furnace, to leave room for the globe to pass between them. A hook is fixed in this wall for the support of the blowing iron, which is rested in the hook, at a few inches from the neck of the globe. This method admits of turning the tube rapidly round as an axis, to which the globe is affixed, and therefore revolves with it. The side of the globe opposite to the end of the blowing iron being exposed to the heat of the fire, is gradually softened; but the neck of the globe, which joins the rod, and all that part of the glass which is more remote from the fire, is not softened in an equal degree. In this situation, the centrifugal force produced by the whirling, causes the equatorial parts of the globe to fly out from the centre, by stretching or enlarging itself; but as this enlargement will be most powerful upon the softest part of the glass, which is the end opposite to the fire, the centrifugal force will cause that end to become flattened almost to a flat plate, or at least to a slightly convex plate, as shewn in Fig. 4. Fig. 4.

In this state the glass is removed from the fire, and the neck is cracked off, by resting the tube across the rod and turning it round, whilst the neck is touched with a piece of iron wetted in cold water. This produces a circular crack round the neck, which is separated from the tube, by laying the glass upon a table, shewn in Fig. 4, which is composed of two planes *d*, inclining towards each other, so as to receive the glass without danger of its rolling off. In this situation, a slight stroke upon the rod breaks off the neck, and leaves the glass upon the table. The workman now dips the end of an iron rod *o* into the melted glass, and takes up as much as will make it adhere firmly to the prominence *c*, so as to serve

Crown Glass.

for a spindle to turn the glass by. The glass being now thin, soon becomes so cool as to require heating, which is done by presenting the open end to the flame, the workman resting the rod in the hook, and turning it slowly round, that the glass may become equally heated. When the open end is sufficiently softened, the workman, supporting the rod over a rest or hook, turns the glass steadily round. The motion opens and enlarges the aperture to the form of Fig. 5; and they take great care, by turning with a regular motion, to preserve the circular figure, such as is represented in Fig. 6. In this state, being whirled rapidly round, the centrifugal force throws it out into a flat circular plate *a b*, of from 3 feet 6 inches to 4 feet diameter.

When the plate is sufficiently cooled, the workman applies a cold iron to crack the neck of the central projection which connects the plate with the rod, and he then lays the plate flat down upon a bed of ashes previously prepared. The rod or spindle is now separated by a gentle stroke, and the plate is taken up upon an iron fork, and conveyed to the annealing oven, where a great number are set up edgewise, and supported by iron frames to keep them flat. The fire of the oven is suffered to burn out, and the heat to diminish as slowly as possible, until the glasses become quite cold: They are then withdrawn from the furnace, by taking down a slight front wall built in the door or arch. The heat of the annealing oven, which is not sufficient to make the glass so soft as to bend by its weight, is allowed to die away.

Window plate, also called German plate, or table glass, is made by the same means of blowing and rolling; but these are managed to produce a cylinder, which is cut open and spread flat upon a table.

In order to form glass plates by the extension of a cylinder, the workman blows the glass into the shape of a pear, as at Fig. 7. The length of this pear must be nearly equal to the length of the plate, and its diameter of such a size, that the circumference, when unfolded, will be equal to the breadth of the plate desired. He now supports the blowing iron over a stool or iron bar, whilst an assistant, with a pointed iron, pierces a hole into the extreme end of the pear, opposite the end of the blowing iron: This opening is enlarged by introducing the blade of a pair of spring tongs, as in Fig. 8. whilst the glass is turned round; and, by a peculiar management of these, the end of the pear is at last opened out to a cylinder, as in Fig. 9. The workman now mounts a stool, and holds the blowing-iron perpendicularly, whilst his assistant cuts open one side of the cylinder with a pair of cutting shears, as in Fig. 9. The blowing iron is next broken off, and a rod *b*, Fig 10. applied to the end of the cylinder, to form a spindle to work the other end by. This rod has a flat circular plate upon the end of it, or three prongs *c*, *c*, *c*, which being dipped in the melted glass, are applied to the end of the cylinder. By this rod the glass is carried to the fire, and the end from which the tube was broken off is heated. It is then opened by the spring tongs, and reduced to a cylinder of the same size as that at the other end. The shears are next used to cut the cylinder open from this end, and leave it in the state of a sheet of paper rolled up. The cylinder is now laid upon a smooth copper table, where the spindle is detached, and the glass spread into a flat sheet, and annealed.

Sect V. *On Flint Glass.*

Flint glass was formerly manufactured from flints calcined, and afterwards ground, well washed, and sifted, to which was added pearl ashes, or an alkali of some kind, to serve as a flux, and a small quantity of arsenic.

The materials now used for the finest flint glass, are, first, a fine white transparent sand, which is termed the body of glass; this is found often mixed with clay, &c. from which it is freed by washing, until the water comes quite clear off; it is then calcined, and afterwards sifted through a very fine sieve of from 40 to 50 passes to the inch. The second article is red lead, or litharge, which serves as a powerful flux, gives greater density to glass, renders it more ductile, less apt to crack from sudden changes of temperature, and imparts to it a high refractive and reflective power. Litharge is preferable to red lead, as it gives a purer glass, is less liable to be adulterated. and acts more powerfully as a flux. The third ingredient is an alkali, either soda or potash; the finest pearl ashes dissolved, and the solution evaporated to drynesss, is considered the best, as it imparts no particular colour to the glass, whereas soda gives it a greenish-blue tinge.

Nitre, the fourth ingredient, is also used as a flux, and serves to correct the imperfections that arise from the lead being insufficiently calcined. A fifth article, viz. arsenic, is sometimes used to aid the fluxing ingredients; but the quantity must be very small, lest the transparency of the glass be hurt by the opake white colour which it imparts when used largely. A sixth, and very important ingredient, is the black oxide of manganese, which is used to destroy any accidental foulness of colour that may arise in the glass, and particularly any tinge given by particles of iron amongst the sand; but while it destroys the green-yellow, or olive colours in glass, by imparting to them a purple tinge, the mixture of colours produces a blacker glass, and of course greatly injures its transparency.

When too much manganese is added, the purple colour may be destroyed by charcoal; but this can only be done partially, as the purple tinge is not visible until a perfect glass is formed, after which the charcoal cannot be mixed with the glass.

When a batch of flint glass is prepared, it is taken from the mixing-house to the glass-house, and then put into the pots in small quantities of ten or a dozen shovelfuls at a time. When this is melted, which it does in two or three hours, more is added till the pot is full. The mouth of the pot is then completely closed, by putting soft clay round the stopper. except a small aperture, which is left to allow the sandover or glass-gall to escape. This substance consists of those salts that are contained in alkalies purified in the common mode, and which have no affinity for silex, and are thrown up to the top. From the glass, or metal as it is termed, being hotter at the back of the pot than it is at the mouth or front, a small declivity takes place on the surface of the glass, and if the pot is full to the brim or mouth, it will be a little higher at the back part, consequently the liquid sandover runs off. Flint glass requires about 48 hours to its complete fusion, although the furnace (Plate CCLXXV. Fig. 3. See Description of Plates) is carried to as intense a heat as possible. After it is *fine*, that is melted into liquid glass, and freed from all air-bubbles, preparation is made for the working of the glass. For this purpose the blower, in order to make a common wine glass, takes a hollow tube of iron about four feet and a half long, which he heats red hot at the one end. He then dips it into the liquid metal contained in the pot, and takes up a quantity of glass, and forms a hollow ball, as described in Sect. III. He then sits down on a chair with two long arms, to one

Flint Glass.

of which there is a plate of iron fastened to prevent the burning of the chair by the hot iron pipe and glass; for the operation must be done with the greatest quickness while the metal is hot. He rests the pipe across the chair arms, and, while he rolls it back and forward with his left hand, he with an instrument similar to a small pair of tongs, catches the solid metal at the end of the hollow ball and draws it out, at the same time giving it the shape required for the stalk of a wine glass; another blower is going on with the same process, and blowing a smaller ball; and after giving it a sharp cut at the end of the blowpipe, he quickly presses it against the point of the stalk of the glass in the other man's hand, to which it readily adheres as firmly as if there had never been a joint; and, by giving the pipe a smart stroke with a small piece of iron, it is separated from the small ball now attached to the stalk of the glass, which is instantly given to the finisher or workman, the others being called blowers or footmakers. This workman then makes the glass just hot enough to keep it from breaking, and sits down on his chair, and with a similar pair of tools, while rolling the pipe rapidly on the arms of the chair, he opens the ball at the stalk of the glass, and forms a foot. A boy then takes a small rod of iron, called a *ponty*, and dips it into the metal in the pot, takes out on the extremity of the rod a small portion of glass, thrusts it immediately against the centre of the foot, to which it instantly unites. The workman then with a piece of iron, which he wets with his mouth, touches the globe intended for the bowl of the glass with the wet part, which is still very hot, although so much chilled as to retain its shape, and this in a second or two cracks it round; and, by giving the pipe a gentle knock, it separates from it, and leaves an open uneven mouth, which the workman instantly heats, and with a pair of shears, clips the heated glass smooth and even in the mouth; but as the shears have put the glass off that circular form, he heats it again, and by a dexterous twirl and swing round his head, he, if an expert workman, gives it the desired shape to a mathematical exactnes, almost without the aid of any tools. The wine glass now finished and chilled a little, by giving the ponty a smart blow, the glass separates from the iron, and is carried by a boy with a long forked iron to the leer, or annealing furnace, where it is placed in a pan already heated for the purpose of annealing.

Method of making wine glasses.

The following is the composition of the finest flint glass: Fine white sand, 300 parts; red lead, or litharge, 200; refined pearl ashes, 80; nitre, 20; arsenic and manganese, a small quantity.

These, all mixed together with the utmost nicety, are termed a flint batch.

Flint glass for optical purposes.

The following results were obtained by M. Zeiher of St Petersburgh, respecting the optical effects of varying the proportions of the ingredients of flint glass.

	Proportion of red lead to flint.		Index of refraction.	Dispersion of the rays in comparison of crown glass.
	Red lead.	Flint.		
1	3	1	2.028	4800 to 1000
2	2	1	1.830	3550 to 1000
3	1	1	1.787	3259 to 1000
4	$\frac{3}{4}$	1	1.732	2207 to 1000
5	$\frac{1}{2}$	1	1.724	1800 to 1000
6	$\frac{1}{4}$	1	1.664	1354 to 1000

From this Table, it is obvious that a greater quantity of lead not only increases the refractive, but also the dispersive powers of the glass. When M. Zeiher mixed alkaline salts with his glass, he found that they diminished the other refraction, without making any change in the dispersion. He then obtained a kind of glass which had three times the dispersive power of crown glass, and a refractive power of only 1.61. See *Mem. Acad. Berl.* 1766, p. 150.

Cazalet's flint glass for telescopes.

M. Cazalet of Bourdeaux, has lately announced a method of making flint glass for telescopes free of all veins and imperfections. It consists of

Red lead, pure and sifted through silk,	100	parts.
Nitre, purified	50	
Very pure and white chalk	1	
Pure white sand	60	

The sand must be calcined and pounded in an iron mortar, and afterwards washed by ebullition with sulphuric acid, and then purified with muriatic acid. These ingredients are put into a platina crucible, capable of holding 12 ounces of flint glass, and then carried to a bottle glass furnace. After 36 hours, it will be melted, and is then poured into water, dried, and reduced to a fine powder. It is then washed and purified in the same manner as sand; again melted and thrown into water; and after being again pulverised and purified with acids, it is melted a third time, and at the end of 48 hours it is poured upon a warm plate of copper, upon which it is allowed to cool gradually. It will then be found free of all imperfections.

A number of interesting experiments on the manufacture of flint glass for optical purposes, has been made by M. D'Artigues. He always found that the excellence of the flint glass depended on the purification of the red lead; that the middle part of a large mass of glass was always the freest from veins; and that it is only good when it is manufactured on a great scale. The middle portion of the pot of glass is blown into cylinders, and afterwards opened into plates. See *Bulletin de la Société d'Encouragement*, N° 83.

Sect. VI. *On the Manufacture of Plate Glass.*

Plate

The materials for making plate glass must be of the finest quality. The principal ingredient is fine white sand, which is caused to vitrify by adding alkali and nitre, or salt, and sometimes other fluxes. The desirable qualities in plate glass are, that it shall be perfectly transparent and colourless, free from bubbles or specks in the casting. To attain this it must melt with a moderate degree of heat; for, without this quality, it is scarcely possible to have it cast so quickly, that it will not cool in some degree during the operation, and thus have specks. The best alkaline substance for the flux is soda extracted from the ashes of barilla by lixiviation. If pearl ashes are used, they should be purified by washing or dissolving them in water, in which the impurities will subside; and the clear liquor which is drawn off must be boiled down in iron pans, till, by the evaporation of the water, the clean ashes are obtained. Borax is very useful to facilitate the fusion, and also the running into plates. Lime has the same quality; but the quantity must be small, otherwise it will affect the transparency.

The composition recommended by the author of the *Handmaid to the Arts*, is 60 parts of white sand washed clean, 25 parts of pearl ashes, 25 parts of nitre, and 7

Plate Glass. Frit furnace.

of borax. To these are sometimes added a small quantity of lime and manganese, according to circumstances.

The sand and alkali, and also the lime and manganese, if any are used, are first well mixed together, and thrown into a reverberatory furnace, represented in section by Fig. 11, where A is the fire-place, situated between two circular ovens or domes B, upon the flat floors of which the materials are laid; and the flame rising from the grate being reflected down by the arched roofs, strikes upon the floors of the ovens with sufficient heat to nearly fuse the materials, and cause the sand to become very white by a semi-vitrification. This calcination is continued for five or six hours, and the materials are constantly stirred and turned over with an iron poker, to expose every part to the heat, until they cease to afford any vapour, or to undergo any farther change.

Furnace. Plate CCLXXVI. Figs. 12, 13.

A plan of the furnaces used by the French is given at Fig. 12. of Plate CCLXXVI. and a vertical section at Fig. 13, the same letters being used in both. The real furnace A, which contains the two large pots *a, a*, and two others on the opposite side, is surrounded by four other furnaces or ovens B, B, B, D, which proceed from the angles, and are heated by the flame of the same fire passing through flues *g, g*. The three ovens marked B, B, B are intended for burning the pots in which the glass is melted and refined, and also the cisterns into which it is put, to be conveyed to the casting tables. The fourth oven D is intended for heating the frit or material, previous to its being put into the pots to be melted down. The four ovens are all of the same form and dimensions, except that the openings *b, b, b* into the three first are larger than the mouth *d* of the latter: all these openings are closed by doors of bricks fitted in iron frames. The fire is made in the bottom of the great furnace at E, Fig. 13, being included between two sloping walls *e, e*, which form the benches or seats for the four pots; two pots *a, a* being placed upon each bench, and likewise two cisterns *m, m*, which are placed at the ends of each bench; and therefore, in the four angles of the furnace, the form of the arched roof FF is intended to reverberate the flame down into and upon the pots, to which it gives the greatest heat, and then passes off by the flues *g, g, g, g*, Fig. 12. into the four ovens B, B, B, D. The fuel is supplied through arches E at the end of the fire-place, which are of sufficient size to introduce a new pot when necessary; but when the furnace is at work, these arches are bricked up, except a small opening at the bottom. On each side of the furnace are three working holes *i, h, h*, to admit ladles, by which the glass is put into the pots *a*, or taken out and transferred to the cisterns *m*; and, in order to withdraw the cistern from the fire, a door or opening is made in the wall before each, as shewn at *l l*, Fig. 12.; and the dotted lines represent a flooring of iron plate at the level of the bench, upon which the cisterns are received when drawn out of the furnace, which is done by a large pair of forceps, Fig. 14. mounted upon wheels.

F. 14.

Pots.

The pots are placed in the ovens B. The flues which admit the fire into them, are provided with dampers, or sliding doors, which are closed until the pots are placed in the oven. The dampers are then opened very little at first, to admit the heat gradually, and avoid the danger of cracking the pots. The cisterns are made and baked in the same manner.

F.

The frit is mixed with the fragments of old glass, which are reduced to powder, by heating them in the oven D to redness, and throwing them into cold water. To this mixture of frit and glass is added the fluxes of nitre or borax, and the composition is baked for some hours in the oven D, until, by the commencement of the vitrification, the materials are reduced to a sort of thick paste. This is taken out of the oven in long ladles, carried to the mouth *i* of the furnace, and put into the great pots *a, a*, which are already heated. Here the great heat vitrifies, and changes the frit into glass. It requires a fusion of 36 or 48 hours to make fine and clear glass, and sometimes more. If it is found thick or opake like porcelain, the heat must be continued for a longer time, or a greater proportion of flux must be added; borax is the best for this additional flux. If it is found to be a perfect substance of glass, but coloured, manganese or the oxide of cobalt is put in. For this purpose, they are tied up in a thick paper at the end of an iron rod, and put down to the bottom of the pot. A mixture of arsenic and manganese is used at other times, according to the nature of the colour, which is intended to be corrected.

Fusion.

When the glass is completely vitrified, it is taken out of the pots in ladles, and poured into the cisterns which stand at the sides of the pots. The cisterns must be introduced into the furnace whilst they are hot, both to save time in heating them in the great furnace, and also to avoid the danger of cracking them by a sudden exposure to so great a heat. For this purpose, a cistern is taken from the oven B, in which it was baked, by drawing it with hooks to the mouth or door; and it is then seized by the tongs, Fig. 14, which are a very large pair of pincers, united by a joint pin *a*, fixed into the axletree of a pair of wheels *b*, upon which the whole runs. The beaks or jaws *d, d*, are properly adapted to receive the cistern between them; and, for this purpose, the cistern has a groove in each side. The opposite ends of the tongs have handles *e, e*, by which the men guide and direct the machine; and also a small arch *g*, with pin holes to make fast the tongs, when they have seized the cistern. Having taken hold of the cistern with this machine, by two men weighing on the handles *e, e*, they can readily take up the cistern off the floor of the oven, and by the wheels transport it to the furnace, into which they introduce it through the lower openings. If it is a cistern which has been used before, they take the opportunity of its being hot to clean out the old glass from its sides. The glass remains five or six hours in the cistern until the whole is brought to a white heat. The door at *l*, Fig. 12, opposite the cistern, is then removed, and the cistern withdrawn by the pincers, aided by long iron hooks. Being then carried to the casting table, represented in Fig. 15, it is taken up by a crane, and its contents poured out upon the table, upon which it spreads into a thin sheet.

Fig. 14.

Casting table. Plate CCLXXVI. Fig. 15.

The table AA is strongly framed in wood, and covered over with a thick plate of copper, made very smooth upon the surface. B is a heavy cylindrical roller of copper, which is used to roll over the fluid glass, and flatten it to the required thickness. To regulate this thickness, two iron rulers *a, a* are laid down upon the table, at such a distance as will include the width of the intended plate; and the thickness of the rulers is equal to that of the plate, because they bear up the roller to that distance from the surface of the table. The roller B has long projecting spindles at each end for two men to roll it along by; and that it may advance steadily, they are counteracted by two other men, who hold rods *c, c*, and regulate the advance of the roller.

The cistern D is taken up in a pair of tongs E, shewn separately in Fig. 16. They open and shut upon the

Plate Glass.

Operation of casting. PLATE CCLXXVI. Fig. 16. Fig. 17.

joint *c*, and are retained by an arch *x* with pin holes. At one end is a cross handle *f*, and at the other end two handles *g*, *g*. These tongs are suspended by four chains, from two levers *h*, *h*, which, as shewn in Fig. 17, are fitted on the ends of a bar of iron *i*, and through the centre of this passes a cylindrical iron pin *l*, which, at the upper end, has an eye to receive the hook of the crane rope, which takes up the whole, as shewn in Fig. 15. An iron plate *k* is fixed on the top of the pin, to preserve the rope from burning.

The operation of casting is performed before the mouth of the annealing oven, into which the glass plate is introduced immediately after casting. These annealing furnaces are arranged round the building, which has the great furnace in the centre, and the table is mounted upon wheels for removing it from one annealing furnace to another. The crane is also moveable as well as a tressel F, formed for the reception of the roller B, when it has travelled over the whole length of the plate. The roller B, which weighs 500 weight, is transported by a carriage on wheels. By these means, the table and all its apparatus can be very quickly prepared for use before any one of the annealing furnaces.

Fig. 15. Fig. 16.

The cistern being brought to the table Fig. 15, is set down at the side, and the tongs (Fig. 16.) being opened, the cistern is included between the blades, which are shut up and fastened. During this time the surface of the glass is skimmed, to remove any scum which may float at the top. By means of the crane the cistern is now drawn up, and conveyed over the table in the situation of Fig. 15. The two workmen, who govern the cistern by its handles *f* and *g g*, now incline it on the centres of the levers *h*, *h*, as shewn in Fig. 17, and pour out a stream of liquid glass upon the table AA. Just before the roller B, an iron ruler R, which is to form the end of the plate, retains the fluid matter from running off at the end of the table; and the workman who manages this by its long handle S, withdraws it as the matter flows forwards upon the table, so as to suffer it to extend itself over the whole table a moment afterwards. When the glass has completely covered the table, the roller B is advanced with great regularity and steadiness. Its great weight presses down and reduces the upper surface of the glass to the level of the side rulers *a*, *a*. In this operation, some glass will often be forced over the edge of the table, in which case it is received into troughs K, placed on the ground for that purpose. The roller having passed over the whole length of the table, is guided into the tressel F at the end. The plate of glass thus cast, is not suffered to remain longer upon the table than to cool itself, so far that it will not warp by its own weight, and it is then shoved off at the end of the table into the annealing furnace, before which the table is placed. This is done by a tool, Fig. 18, which has a very long handle for two or three men to push it forwards, and the cross end is made to receive the end of the plate. The rest of the men guide the plate sidewise with irons, and assist in placing it properly in the annealing oven, which does not require a particular description, as it so nearly resembles the oven used by bakers; but its dimensions must be sufficient to contain the largest glasses, which continue here baking in a moderate heat for fully 14 days, the heat being at last suffered to die away as gradually as possible. When quite cool, the plate of glass is withdrawn and carried to the magazine, where it is examined and cut square by a large diamond, fixed in a wooden handle, and attached to a block of wood to hold it in the proper position, to cut in the same manner as the cutter of a plane. This tool being drawn over the surface of the glass, cuts so far, that very slight blows with a sharp edged hammer on the opposite side of the glass will break it; and if the fracture is very rough, the irregularities are reduced by breaking them off with pincers.

Annealing. Fig. 18.

Squaring the plates.

Grinding.

The glass plate only requires to be ground and polished, which is performed by bedding the plate with plaster of Paris, upon a table covered with a large slate stone, and laying a smaller plate upon it, which is loaded with weights, and drawn backwards and forwards over the great plate: Sand plentifully moistened with water, grinds away all the prominences of the glasses, until the surfaces of both plates become plane or even. The upper or moveable glass is defended by cementing it to a strong plank, and upon the back of this the weights are laid, which cause the pressure. To give the workmen hold of the plate, a large light coach wheel is placed upon a pin, which projects upwards from the centre of the plank, and two or four workmen take hold of the rim of the wheel on opposite sides, alternately pushing and pulling it in all directions. As this action is transferred by the wheel to the centre pin, the plate is at liberty to move in any direction; and the workmen must take care to vary this every instant, to prevent the glasses grinding each other into furrows or channels. The table upon which the grinding is performed, is surrounded by a ledge of about two inches high, to retain the sand and water with which the lower plate is covered. When great nicety is required, the upper plate should be changed for another upper plate which has been ground on a different table; because two plates may grind themselves to a portion of a sphere, one becoming concave and the other convex; but by changing the grinding plates so as to bring two convex or two concave surfaces together, they will correct each other. When the plates are small, the wheel is not used to move the upper one; but the board to which the upper glass is cemented has four small handles projecting up from it, by which the workmen take hold. When, by the grinding, a perfect surface is obtained, a finer sand is used to produce a smoother surface. A succession of emeries, of different degrees of fineness, are used after the fine sand, and with these the operation of grinding is finished.

Polishing.

The grinding of both sides being completed, the glass is polished by bedding it with plaster upon a flat table, and rubbing on the surface with the polisher, which is a block of wood, covered on the lower side with woollen cloth. The workman keeps it supplied with fine polishing powders, as tripoli and putty; at first using the coarsest, and, towards the end of the operation, the finest. The block of the polisher for large plates is about ten inches square, and has two handles projecting from it. But to regulate the pressure, a springing pole is put upon the back of the block, and being bent to a curve, is supported in the ceiling of the workshop. When both surfaces are polished, the glass is laid upon a table covered with a cloth, and any deficiences are removed, by a small polisher applied by the pressure of the hand without a spring.

In the plate glass manufactory at Ravenhead in Lancashire, which we have had occasion to examine, the operation of grinding and polishing is performed by appropriate machinery driven by two large steam engines. There is nothing very peculiar in the nature of this machinery, excepting the ingenious contrivance for changing the path of the polisher in advancing and returning over the plate of glass. See ENGLAND, vol. ix. p. 10.

Coloured Pastes.

Sect. VII. *On the Formation of Coloured Pastes.*

In our article on Gems, p. 128, we have already had occasion to consider the subject of coloured pastes, or fictitious gems. We have described the method of Fontanieu of making a colourless base, and afterwards communicating to it any particular tint by metallic oxides; but as we have followed that ingenious author only in so far as his experiments relate to the imitation of precious stones, such as the oriental topaz, the amethyst, the hyacinth, and the beryl, we shall here resume the subject, and give an account of his method of producing other colours.

Method of obtaining colours from different metals.

1. From *Gold*.—To obtain the purple colour known by the name of precipitate of Cassius, M. Fontanieu employed the following process.

Distil in a glass retort, placed in a bath of ashes, some gold dissolved in aqua regia, made with three parts of nitrous, and one part muriatic acid; when the acid is passed over, and the gold contained in the retort appears dry, leave the vessel to cool, then pour it into some new aqua regia, and proceed to distil as before. Replace the aqua regia twice upon the gold, and distil it. After these four operations, pour by little and little into the retort some oil of tartar per deliquium, which will occasion a brisk effervescence; when this ceases, distil the mixture till it becomes dry, and then put some warm water into the retort. Shake the whole, and put it into a cucurbit, when a precipitate is deposited, the colour of which is either brown or yellow. After having washed this precipitate, dry it.

2. From *Silver*.—The oxide of silver being vitrified, produces a yellowish-grey colour. This oxide enters only into the composition of the yellow artificial diamond and opal. Mr Fontanieu introduces it into the base in the form of horn silver (*luna cornea*). In order to prepare it, he dissolves the silver in nitrous acid, and afterwards pours into it a solution of sea salt: a white precipitate is obtained, which, being washed and dried, melts easily in the fire, and is soon volatilized, if not mixed with vitrifiable matter.

3. From *Copper*.—The oxide of copper imparts to white glass the finest green colour; but if this metal be not exactly in a state of oxidation, it produces a brownish-red colour.

4. From *Iron*.—Though it is commonly believed that the oxides of iron communicate a very fine transparent red colour to white glass, M. Fontanieu could only obtain from it a pale red, a little opaque. The oxide of iron he employed, was in the proportion of the 20th part of the base. There are various ways of preparing the oxide of iron called crocus martis. In general it is necessary that this metal be so far oxidated that the magnet ceases to attract it. Thus one may use the scales of iron found upon the bars of furnaces, which serve to distil aquafortis. By digesting filings of steel with distilled vinegar, then evaporating and replacing the vinegar ten or twelve times upon these filings, and drying them alternately, an oxide of iron is obtained, which must be sifted through a silk sieve, and then calcined. The oxide of iron, thus obtained by the vinegar, only introduced into the bases a green colour inclining to yellow. By the following process, one of the finest red colours is obtained:—Let an ounce of iron-filings be dissolved in nitrous acid, in a glass retort, and distilled over a sand-bath to dryness. After having replaced the acid or the dry oxide, and re-distilled it a second and a third time, it is then edulcorated with spirits of wine, and afterwards washed with distilled water.

5. From *Cobalt*.—The oxide of cobalt is made use of for introducing a blue colour into glass: but as this metal is rarely free from iron and bismuth, it is first necessary to separate them from it. This is done by calcining the cobalt ore in order to disengage the arsenic; and next distilling the oxide in a retort with sal ammoniac, when the iron and the bismuth are found sublimed with this salt. The distillation must be repeated with the sal ammoniac till this salt is no longer coloured yellow. The cobalt which remains in the cornute is then calcined in a potsherd, and becomes a very pure oxide, which being introduced into the base, in the proportion of a 900th part, gives it a very fine blue colour.

6. From *Tin*.—The oxide of tin, which is of a white colour, renders opaque the glass with which it is melted, and forms white enamel. For this purpose, calcine the putty of tin; then wash and dry it, and sift it through a silk sieve. Take six pounds of the second base, (See Gems, p. 128.) the same quantity of the calcined putty of tin, and 48 grains of manganese.

7. From *Antimony*.—Antimony is only susceptible of vitrification in a certain state of oxidation, and then it produces a reddish hyacinth-coloured glass; but if the antimony be in a state of absolute calx, such as the diaphoretic antimony, then it is no longer vitrifiable, and may be substituted for oxide of tin, to make white enamel.

8. From *Manganese*.—Employed in a small quantity, this metallic substance renders the glass whiter; a larger quantity produces a very fine violet colour, and a still larger dose renders the glass black and opaque. There are two ways of preparing manganese. The most simple consists in exposing it to a red heat, and then quenching it with distilled vinegar: it is then dried and powdered, in order to pass it through a silk sieve. The other method of preparing the manganese proper to furnish a red colour, is described by Blancourt, who calls it "fusible manganese." Take of manganese of Piedmont, one pound; torrefy and pulverize it; then mix it with a pound of nitre, and calcine the mixture during 24 hours; afterwards wash it repeatedly in warm water, till the water of the leys has no longer any taste; dry the manganese, and mix with it an equal weight of sal ammoniac; levigate this mixture on a slab of porphyry, with sulphuric acid, diluted with water to the strength of vinegar. Dry the mixture, and introduce it into a cornute: distil by a graduated fire; and when the sal ammoniac is sublimed, weigh it, and add to the mixture an equal quantity. Then distil and sublime as before, and repeat the operation six times, being careful at each time to mix the sal ammoniac and the manganese upon the porphyry with diluted sulphuric acid.

Compositions to imitate the precious stones.

Compositions.—To make the *white diamond*, take the Mayence base. This base is very pure, and has no colour. It is similar to the beautiful white paste, so generally known by the appellation of *Strass*.

For the *Yellow Diamond*.—To an ounce of the fourth base, add, for colour, 24 grains of horn silver, or ten grains of glass of antimony.

For the *Sapphire*.—To 24 ounces of the Mayence base, add two drachms 46 grains of the calx of cobalt.

For the *Oriental Ruby*.—1. To 16 ounces of the Mayence base, add a mixture of 2 drachms 48 grains of the precipitate of Cassius, the same quantity of crocus martis prepared in aquafortis, the same of golden sulphur of antimony and of fusible manganese, with the addition of two ounces of rock crystal: or, 2. To 20 ounces of the base made with flints, add half an ounce of fusible manganese, and two ounces of rock crystal.

For the *Balas Ruby*.—1. To 16 ounces of the May-

Staining of Glass.

ence base, add the above colouring powder, but diminished a fourth part: or, 2. To 20 ounces of the base made with flints, add the same colouring powder, but with a fourth less of the manganese.

For the *Brazil Topaz.*—To 24 ounces of the second or third base, add, for colour, 1 ounce 24 grains of the glass of antimony, and 8 grains of the precipitate of Cassius.

For the *Saxon Topaz.*—To 24 ounces of the first or third base, add six drachms of the glass of antimony.

For the *Emerald.*—1. To 15 ounces of either of the bases, add, for colour, one drachm of mountain blue and six grains of glass of antimony; or, 2. To an ounce of the second base, add, for colour, 20 grains of glass of antimony, and three grains of calx of cobalt.

For the *Common Opal.*—To an ounce of the third base, add, for colour, 10 grains of horn-silver, two grains of calcined magnet, and 26 grains of an absorbent earth.

Sect. VIII. *On the Art of Staining Glass.*

Glass Staining.

Glass staining is the method of ornamenting glass for the windows of churches, or other edifices, by pictures or designs painted in colours, which are made to penetrate into the substance of the glass, by means of fire. Stained glass is frequently called painted glass, but the distinction should always be preserved between the painting with transparent colours upon a surface of glass, and the staining or tinging of the glass itself, with the colours which produce the picture. As pictures in coloured glass are always placed between the spectator and the light, they have an effect altogether different from any other species of painting; and, from the transparent brilliancy of the colouring, the spectator is often struck with admiration, independent of any excellence in the subject of the picture.

Transparent colours painted on glass, either in water or varnish, can never attain the brilliancy of the coloured glass, but from the great difficulty of staining certain colours, it is very common to find, in modern windows, part of the colours painted on the surface, whilst the large tints are stained.

It was not until the 15th century that the stained glass was made to produce the effect of strong lights and shades; but respecting the methods employed by the painters of those superb specimens which we find in cathedrals, we are wholly uninformed; and our information is now chiefly drawn from a Memoir of M. Leviel, published in the *Description des Arts et Metiers*, vol. xiii. This gentleman was himself a painter on glass, and the only one of eminence who has written upon the art.

The glass upon which it is intended to paint should be very hard, without spots, or any colour. Crown window glass is the best; for cast or plate glass has borax in its composition, which would make the colours to run or spread. When the design is too large to be contained on a single piece of glass, several must be fitted to one another, and a bed of some resinous cement prepared, upon which they can be readily put together, and held on one flat surface whilst painted, with proper spaces for the lead frames, and yet be readily separated, to subject the pieces separately to the fire.

In arranging the pieces of glass which are to be painted, care must be taken to dispose the joints so that they may do the least injury to the design by the opacity of the lead frames, by which the pieces must be joined together, in order to form a large window.

The design which is intended to be painted upon the glass, must be accurately drawn upon a sheet of paper in outline; or, if necessary, in its proper colours. In this species of painting, the artist works quite in the dark as to the effect of his picture, because the colours are produced by the fire; and when the preparations are laid on the glass, they are either colourless, or perhaps have colours quite different from that with which they will ultimately stain the glass.

Method of laying on the colour.

The design drawn upon the paper, is placed beneath the plate of glass, or upon the bed, when several separate pieces are used. The upper side of the glass is then brushed or sponged over with a fine clear gum-water. This, when perfectly dry, forms a surface proper to receive the colours, without danger of their running or spreading beyond their intended limits, as they would do if laid upon the smooth surface of the glass. The first operation, is to draw upon the glass with a fine pencil, all the lines which are necessary to produce the shades, and to mark the outlines. This is usually done in a black colour, or at least in some deep colours, such as brown, blue, or green, and sometimes red. In laying on these, the artist is guided by the same principles as the engraver, when he produces the effect of light and shade, by dots, lines, or hatches; and he employs that colour to produce the shades, which will best accord with the colour which is intended afterwards to be laid on; but, in general, black is used in the outline for all the deeper shades. When this is finished, the whole picture will appear represented in lines or hatches similar to an engraving, finished up to the highest effect possible; and afterwards, when it is perfectly dry, the colours are laid on by means of larger pencils. Each colour is spread upon the part of the design which requires it; as the flesh colour upon the faces of the figures, the green for trees, blue for the sky, &c.; but in doing this, the artist labours under the disadvantage of being unable to see the effect of his work, until it has been subjected to the fire. He therefore avails himself of a number of trials made upon small pieces of glass, which he keeps as specimens of the effect of the different colours, properly numbered, to correspond with the preparations which he employs for colouring: he must, therefore, search among these specimens for the tint, and apply the proper preparation.

In laying on the colours, it must be observed, that some preparations which produce beautiful colours, are liable to run or mix with those which are adjacent to them, so as to confound the outlines of each respective colour, by producing a mixture of the two. This is a serious difficulty; the artist must refer himself to his trials; and when he finds it necessary to lay two adjoining colours which will run together, he must lay one of them on the back of the glass. The few principal colours, of which we shall presently give the preparation, are all fast colours such as will not run, except the yellow, which must therefore be laid upon the opposite side. It should be observed, that those colours which will mix or run, are equally useful with the others when applied to produce compound tints; but the artist should not attempt to use them without being well acquainted with their properties, otherwise he may by a very small tint of improper colour destroy all his work.

After colouring, the artist proceeds to produce the very light parts of his subject, by taking off the colour from them by a goose quill, cut like a pen without a slit. By working this upon the glass, he removes the colour from the parts where the lights should be the strongest; such as the hair, eyes, the reflection of bright surfaces, and light parts of draperies. The blank pen may be either employed to make the lights by lines, or hatches and dots, as will be most suitable to the subject, and the part where they are required, in the same manner as the black was used to produce the shades.

Staining of Glass.

The glass is now ready for burning, to fix the colours, or rather stain the glass, by the preparations which have been laid upon it. The furnace most proper for the purpose, is similar to that used by assayers or enamellers. It consists of a muffle, or arch of fire clay or pottery, so placed over a fire-place, and surrounded by flues, as to receive a very considerable heat, but in the most equable and regular manner throughout the whole; for if this is not attended to, some parts of the glass will become too much stained, before the colour takes place in others. The mouth of the muffle, and the entry to the fire through which the fuel is supplied, should be on opposite sides, to prevent as much as possible the entry of dust into the muffle; and the mouth of the muffle should be closed by iron folding-doors, with small openings or peep holes through them, to allow the artist to observe the progress of the burning, by withdrawing small trial slips of glass, which are stained with the principal tints employed in the picture.

Method of burning the colours by fire.

The muffle must be made of very good fire clay, flat at the bottom, and only five or six inches high, being so much arched at the top as is necessary to render the roof strong, and resist falling in by its weight when heated; the muffle must be so close on all sides, as to admit no smoke or flame. Before the plate of glass is introduced into the furnace, a bed is prepared upon the bottom of the muffle. For this purpose, lime is used. It must be previously burned, so as to yield no more gas, and then reduced to a fine powder. In this state, the bottom of the muffle is strewed half an inch deep, and levelled with a feather. The glass is then introduced, and sometimes the muffle is filled up with other glasses laid above the first, having beds of lime between each. The fire is lighted after all is shut up close, and the heat is raised very gradually at first, lest the glass should be broken by it; but after the fire has attained its full heat, it is continued for three or four hours, more or less, according to the appearances observed upon the trial slips of glass, which are withdrawn for that purpose; and the yellow colour is principally attended to, as that is found the best test for the others. The operation of burning being thus finished, the fire is extinguished, or rather suffered to die away, and the heat to subside gradually, to prevent the glass becoming brittle, as it would do without this precaution; for the heat when at the greatest, must be sufficient to make the glass very flexible, as is seen by the trial glasses.

Method of preparing the colours.

We shall conclude this Section with the preparations for a few principal colours.

Preparation for staining glass of a flesh colour.—Take one ounce of minium, and two ounces of red enamel, of that kind which is called Venetian glass enamel; pound them to a fine powder, and grind it with brandy upon a hard stone. This mixture, when slightly baked, will produce a fine flesh colour.

Black colour.—Take 14½ ounces of those scales of iron, which are found round the anvil of a smith's shop; mix with it two ounces of white glass, an ounce of antimony, and half an ounce of manganese; pound and grind them together with strong vinegar. Brilliant black may also be obtained, by a mixture of blue with the oxides of manganese and iron.

Another black colour.—Take equal parts of iron scales and of small beads or fragments of glass; pound them exceedingly fine, and grind them to a consistence to work with a pencil.

Another black is made from three parts of glass of lead, two parts of the scales of copper, and one of antimony, treated as before.

For brown.—Take one ounce of white glass or enamel and half an ounce of good manganese; grind them first very fine with vinegar, and afterwards with brandy.

Method of preparing the colours.

Red, rose, and brown colours, are made from red oxidated iron prepared with nitric acid. Their flux is composed of borax, sand, and minium, in small quantity.

For red.—Take one ounce of red chalk pounded, and mix it with two ounces of white hard enamel, and a small proportion of the scales of copper which fall off when it is much heated in a forge. This will make a very good red, but requires trial if it will support the fire; and if not, add more of the scales of copper.

For another red.—Take one part of red chalk, which is too hard to write with, one part of white enamel, and a fourth of orpiment; grind them together with vinegar. This is a strong poison.

Or a red may be composed of rust of iron, glass of antimony, and yellow glass of lead, such as is used by potters, these three in equal quantities; to which add a little silver, calcined with sulphur. This composition ground fine, produces a very fine red colour on glass.

When the oxide of copper is used to stain glass, it assumes a bright red or a green colour, according as the glass is more or less heated in the furnace.

Bistres and brown reds may be obtained, by mixtures of different proportions of manganese, brown oxide of copper, and the oxide of iron called umber. They are previously fused with their solvents.

For green.—Take two ounces of brass burned until it becomes a calx, two ounces of minium, and eight ounces of fine white sand; reduce them to a fine powder, which inclose in a well luted crucible, heated in an air furnace with a strong fire for an hour. When this mixture is cold, pound and grind it in a brass mortar. Green may often be advantageously obtained, by a yellow on one side, and a pale blue on the other.

For a fine yellow colour.—Take fine silver in thin plates, and dissolve it in nitrous acid, and precipitate it; mix the precipitate with three times the quantity of pipe-clay, well burnt, and pounded. With this the back of the glass must be painted, or it will run into the other colours.

Another yellow can be made by melting silver in a crucible, and whilst in a state of fusion throw into it powdered sulphur in small quantities, and stir it up until the silver is reduced to a calx. Grind this upon a stone, and mix with it as much antimony as the silver, and some yellow ochre, which has been previously calcined in a crucible, until it is changed to a red brown colour. Work all these together with urine, and paint it on the back of the glass.

Another yellow.—Cut thin plates of silver into small pieces, and put them into a crucible with sulphur and antimony. When melted, throw out the contents into clear water, and afterwards pound and grind the preparation, so that it will work with a pencil.

A pale yellow.—Fill a crucible with thin plates of brass, with beds of sulphur and antimony in powder. Burn it till it ceases to smoke, and throw it hot into water. Reduce this to fine powder, and having added six times as much yellow ochre burnt, mix it with vinegar.

A fine yellow, equal in beauty to that of the ancient painters, has been discovered by M. Meraud. He employs muriate of silver, oxide of zinc, white clay, and the yellow oxide of iron. These colours are applied to the glass simply ground, and without flux.

Blue colour.—Take mountain blue, and beads of glass, equal portions; grind them whilst dry to an impalpable powder, and proceed as with the others.

In general, the same colours as are used for painting on porcelain, and many of those used in enamel paint-

Methods of cutting Glass.

ing, may be employed with success upon glass. But after all, the painter must employ no colour without making trial of it upon the slips of glass. The colours in general become more faint by longer continuance in the fire, because they sink deeper into the glass. But every preparation varies in this respect. All the colours are mixed up for the pencil with gum water in sufficient quantity to make them work properly.

Brongniart's experiment on the colours from metallic oxides.

A number of very interesting experiments on the colours obtained from metallic oxides, and fixed by means of fusion either on porcelain or glass, have been made by M. Brongniart, director of the royal porcelain manufactory at Sevrés. In the preceding list, we have already given some of his results; but in our article PORCELAIN, which that celebrated mineralogist has undertaken to furnish for this work, our readers may expect the fullest and most recent information on the subject.

SECT. IX. *On the different Methods of Cutting Glass.*

Method of cutting glass.

A plate of glass may be cut into any shape, either by the diamond, or by a bar of red hot iron.

With the diamond.

A late and intelligent writer (see Parkes' *Chemical Essays*, vol. v. p. 208) remarks, that there is something very mysterious respecting the action of the diamond in cutting glass: and he informs us, that if a sheet of glass, cut with a diamond, be examined before it is actually broken into its intended divisions, it will be seen that it is entirely cut through except at the *uppermost* surface. If this statement be correct, the operation of the diamond might well be pronounced mysterious; but we can assure our readers, that we have had occasion to examine the fissures or clefts produced by a diamond, and we have always found, that they commence on the upper side of the glass where the diamond is applied, and extend gradually downwards. This may be distinctly seen, by reflecting light from the separated faces, and the progress of the fissure downwards will be marked by the change produced upon the reflected light. We conceive, therefore, that there is no mystery whatever in the action of the diamond. A piece of soft and smooth wood will cut a plate of coagulated isinglass without any difficulty; a piece of steel will, with the same ease, cut a plate of wood; and, in like manner, a diamond will cut a plate of glass with the same facility, because it is as much harder than the glass, as the wood is harder than the isinglass, or as the steel is harder than the wood.

In order that the wood may cut the isinglass, or the steel the wood, the cutting point must be smooth, otherwise the surfaces to be cut will be torn up or scratched, instead of being really divided. For the same reason, the diamond must have a smooth natural point, or solid angle; for if a piece broken from a diamond is employed, it will only scratch the glass.

Mr Atwood, in a communication to Mr Parkes, informs us, that a good cutting diamond should be of a regular rhomboidal form, or have one regular smooth edge and rhomboidal point. The least deviation of the diamond from a particular position and inclination will prevent the cut from taking place. The workman, who is guided altogether by his ear, judges by the peculiar creaking of the glass; and if he does not hear this particular noise, he varies the position of the diamond till it occurs, and then draws it onwards. The diamond apparently wears down at the cutting point by long use, though it will last an ordinary glazier for many years.

"When the cut is perfectly good," says Mr Atwood, "it should be an *internal* fracture, unaccompanied with any scratch, or any visible impression on the surface whatever; for in proportion as any such superficial injury is produced, the completeness of the internal fracture is diminished. This fracture, therefore, which is called a *cut*, from its resemblance thereto in its effects, as also in the similarity of its appearance to a real cut, produced on any other substance by a sharp edged instrument, but which has closed again, (the expression being further countenanced, by the sharp form of that part of the diamond which comes in contact with the glass,) is really no cut at all, nor does the diamond so much as enter the surface." If this reasoning be just, it will follow, that a good diamond is not capable of making any impression upon the surface of a plate of glass over which it is drawn, and that it acts where it is not, and does not act where it is. It would require singular ingenuity to support such paradoxes.

Shaw's patent diamond.

Mr Shaw, an ingenious watchmaker in Leicestershire, being desirous of giving some assistance to a relation of his own, who was a glazier, and who, by a paralytic affection, was unable to pursue his trade, invented a method of fitting up a diamond, by which any person can cut glass as perfectly as the most experienced glazier. This invention was made about a year ago, and its advantages have been secured by a patent. "By the use of one of these instruments," says Mr Atwood, "a person not at all accustomed to a diamond, may produce a perfect cut over a table of glass so uneven in its surface, that the most skilful workman, with a common glazier's diamond, would not be able to produce a cut of any kind upon it. This consists in giving the diamond perfect play, and at the same time affording it such guide and support, as effectually prevent it from being affected by the unsteadiness of the hand, or unevenness of surface in respect of its inclination to the plane of the table; whereby the diamond, being well set or mounted in its carriage, becomes equally certain in the hands of every person." Parkes' *Chemical Essays*, vol. v. This patent diamond is represented in Plate CCLXXV. See the description of this Plate at the end of the volume.

Method of cutting glass by hot iron.

When a plate of glass is very thick, it cannot be easily cut by the diamond; but the same effect may be produced by the proper application of a hot iron. The part of the glass where the cut is to commence must be marked by a file, and a hot iron must be applied to the place, and held a little below the groove which the file has made. In a few minutes the glass will give a crack, and the iron must be instantly removed. The iron must be again applied a little below the termination of this crack, sometimes one-tenth or two-tenths of an inch distant from it, and in the line in which the cut is to be made, and the crack will advance in the direction of the iron. By again applying the iron in a similar manner, the crack may be conducted in any required direction. If the glass is to be cut in the form of a curve, then the hot iron must always be held very near the termination of the crack, in order that it may advance by short steps. The fissure is often most complete on the side of the glass where the iron is applied, and it is sometimes advisable to apply the iron to the opposite side. By this means, we have often cut plates of glass four-tenths of an inch thick with the utmost accuracy.

Glass may also be cut under water by a pair of scissars, but in an imperfect manner. If the operation were performed under a thick viscid fluid, the effect would be still more complete.

SECT. X. *Physical Properties of Glass.*

There is perhaps no substance to which the progress of the arts and the sciences has been so much indebted as glass; and there is none which has contributed more to the splendor and the comfort of civilized society.

We do not propose to enter at present into any detailed account of the electrical, the chemical, or the optical properties of glass, which the reader will find fully discussed under our treatises on CHEMISTRY, ELECTRICITY, and OPTICS. We intend merely to enumerate some of the physical properties which either distinguish it from other bodies, or which could not with propriety be noticed under other heads.

Glass possesses the remarkable property of suffering no change by the application of the most intense heat. The effect of great heats is only to melt the glass, or to dissipate it in vapour; but as long as any of the glass remains, it still preserves its transparency, and other distinguishing properties. The conversion of glass into porcelain by long continued cementation with other materials, happens only to that particular kind which is made of alkaline salt and sand.

Of all the solid substances whose expansibility has been accurately examined, glass possesses the property of being the least affected by heat and cold. Its expansion, according to General Roy, with an increase of heat equal to 180° of Fahrenheit's thermometer, is only 0.000776, while that of platina is 0.000856, and that of hammered zinc 0.003011. On account of this property, glass is peculiarly fitted for containing fluids whose expansions are under examination, as its own change of form may in ordinary cases be neglected. For the same reason, it is better than any other substance for the simple pendulum of a clock. See EXPANSION, p. 254, 255.

The great ductility of glass is one of its most remarkable properties. When heated to a sufficient degree, it may be moulded into any possible form with the utmost facility, and it can be drawn out into the finest fibres. The method of spinning glass is very simple. The operator holds a piece of glass over the flame of a lamp with one hand; he then fixes a hook to the melted mass, and withdrawing it, he obtains a thread of glass attached to the hook. The hook is then fixed in the circumference of a cylindrical drum, which can be turned round by the hand; and a rotatory motion being given to the drum, the glass is drawn in the finest threads from the fluid mass, and coiled round the cylindrical circumference. M. Reaumur supposed, with great probability, that the flexibility of glass increased with the fineness of the threads, and he therefore conjectured, that if they were drawn to a sufficient degree of fineness, they might be used in the fabrication of stuffs. He succeeded in making them as fine as a spider's web, but he was never able to obtain them of a sufficient length when their diameter was so much reduced. The circumference of these threads is generally a flat oval, about three or four times as broad as it is thick. By using opake and transparent glass of different colours, artists have been enabled to produce the most beautiful ornaments.

When glass has been annealed or cooled slowly, it is able to resist very considerable force without being broken; but when it has been cooled suddenly, either by exposure in the open air, or by immersion in water, it exhibits very remarkable properties. These properties are shewn in what are called Prince Rupert's drops, and glass cups.

The phenomena and the formation of Prince Rupert's drops, and the theory of their explosion, have already been explained in our article ANNEALING. The earliest experiments upon glass tears were made in 1656, both in London and Paris; but it is not certain in what country they were invented. They were first brought to England by Prince Rupert, third son of the Elector Palatine Frederick V. and the Princess Elizabeth, daughter of James I. and experiments were made upon them by the Right Hon. Sir Robert Moray, in 1661, by the command of his Majesty. An account of these experiments is to be found in the Registers of the Royal Society, of which he was one of the founders.

Physical Properties. Prince Rupert's drops, or glass tears.

The following experiments have been recently made on these drops by Dr Brewster, and published in the *Phil. Trans.* for 1814, Part II. and 1815, page 1.

Dr Brewster's experiments on glass tears. PLATE CCLXXIV. Figs. 1, 2.

"Having ascertained that glass melted and suddenly cooled, possessed all the optical properties of crystallized bodies, I was anxious to determine if it exhibited any other marks of a crystalline structure. Upon examining the bulb of an unannealed drop AB, Plate CCLXXIV. Fig. 1. by holding it between the eye and a sheet of white paper, I observed a number of lines converging to the vertex *a*, as represented in Fig. 2. This structure was more or less apparent in every bulb which I examined, but never appeared in annealed drops. It exhibited itself even on the surface, and seemed to be owing to an imperfect crystalline form, yet it was not marked with sufficient distinctness to entitle me to consider it as the effect of crystallization. In one specimen, however, where the bulb AB remained unshattered, while all the rest of the drop was burst in pieces, the lines diverging from *a* were most distinctly marked, and the bulb was actually cleft in the direction of these lines, so as to produce a real dislocation at the *surface* of the drop. We may therefore consider the drop as possessing that crystalline structure which gives cleavages in the direction of lines diverging from its apex. By examining the fragments of the drop after it is burst, another cleavage is distinctly perceptible: it is parallel to the outer surface, and produces a concentric structure like that of an onion. A third cleavage is visible in the direction of lines inclined to the axis of the drop, as represented in Fig. 3; but it is not so distinct as the two first. These cleavages are represented in section in Fig. 4.

Figs. 3, 4.

As it appeared probable that the glass drops possessed a less degree of density than if they had been annealed, I attempted to ascertain this point by measuring their specific gravities in these two different states. The unannealed drops, however, had always one or more vacuities, such as E, F, Fig. 1. so that I was able to obtain only approximate results by estimating the magnitude of these cavities.

The following specific gravities were measured by my friend Mr Jardine, with his usual correctness.

Unannealed flint glass drop, Fig. 1. . . . 3.20405

Annealed flint glass from the same pot . 3.2763 .

In order to correct the first of these measures, I moulded a piece of bees' wax into the size and form of the cavities E, F, Fig. 1. by examining them under a fluid of the same refractive power as the glass. I then formed the two pieces of wax into a sphere, and thus ascertained, with tolerable accuracy, the weight of a quantity of water of the same magnitude as the cavities. By this means, I obtained the corrected specific gravity of the unannealed drop 3.264.

With the view of obtaining some farther insight into the structure of the crystallized drop, I brought the one, represented in Fig. 1, nearly to a red heat. Its shape suffered no change at this temperature, and the vacuities E, F, still remained; but it had now lost the faculty of depolarisation, and the particles had therefore

Physical Properties.

Dr Brewster's experiments on glass tears.

assumed a new arrangement. By increasing the temperature, the cavities E, F, disappeared: the lower side of the drop, upon which it rested, was indented by the bottom of the crucible; but it had in no other respect lost its external shape, the appearance of the cleavage in Fig. 2. remaining unaltered. In this state Mr Jardine measured the specific gravity of the drop, and found it to be 3.278, which is almost exactly the same as that of the annealed drop.

In order to observe the manner in which the cavities disappeared, I suspended one of the drops by a wire, and viewed it with a telescopic microscope when exposed to a strong heat. Soon after the drop became red hot, the cavities gradually contracted, and at last vanished, the centre of the cavity being the part that was last filled up. The drop had begun to melt at its smaller extremity, but the lines represented in Fig. 2. were still visible, the heat probably not having been sufficiently intense to affect its superficial structure.

As the specific gravity of the crystallized drop is nearly the same as that of the annealed drop, the cavities must be produced by the contraction which the internal part experiences in cooling, for the sudden induration of the outer layer prevents the contraction from taking place in any other way. The manner, too, in which the cavities disappear, is a complete proof that they contain no air, and hence we may consider their magnitude, which increases with the size of the drop, as a measure of the contraction which the glass undergoes in its transition from the temperature at which it melts, to the ordinary temperature of the atmosphere. See Expansion, p. 255.

I am informed by Dr Hope, that he has obtained unannealed drops of crown glass, in which there were no vacuities, and that they all burst spontaneously in the course of a few months." *Phil. Trans.* 1815, p. 1.

Unannealed glass cups. Plate CCLXXIV. Fig. 5.

The unannealed glass cups, which we have mentioned under Annealing, are represented in Fig. 5. Plate CCLXXIV. The lower end B is made very thick, and the bodies, such as a musket ball or a fragment of flint, are dropped into the mouth of it at A. The stroke of the ball upon the thick bottom will produce no effect, while the blow of the small fragment of flint will burst the cup with great violence. The following are the dimensions of the cup represented in Fig. 5:—Length 4½ inches; width at top I; width at bottom 1$\frac{1}{10}$; thickness of glass at top $\frac{1}{10}$; greatest thickness of glass at bottom $\frac{4}{10}$.

The bursting of these cups is effected, when they are even three inches thick at the bottom. In an experiment made by Dr Littleton upon a cup of this magnitude it resisted a blow from a musket ball let fall from a height of nearly three feet, while it was instantly broken by a shiver of flint weighing only two grains. An account of numerous experiments made with these cups will be found in the *Philosophical Transactions* for 1745, vol. xliii. No. 477, p. 505.

Unannealed hollow balls.

The Right Hon. Sir Robert Moray discovered that hollow balls made of unannealed glass, with a small hole in them, would be burst in pieces by the heat of the hand alone, by stopping up merely the small hole with the finger. This obviously arose from the pressure of the expanded air on the interior of the ball.

Rotatory motion of glass tubes.

About the year 1740, when Mr C. Orme, of Ashby de la Zouch, was drying the glass tubes for his diagonal barometers, he observed that they had not only a rotatory motion about their axis, but also a progressive motion towards the fire. These tubes were about four feet long, and half an inch thick, and when placed about 6 or 8 inches from the fire, they moved "not only progressively, but about their axis along the side wall against which they leant, and along the front wall of the chimney, which made an obtuse angle with the other, so that they seemed to move up hill, and against their weight." The Rev. Granville Wheler, to whom Mr Orme shewed these experiments, repeated them with great care, and found that the experiment succeeded best with a moderate fire, and when the tubes were about 20 or 22 inches long, and about one-tenth of an inch in diameter, when they had in each end a pretty strong pin fixed in a cork as an axis, and when they were supported on other glass tubes of nearly the same diameter. When the progressive motion of the tubes was stopped by an obstacle, they still revolved about their axis. When the tubes were placed horizontally on a large fragment of plate glass, instead of advancing towards the fire as formerly, they moved from the fire, and about their axis in a direction contrary to what they had done before. In this case, as formerly, the tubes receded from the fire, even when the plate of glass was a little inclined. Mr Wheler very ingeniously explains these phenomena by the expansion of the parts of the tube nearest the fire, which, by placing the glass at a greater distance from the centre of motion, destroys its equilibrium. The heavy side of the tube therefore descends, and a fresh part of it being exposed to the fire, expands and descends as formerly. A writer in a modern dictionary opposes this explanation on the ground that "the fundamental principle on which it proceeds is false, for though fire, indeed, will make bodies expand, it does not increase them in weight, and therefore the sides of the tube, *though one of them is expanded by the fire, must still remain in equilibrio*, and hence we must conclude that the causes of these phenomena remain yet to be discovered." In this extraordinary reasoning, the author has overlooked the fundamental truth in mechanics, that the force with which any quantity of matter tends to turn round a fulcrum, is proportional to the sum of all the products of each particle of matter multiplied by its distance from the centre of motion. In the case of the glass tube, the number of particles remains the same, and the distance of all of them from the centre of motion is increased. Hence the sum of the products is increased, and consequently the equilibrium destroyed.

When we look at the sun, or any luminous body, through the common coloured glasses, the transmitted light, though tinged with one colour, nevertheless transmits rays of all the other colours, as may be proved by decomposing it with a prism. It was observed, however, by M. Monge, and the observation has been subsequently confirmed by M. Hassenfratz and M. Arago, that the glass of old churches which has been stained either red or green by the oxide of copper, has the surprising property of transmitting nothing but the homogeneous green or the homogeneous red rays. This property will be of the greatest use in solar observations, as it will remove completely the imperfections of telescopes arising from their different refrangibilities. A telescope should be constructed with a compound object glass, to destroy as much as possible the aberration of sphericity. The red or green glass will remove all the heterogeneous rays, and the most perfect image of the sun will thus be obtained.

A series of new experiments have recently been made upon glass by Dr Brewster, and the results which he has obtained are of such a singular nature, as to lay the foundation of a new science, analogous in its general character to the sciences of electricity and magnetism. He has shewn that when radiant heat

Glass, Glastonbury.

is propagated along a plate of annealed glass, its progress may be rendered visible by exposing it to polarised light, a series of beautiful coloured fringes advancing along the glass. The opposite edge of the glass, however, where the radiant heat does not exist in a sensible state, exhibits the same fringes, and consequently it follows, that in its propagation along glass, radiant heat possesses the singular property of *altering the structure or the mechanical condition of those parts of the glass where it does not exist in a sensible state.* When the heat is uniformly diffused over the plate of glass, all the coloured fringes vanish. By a particular process which we have not time to describe, he has succeeded also in communicating a permanent structure to glass, similar to that which it possesses during the propagation of radiant heat. The pieces of glass that have been subjected to this process, exhibit, by exposure to polarised light, the most brilliant and varied colours, arranged in the finest geometrical forms, and infinitely superior, in point of beauty, to any analogous production of art.

These plates of glass have exactly the same relative action upon the particles of light, as a magnet has upon particles of iron. The glass has a polarity as distinct as that of the magnet, and a piece cut from one pole of the glass, acquires a new polarity exactly similar to what takes place by cutting off a part of a magnet. The results which have now been mentioned, lead also to the construction of a *chromatic thermometer,* which measures all differences of temperature, up to the melting point of the glass which is employed in its construction. A full account of these experiments will be found in our articles OPTICS, POLARISATION, and THERMOMETER. For an account of the sounds produced by glass, see HARMONICA.

(Chromatic thermometer made of glass.)

GLASS CUTTING. See GLASS, Sect. VIII.

GLASS, ENGRAVING ON. See ETCHING.

GLASS, GILDING ON. See GILDING.

GLASS GRINDING. See OPTICS, *Practical.*

GLASS TEARS. See GLASS, Sect. IV.

GLASS TUBES, *Rotation of.* See GLASS, Sect. IX.

GLASTONBURY, a town of England in Somersetshire, is situated in a low marshy country, and is almost surrounded by the river Brue and its branches. It consists of two streets, crossing each other in the direction nearly of the four cardinal points, and the houses are built principally of the stones from its celebrated abbey. At the intersection of the two streets stands the cross of Glastonbury, which consisted of a large central column piercing the roof, and sustaining a naked figure; and clustered columns at each angle, with strangely shaped capitals and pinnacles. This singular building has been allowed to fall into ruins, and only a part of the central column now remains. The church of St John the Baptist is a handsome building, with a lofty tower, remarkable for its lightness and beauty. It contains several monuments, and numerous marks of its former splendor. The church of St Benedict, or the Lower Church, is in no respects remarkable.

The ruins of the celebrated abbey of Glastonbury stand on the south side of the High Street. It was originally constructed of wattles and wreathed twigs, and was afterwards built of more substantial materials. Ina, king of the West Saxons, demolished all the old buildings, and erected a splendid monastery in honour of our Saviour; and the chapel which he added to it contained about 2640 pounds of silver plating. The altar was adorned with gold to the amount of 260 pounds weight; and the church plate was set with jewels. The abbey suffered many subsequent changes, and a very small portion of it now remains. The great church is a heap of ruins. The chapel of St Joseph is tolerably entire, and also the abbot's kitchen. Besides the two parish churches, Glastonbury possesses two dissenting meeting-houses, two alms-houses, and a good free-school. A little way to the north-east of the monastery stands the tower of St Michael, situated on the summit of a high hill. The view of the tower from the plain below is much admired. The principal manufactures of the town are those of silk and silk stockings. The following is the statistical abstract of the two parishes of St John and St Benedict for 1811.

Number of houses	448
Number of families	499
Number of do. employed in agriculture	255
Number in trade and manufactures	121
Males	1067
Females	1270
Total population	2337

See Collinson's *History of Somersetshire;* Warner's *Western Counties;* and the *Beauties of England and Wales,* vol. xiii. p. 484.

Glatz ‖ Gloucestershire.

GLATZ. See SILESIA.

GLAZING. See PORCELAIN and POTTERY.

GLENDALOUGH. See WICKLOW.

GLOBES, CONSTRUCTION OF. See GEOGRAPHY, p. 153.

GLOBES, USE OF THE. See GEOGRAPHY, p. 156.

GLOGAU. See SILESIA.

GLOUCESTERSHIRE, one of the western counties of England, is bounded on the north and north-east by Worcestershire and Warwickshire; on the east, by Oxfordshire; on the south-east, by part of Berkshire and Wiltshire; on the south and south-west, by Somersetshire and the Bristol Channel; and on the west and north-west, by Monmouthshire and Herefordshire. It stretches from north-east to south-west, from the parish of Clifford Chambers, near Stratford upon Avon, to Clifton, beyond the city of Bristol, nearly 70 miles; and in breadth, from Lechlade north-west to Preston, about 40 miles; but its general breadth is not more than 26 miles. In circumference it is about 156 miles. The form of the county is elliptical. Its area has been variously estimated: by Sir Robert Atkyns, in his *History of Gloucestershire,* and by the author of the agricultural report, it is supposed to contain 800,000 acres. According to the returns to parliament of the poor rates, drawn up under the inspection of Mr Rose, its area is estimated at 718,080 acres. According to other statements, it contains only 705,000 acres.

(Extent and boundaries.)

It is divided as follows: 1. Kifsgate division, which comprehends the north and north-east parts; this is subdivided into 8 hundreds; viz. Kifsgate hundred, upper part, which contains 20 parishes, and one market town, Chipping Camden: Kifsgate, lower part, which contains 19 parishes, and one market town, Winchcomb: Slaughter hundred, upper part, which contains 10 parishes, and one market town, Stow; Slaughter hundred, lower part, which contains 13 parishes, but no market town: Tibbaldston hundred, containing 3 parishes, and no market town: Cleeve hundred, which contains only Cleeve with its tythings: Cheltenham hundred, containing 4 parishes, and one market town, Cheltenham: Deerhurst hundred, containing 4 parishes in the upper part, and 7 parishes in the lower part, but no market town in either: Tewksbury hundred, containing in the upper part 10 parishes, and in the lower 9, and one market town, viz. Tewksbury; Westminster hundred, containing in the

(Divisions.)

Gloucestershire.

Political divisions.

upper part 4, and in the lower part 7 parishes. The second division is called Seven Hundreds Division, and contains the following hundreds: Cirencester hundred, in which is only the town of Cirencester: Crowthorne and Minets hundred, containing 19 parishes, but no market town: Brightwell's Barrow hundred, containing 12 parishes and two market towns, Fairford and Lechlade: Bradley hundred, containing 19 parishes, and one market town, Northleach: Rapsgate hundred, containing 11 parishes, but no market town: Bisley hundred, containing 7 parishes, and 2 market towns, Stroud and Painswick: Longtree hundred, containing 11 parishes, and 2 market towns, Minchen Hampton, and Tetbury: Whitstone hundred, containing in the upper part, 9 parishes, and in the lower part 7 parishes, but no market town: Seven hundreds Division lies to the south and south-west of Kifsgate Division. The third is the Forest Division, which is bounded on the west by the river Wye; on the north-west by Herefordshire and Worcestershire; and on the east, partly by the two former divisions, and partly by the Severn: this division contains six hundreds; viz. Botloe hundred, which contains 9 parishes and one market town, Newent: Duchy of Lancaster, which contains 5 parishes, but no market town: Westbury hundred, containing 6 parishes and one market town, Newnham: Bledesloe hundred, containing 3 parishes, but no market town: St Briawl's hundred, which contains 12 parishes and two market towns, Mitchel Dean and Colford: and Dudstone and King's Barton hundred, which in the upper part contains 10 parishes, in the middle part 11, and in the lower 5; the city of Gloucester is in this hundred. The last division of this county is Berkley Division, which is bounded by the Severn on the west, part of Dudstone and King's Barton hundred on the north; Seven hundreds Division on the east, and the Lower Avon and Somersetshire on the south: Berkley division is subdivided into 7 hundreds; viz. Berkley hundred, the upper part of which contains 19 parishes and 2 market towns, Berkley and Wotton under Edge, the lower part contains 6 parishes, but no market town: Grumbald's Ash hundred, the upper part of which contains 11 parishes, and one market town, Wickwar; and the lower part, 10 parishes, and one market town, Sodbury: Pucklechurch hundred, containing 5 parishes, but no market town: Barton Rape's hundred, containing 6 parishes, but no market town: Langley and Swine's Head hundred, the upper part of which contains 4, and the lower part 5 parishes, but no market town: Thornbury hundred, the upper part of which contains only the market town of Marshfield; and the lower part 5 parishes; and one market town, Thornbury; and Hanbury hundred, the upper part of which contains 5, and the lower 2 parishes, but no market town. Gloucestershire contains one city, Gloucester, and part of another, Bristol; it returns eight members to Parliament, viz. two for the county, two for Gloucester, two for Tewksbury, and two for Cirencester. It is in the province of Canterbury and diocese of Gloucester, with the exception of two chapelries. It pays 12 parts of the land tax.

Natural divisions.

Gloucestershire is naturally divided into three longitudinal stripes, or districts, which differ materially from one another. The Coteswold district comprehends the whole tract of hill country, from Chipping Camden northward to Bath, and is often divided into the upper and lower Coteswolds. This is a long tract of high ground, for the most part bleak and bare: the sides of this tract are extremely beautiful as they sink into the vale, from the hills of Stinchcombe and Nibley on the south, to that of Bredon on the north. The Stroudwater-hills form a tract connected with and similar to the Coteswold. The second natural division of this county is the vale, which comprehends the whole of the lowlands from Stratford upon Avon to Bristol: it is usually divided into the Vales of Evesham, Gloucester, and Berkley; but as the Severn and the Avon are the natural boundaries of it, it might more properly be divided into the Vales of Severn and Avon, the former comprehending all the low country between Tewksbury and Bristol, and the latter the lowlands between the upper Coteswold and the Avon from Tewksbury to Stratford. The last natural division, which is by much the shortest of the longitudinal stripes, is wholly varied with hill and dale: it includes the parishes on the west side of the Severn up to Gloucester; and afterwards on the west side of the Leden, till it enters Herefordshire; this natural division is chiefly occupied by the Forest of Dean, once reckoned the principal support of the English navy, and which, it is said, the Armada was expressly commissioned to destroy: it is now thinned very much, though a few solitary deer continue to run wild in its remoter parts.

Climate.

The climate of these different parts of Gloucestershire varies considerably, though perhaps not so much as might have been expected from the difference of their elevation, cultivation, and soil, since the climate of the Coteswold hills, considering their natural elevation and nakedness, is unusually mild. The climate of the vale lands is perhaps as genial as that of any district in England; and that of the forest district is by no means severe, so that Gloucestershire may justly be regarded as highly favoured in this respect. The soil of the Coteswolds is for the most part a shallow calcareous loam, on a stratum of rubble; clay is met with in some parts, especially on the declivities. The soil of the vale is uncommonly rich, being either a fine black loam, or a red loam of equal fertility. In all parts of this district, except where the compact limestone rocks are found, a blue clay forms the under soil. In most of the forest district, the soil inclines to sand, in general not of a fertile quality: in the forest of Dean, a kind of peaty soil prevails. The principal rivers in Gloucestershire are the Severn, the Thames, and the Upper and Lower Avon. The Severn enters the county near Tewksbury, where uniting its waters with those of the Upper Avon, and pursuing a south-west course, it traverses a wide vale of uncommon richness and beauty. About a mile above Gloucester, it divides into two streams, which reunite a little below the city, forming Alney island. Soon afterwards, the breadth and depth of the river are much increased by the streams that fall into it, and its character becomes more bold and picturesque. Near Franiclode it takes a northerly direction, forming nearly a semicircle in the next ten miles of its course; after this it gradually grows wider, till it receives the Wye near Chepstow and the Avon from Somersetshire, thus forming the Bristol Channel. In its passage through Gloucestershire, it receives the Upper Avon, the Chelt, the Leden, the Frome, and the Lower Avon, near Bristol. This river frequently overflows its banks, particularly below Gloucester; in consequence of which, drains, sea-walls, &c. have been made, which are under the superintendance of a society called the commissioners of the sewers. The Severn is remarkable for its tide, which rolls in with an elevation of three or four feet. The Upper Avon divides a small part of Gloucestershire from Warwickshire, at the north extremity, and another small portion from Worcestershire, near Tewksbury.

Soil.

Rivers.

ucester- hire. The Thames has its source in this county, about two miles south-west of Cirencester; it then enters Wiltshire, and again becomes a Gloucestershire river at Kempsford, continuing the southern boundary of it to Lechlade, where it enters Oxfordshire. The Wye divides part of Gloucestershire from Monmouthshire and Herefordshire, and forms the natural western boundary to the forest of Dean. The canals in this county are the Stroudwater, which begins at the town of Stroud, and enters the Severn at Framilode: its width is 42 feet, its length nearly eight miles, and its rise above the level of the Severn 102 feet. The Thames and Severn canal begins at Walbridge, where the Stroud navigation ends, and joins the Thames at Lechlade; its length is 28 miles; its general breadth 40 feet; its fall 130 feet. It runs by a tunnel through Sapertowhill. The Berkley canal, which was intended to open a communication between Gloucester and the Severn at Berkley, has not been completed. The Hereford and Gloucester canal begins at Hertford, and joins the Severn opposite to Gloucester; the total length is 35 miles.

rals. The mineral productions of this county are not very numerous or important, coal only excepted; this is found in abundance in almost every part of Dean forest, where there are not fewer than 150 pits: the lower parts of the vale also abounds in coal, but of a less sulphureous quality than that of the forest. Iron ore abounds in the forest, but only a small quantity is raised. In this district also a good compact limestone is found, but inferior to that which forms vast beds at the southern extremity of the county: the lime made from this stone is uncommonly white and strong. Blue clay-stone is found in the vale, in layers of from four to ten inches thick; it is useful for building: it contains a considerable portion of calcareous matter. Freestone, of excellent quality, is raised from the Coteswold quarries; and paving stones and grits are found in the forest; of the latter, one of extraordinary hardness and durability, deemed superior to any other for cyder mills. Stone tiles are raised in the Coteswold hills; and in the parish of Henbury there is a fine bed of plaster of Paris.

The principal mineral water is at Cheltenham, which, for upwards of 30 years, has been much resorted to. According to the analysis of Dr Fothergill and other chemists, its component parts are Epsom and Glauber salts, a small portion of chalybeate, and some fixed air. It is particularly efficacious in all disorders of the liver. See Cheltenham.

s and m There are no very large estates in this county; but the number of yeomen who possess freeholds is very great. About a fortieth part of the whole land is held under corporations; there is very little copyhold. The average size of farms is small, though there are some large grazing farms in the vale. Before the injudicious rise in the rent of land, the average rent on the Coteswolds was, for arable 15s. for pasture 25s. per acre. In the vale, for arable 20s. for pasture 30s. In the forest district, for arable 20s. for pasture 25s. per acre. Within the last century, more than 90 acts of Parliament have been passed for the inclosure of waste and commonable lands in this county.

…ments …han… Of the implements of husbandry used in Gloucestershire, the waggon deserves particular notice, being, in the opinion of Mr Marshall, the best farm-waggon in the kingdom. Its most striking peculiarity is that of having a crooked side-rail, bending archwise over the hind wheel; the body is wide in proportion to its shallowness; and the wheels run very wide: its advantages therefore, in carrying a top-load, are obvious. The old plough, with one wheel, but shortened in the beam, is mostly used on the Coteswolds; through the greater part of the vale, the old swing plough is retained. There are but few thrashing machines in the county. A very useful cradle scythe is used in the vale for cutting beans.

As the forest of Dean is still comparatively speaking a waste, the agriculture of Gloucestershire must be sought after in the other parts of the county. The vale of Gloucester is a rich vale district, equally abundant in grass and corn; the Coteswold hills is an upland arable district; and the vale of Berkley is a grassland dairy country. It is computed that there are about 300,000 acres under tillage in Gloucestershire. The most striking practice with respect to the tillage land, is followed on the Coteswold hills, where the crops are generally sown after one plowing. Fallowing is practised on the strong vale lands. In the open fields, below Gloucester, two crops and a fallow are the general practice; and three crops and a fallow above that city. On the Coteswold hills turnips are substituted for a fallow, after which barley, grass for two years, wheat, and oats, pease or vetches. Wheat is drilled and planted in some parts of the vale lands; and is carefully hoed while it is growing. The produce on the Coteswolds averages 15 bushels, and in the vale nearly double that quantity per acre. Barley forms an important crop in the Coteswolds, but is seldom sown on the strong lands of the vale. Oats are chiefly grown in the forest district. In the management of all these crops there is nothing particularly striking or commendable; but in the entire management of the bean crop, Gloucestershire may afford a valuable lesson to almost every other part of the kingdom. Beans are principally the produce of the clay soils of the vale. In the ordinary practice of the district, they are planted by women, and hoed by women and children, always twice, and sometimes thrice; they succeed wheat or barley. The ground being ploughed nine or ten inches deep, manure is seldom given. They are planted early in February, by setting pins either across or down the ridges. The quantity of seed is $2\frac{1}{2}$ or 3 bushels. The distance between the rows from 10 to 14 inches; the distance in the rows about two inches; the depth two inches. The produce varies from 20 to 40 bushels per acre. Pease are principally grown on the Coteswolds. Tares, both winter and spring, are grown in all parts of the county, and on all soils. Turnips are pretty extensively cultivated; they are seldom drilled, but always carefully hoed. Swedish turnips are mostly confined to the rich lands of the vale; both kinds are almost exclusively given to sheep. Rye is grown in abundance in that part of the forest district called the Ryelands, but scarcely any where else. Potatoes are particularly attended to in the southern parts of the county. The culture of flax and teasels has much declined within these late years.

Gloucestershire.

Tillage.

Beans.

Meadows.

On the banks of the Severn, and the other rivers which flow through the vale, there are very rich natural meadows and pastures; their fertility principally arises from the mud which is deposited upon them during the inundations. The Avon is said to bring down the richest deposit from the hills of Warwickshire. The meadows on the banks of the Severn, considerably below Gloucester, partake of the nature of salt-marshes. For some miles above and below that city, the meadows are mowed every year, and the average produce is two tons per acre, though no manure is ever laid on them. Sainfoin has been cultivated on the Coteswold hills for upwards of 150 years, and is still a very general and useful crop there: its duration, how-

Sainfoin.

Gloucestershire. ever, is short, seldom more than ten years. The only other artificial grass for which this county is remarkable is Peacey's rye grass, which was first selected from the finest meadows in the vallies of the Coteswolds, and is now well known in almost every part of the kingdom. The management of the stall is no where better attended to than in Gloucestershire. The cattle usually fed are of the Herefordshire breed; they are worked till they are 6 or 7 years old: when fat they are sent either to Smithfield or Bristol market. Great attention is also paid to the fattening of calves. The principal breed of sheep in the county is that of the Coteswold, large and coarse in the wool; at three years old weighing from 30 to 45 lbs. per quarter, and affording a fleece of 9 or 10 lbs. The new Leicester and the south Down are also kept in many parts, and the Ryeland in some parts of the forest district. The real forest sheep are nearly extinct; these are very small, finely formed, and with fine wool. There is no peculiar breed of horses in this county. The old Gloucestershire breed of swine are now seldom kept.

Rye-grass. Cattle. Sheep.

Cheese. We now come to the two most important objects of Gloucestershire husbandry, its cheese and cider. Cheese is made both in the vale of Gloucester and in the vale of Berkley; or, as they are sometimes termed, the upper and lower vales: but the management of the two vales differ in one most material article, the quality of the milk. In the lower vale, the milk is run neat from the cow; in the upper vale, the practice is to set the evening's milk for cream in the morning, and to skim it, and then to add it to the new milk of the morning's meal. The cheese made from this mixture is termed two meal cheese; that from the neat milk, milk cheese, or best making. There are other differences in the practices of the two vales. In the vale of Gloucester, rye-grass is the predominant and favourite grass; in the vale of Berkley, the dog's-tail, with a mixture of rye-grass, the poag, and white clover. The Gloucestershire breed of cattle, a variety of the middle horned species, still predominate in both vales for the purposes of the dairy; though in the higher vale, long-horned cows, from the improved stock of Bakewell, are often kept; few dairies, however, in either vales, are without admixture. As soon as a " pack" or stock of cows is formed, the first consideration is to mark out those inclosures, the herbage of which is most favourable to the production of good milk; among the plants which are useless or injurious, are white honeysuckle, crowfoot, and garlic. About the first of May, the pastures are ready to receive the cows, and soon afterwards cheese-making commences: great care is taken in the selection or preparation of the rennet, and most minute and particular attention is paid to the temperature at which the coagulation takes place most kindly and equally. Previous to adding the rennet, the colouring is put in. In some places, the curd is scalded; where this is not done, a handful of salt is commonly thrown on the curd, immediately after the whey has been taken from it. The next operation consists in crumbling the curd, and pressing it fine in the vat, which is done with great nicety, being turned and salted repeatedly. If the cheese is small, this part of the process is continued only three days. The cheese is then removed to the shelf, and turned every day for a fortnight; then every other day for a fortnight more. At the end of this time, it is fit for the cheese loft: here it is turned twice a week, for three weeks; then the coat is scraped and coloured on the outside, or painted with carnation-red, mixed with water, and rubbed on with flannel. About Michaelmas, the cheese-factor examines the cheeses by walking over and treading upon each of them; those which yield to the tread are said to be heaved, and are unfit for the London market. The cheese of the hundred of Berkley is the most celebrated of all the Gloucestershire cheese; what in the kingdom at large is termed Gloucester cheese, particularly double Gloucester, is in Gloucestershire called double Berkley, not more on account of the superior quality of the cheese of this district, than because the principal part of the thick cheese of Gloucestershire is made within this hundred. It is calculated that a cheese of 11lbs. requires 15 gallons of milk, or one gallon and one-third to one pound of two meal cheese. The year's produce of a cow is estimated at three hundred weight. The vale of Berkley contains 50,000 acres, two-thirds sf which are occupied by cows, to the number of 7000 or 8000; and their annual produce of cheese is from 1000 to 1200 tons. As connected with this subject, the whey-butter of the vale of Berkley may be mentioned, which, if well made, and eaten fresh, is superior to the milk-butter of many districts: the produce of whey-butter is estimated at half a pound a cow a week. See Dairy, p. 559.

Cider. There are few orchards on the Coteswold hills, but in the vale and forest districts, they are abundant and valuable. Of the different kinds of cider made in this county, the Stire cider is deemed the best. The fruit from which it is made, flourishes particularly on the thin lime-stone soils on the margin of the forest of Dean. It is remarked, that the cider made from the Stire apple which grows here, is distinguished by richness, sweetness, and fulness of flavour; whereas, the same apple, in the vale of Gloucester, a strong, deep, rich soil, affords a liquor whose predominating qualities are roughness and strength. There is nothing peculiar in the mode of manufacturing cider in this county. Of pears, the squash is in much the highest esteem: in the township of Taynton, on the Gloucestershire side of Mayhill, where the soil is a strong brown clay, squash-pear perry, of a very superior quality, is made. It is said the perry of this district is the basis of most of the wine sold for Champagne in the metropolis.

Perry.

Wood. On the Coteswold hills, beech and ash are the principal trees. In the vale, there are but few tracts of woodland. The quantity of ground in Dean forest, belonging to the crown, is upwards of 23,000 acres. It formerly supplied about 1000 tons of ship timber annually. The forest is under the government of a lord warden. At Totworth, the chesnut tree is still growing, which, according to Evelyn, was 500 years old in the reign of King John. It was measured in 1791, when it was 44 feet and four inches in circumference. Till the year 1790, when it was burned down, there was an oak growing at Bodington, the circumference of which, at the ground, was 18 yards: the stem was hollow, forming a room more than 16 feet in diameter.

Labour. The wages of farm servants in Gloucestershire are not high, but the allowance of drink is enormous; six quarts a day is the common allowance, frequently two gallons, sometimes nine or ten quarts; drinking a gallon bottle full of cider at a draught is said to be no uncommon feat. In the immediate neighbourhood of the forest, coal, being cheap and abundant, is the common fuel: in other parts of the county, the Staffordshire and Shropshire coal is burnt; but on the Coteswolds, all kind of fuel is scarce and dear. The roads of this, like most of the other western counties, are by no means good; on the Coteswolds, the calcareous grit is too soft for durable roads; and there are still greater difficulties in the vale, from

Roads.

Gloucestershire. the nature of the soil, and the extreme scarcity of materials. The compact lime-stone, from St Vincent's rocks, makes the bests roads; but it is very expensive.

Manufactures. The most considerable markets are those of Gloucester, Cirencester, and Tewksbury; they are abundantly supplied with corn, meat, poultry, and the other necessaries of life. The principal manufactures of the county are those of woollen broad cloths, chiefly superfine, made of Spanish wool: there are also fine narrow goods, in the stripe and fancy way, made to a very great amount. The whole of these manufactures are carried on in that district called the Bottoms. Of this district, the town of Stroud may be regarded as the centre, all the surrounding valleys exhibiting a continued range of houses or villages, occupied by manufacturers. The waters of this district are peculiarly adapted to dyeing scarlet, blue, and black. At Cirencester, thin stuffs of worsted are made: carpets are also made here. At Tewksbury, the stocking-frame knitting is the principal manufacture. Rugs and blankets are made at Dursley, &c. Felt hats, for the Bristol trade, are made in several villages. In the forest of Dean, there are extensive iron works: at Framilore, there is a manufactory of tin-plate. The other manufactures of the county are iron and brass wire, wire cards for the clothiers, pins, nails, and writing paper. The articles of agricultural commerce are cheese, bacon, cider, and perry. The salmon of the Severn is now become scarce, but formerly it was caught in great abundance, and sent to London and other places, where it always obtained a very high price.

Poor. By the returns respecting the poor, presented to Parliament in the year 1803, it appears, that in this county at that time, 33,113 persons were relieved in and out of workhouses, at the expence of £3 : 1 : 7¼ per head, or £102,013 : 12 : 8 total; which, at a rental of £1,128,312, gives about 1s. 9½d. in the pound per annum. By the same return, it appears that there were, in 1803, 19,606 persons belonging to friendly societies.

Population. In the year 1810, the number of families employed in agriculture was 20,782; and in trade, manufactures, &c. 29,988. In the year 1700, the population of the county was 128,341; in 1770, 161,693. In the year 1801, 210,267; and in 1811, 295,100. At this last period, the number of people to a square mile was 263; and on an average of years, there had been one baptism to 36 persons; one burial to 61 persons; and one marriage to 120 persons.

History. The ancient Britons seem to have had no peculiar name for this tract of country, designating it and the whole adjoining low lands by the name of *Duffin*, which is said to signify a vale. It was inhabited by the Cattienchlani. When the Romans occupied England, the Dobuni seem to have inhabited Gloucestershire. This county being divided by the Severn, lay partly in Brittania Prima, and partly in Brittania Secunda; that on the south-east side of the river being in the former, and governed by the president residing in London; whereas that part beyond the Severn was in Brittania Secunda, and governed by the president residing at Caerleon. The Saxons called the inhabitants near this part of the Severn, Wiccii, from the Saxon Wic, *a creek*, because the river near its mouth is full of creeks. During the heptarchy, it was a long time subject to the West Saxons, but was afterwards included in Mercia. See *General View of the Agriculture of the County of Gloucester*, by Thomas Rudge, B. D. *Beauties of England and Wales*, vol. v. *The Rural Economy of Gloucestershire*, by W. Marshall. (J. S.)

Gloucester. GLOUCESTER City, is situated in Dudston and King's Barton hundred, Gloucestershire, 105¼ miles west from London. This city is situated in the Vale of Gloucester, on a gentle eminence, rising on the east side from the river Severn. Its situation, however, though it affords a fine object to the hills around, is by no means pleasant, the country round it partaking of little variety; and though its walls are washed by the Severn, that river loses here much of its dignity and interest, by being divided into two small channels, with a long connecting causeway. Gloucestor has lately been much improved. Its four principal streets are admired for the regularity of their junction in the centre of the town.

Cathedral. The cathedral is a fine building; its lofty tower, and 4 transparent pinnacles, adorned with exquisite fret work, make a conspicuous figure. Within, the high roof and Gothic ornaments of the choir, form a noble contrast with the simple grandeur of the ponderous Saxon pillars and arches which support the aisle. Its principal curiosities, are the beautiful painted glass in the chapel of our Lady; the whispering gallery; the tombs of Edward II. who was murdered in Berkley Castle, and of Robert Duke of Normandy, eldest son of William the Conqueror; and the great bell, suspended in the first story of the central tower. The walls surrounding Gloucester, in the time of William the Conqueror, were completely demolished soon after the Restoration, the only remains being the west gate, standing on the banks of the Severn, at the end of a stone bridge of 5 arches, built in the reign of Henry II. This bridge is connected on the west with a causeway of stone, which extends through the low meads and isle of Alney to the distance of about half a mile. The castle of Gloucester, of which the remains were destroyed a few years ago to make room for the county gaol, was probably erected about the time of the Norman invasion, as the Domesday Book mentions, that 16 houses were taken down for its scite. Camden states, that in his time it was for the most part decayed.

County gaol. The county gaol well deserves the inspection of the stranger. It was commenced, from the designs and under the direction of Sir George Onesiphorus Paul, Bart. a gentleman well known for his judicious and indefatigable exertions in the cause of the best interests of society, nowhere better exemplified than in the plan of this structure, and in the code of laws which he drew up for its government. The gaol consists of 3 divisions; the penitentiary house, the bridewell, and the sheriff's prison. These have all their distinct and appropriate regulations. It contains 203 separate cells; 164 for sleep, and 39 for employment. At stated hours during the day, the prisoners are permitted to enjoy the fresh air, in a court-yard 210 feet long and 57 broad. The same class of prisoners only are allowed to associate together. The internal economy is under the management of the chaplain, governor, and surgeon, who act according to fixed rules, and who are themselves subjected to the controul of the county magistrates. There are besides a house of industry, and a county infirmary, under excellent regulations. Gloucester receives its supply of water from springs about two miles to the south; and it appears from ancient records, that an aqueduct was carried thence to the city, upwards of 400 years ago.

Musical festival. Besides the amusements common to all provincial towns, there is in Gloucester, Worcester, and Hereford, a musical festival, established by the choirs of those cities, with the assistance of the first performers in the kingdom. The profits are applied to relieve the widows and orphans of clergymen. The meetings are held yearly, alternately in each city, and continue for three days.

Gloucester, Glover.

Trade.

The principal trade of Gloucester arises from the pin manufacture, and from the navigation of the Severn. This river is navigable to the wharf near the bridge for barges, vessels of larger size being obstructed by the rocks and sand banks in the narrow channel near the city. To remedy this inconvenience, the Gloucester and Berkley canal was begun, which was intended for the passage of ships of 400 tons burden. There has also been a bell foundery here since the year 1500. For the last 150 years, this business has centered in one family, who, in that period, have cast upwards of 3000 bells.

Government.

This city is the see of a bishop. It returns two members to parliament, the number of electors being about 2000. It was anciently regarded as a distinct hundred, and is still privileged as a county within itself. The corporate officers consist of a mayor, 12 aldermen, a high steward, a recorder, a town clerk, 2 sheriffs, 26 common councilmen, and 4 sergeants at mace. The population returns of 1811, give the following results respecting this city:

Population.

Houses inhabited	1509
Families occupying them	1706
Houses building	15
Houses uninhabited	20
Males	3726
Females	4554
Total population	8280

(J. S.)

GLOVER, Richard, an eminent English poet and political character, was born in St Martin's Lane, Cannon Street, London, in the year 1712. His father was a respectable Hamburgh merchant in the city.

Glover was educated entirely at Cheam school, under the Rev. Daniel Sanxay, having never studied at either of the universities. At the seminary above mentioned, he distinguished himself by the rapidity of his progress, and exhibited early specimens of his poetical powers. At the age of sixteen, he wrote a poem to the memory of Sir Isaac Newton, which was prefixed to the *View of Sir Isaac Newton's Philosophy*, published in 1728, by his friend Dr Pemberton. The seductive charms of literature, however, did not allure him from the pursuits of commerce, to which he was destined; for, in due time, he embraced his father's profession, and became a Hamburgh merchant; to which he alludes at the commencement of his poem called *London*.

The talents of Glover soon brought him into distinguished notice. In all matters regarding the interests of commerce, he took a lively and active concern. Nor did the cares and duties of a life of business estrange him from the study of poetry, for which he had shewn an early partiality. He cultivated the society of those men who were eminent in politics, science, and literature, especially such as belonged to the party in opposition to the administration of Sir Robert Walpole; and he enjoyed the esteem and confidence of several persons distinguished for their rank and talents.

On the 21st of May 1737, he married Miss Nunn, who brought him a fortune of £12,000; and in the same month he published his *Leonidas*, an epic poem, in nine books, which established his reputation as a poet. This poem was extremely popular on its first appearance, but was, no doubt, in a great measure, indebted for its favourable reception to the zealous and enthusiastic applause of the party then in opposition to the court. Their extravagant zeal, however, seems to have ultimately proved disadvantageous to the legitimate pretensions of the author, by encouraging exorbitant expectations, which the poem was not calculated entirely to gratify; for although possessing great and obvious beauties, it has since sunk into an unmerited neglect.

Glover

In 1739, he published his *London, or the Progress of Commerce;* upon which there followed soon after, his ballad, intituled, *Hosier's Ghost*. Both these pieces appear to have been written with a view to stimulate the nation to resent the depredations of the Spaniards; and the latter produced a considerable sensation.

During the last mentioned and subsequent years, Glover took a very active part in the politics of the city; and his talents, his political knowledge, and his extensive information in matters regarding trade and commerce, placed him so high in the estimation of his fellow-citizens, that he was appointed to conduct the application of the merchants of London to parliament, in 1741 and 1742, on the subject of the neglect of their trade. He accepted the office, and his exertions were crowned with success. In summing up the evidence, upon that occasion, he exhibited striking proofs of his oratorical powers. On the death of Sarah, Duchess of Marlborough, in 1744, she left, by her will, £500 each to Glover and Mallet, to write the history of the Duke of Marlborough's life. Glover, it is believed, very early renounced his share of the bequest; and Mallet, though he constantly promised, never made the least progress in the performance of the task.

About this period, Glover's affairs became somewhat embarrassed, in consequence of unavoidable losses in trade, and, perhaps, of too zealous an attention to the public interests, to the neglect of his own private economy. For this reason he determined to withdraw himself, for a time, from public notice, until he should be able to put his affairs into a more prosperous state. In the beginning of the month of May 1751, he was drawn from his retreat by the importunity of his friends, and condescended to stand candidate for the office of chamberlain to the city of London, in opposition to Thomas Harrison, Esq. Unfortunately, however, most of the Livery had engaged their votes before he declared himself; and after a few days, finding that his antagonist gained ground upon the poll, he gave up the contest. Upon this occasion, he addressed the Livery in a speech full of eloquence and manly resignation. In his retirement, he finished the tragedy of *Boadicea*, which he had begun many years before; and in 1753, it was brought upon the stage at Drury-Lane, and acted nine nights with great success. In 1761, he published his *Medea*, a tragedy, taken from the dramas of Euripides and Seneca, and professedly constructed upon the ancient plan, each act terminating with a chorus. It was not acted till 1767; and has since been often performed with success.

Having at length surmounted the difficulties of his situation, Glover again relinquished the pleasures of retirement; and in the parliament which met at the accession of his present Majesty, in 1761, he was elected member for Weymouth, and sat till March 1768. In 1770, he published a new edition of *Leonidas*, corrected throughout, and extended from nine books to twelve. In 1772 and the following years, he took a very active interest in winding up the complicated concerns of Douglas, Heron and Company at Ayr. He also undertook to manage the interests of the merchants and traders in London, concerned in the trade to Germany and Holland, and of the dealers in foreign linens, in their application to parliament, in the month of May 1774. In 1775, he assisted the West India merchants in their application to parliament; and examined the witnesses, and summed up the evidence, in the same masterly manner he had done on former occasions. For his assistance upon this occasion, he was complimented with a service of plate of the value of £300. The speech he delivered to the House was printed in the above-mentioned year.

Glover had now arrived at a period of life which demanded relief from the cares of business. He therefore retired to ease and independence, devoting himself principally to the exercise of private virtues and domestic duties, and to the pleasures of literature. He died at his house in Albemarle Street, on the 25th of November 1785, in the 73d year of his age. Among other manuscripts, he left behind him, *The Athenaid*, a sequel to *Leonidas*, which was published in 1788. He also wrote a sequel to his *Medea*, which, however, has never been exhibited on the stage.

In his person and habits, Glover was a finished gentleman of the old school, slow and precise in his manner, grave and serious in his deportment, and always in the highest degree decorous; but although his natural temper was benevolent, he is said to have been at once irritable and violent. He was very strict in his moral conduct; and although he was brought up in the principles of a dissenter, he attended the established church. He appears to have been an accomplished scholar; and it is evident from his life and writings, that his mind was much devoted to political subjects; but he always avoided such topics of discussion in his own domestic circle. As a poet, Glover displays a cultivated mind, a poetical fancy, and a vigorous and harmonious flow of versification; but he appears to have wanted that inventive imagination, and that higher spirit of enthusiasm, which give birth to the noblest productions of art. The chief defect of his *Leonidas* appears to consist in the subject: the historical facts upon which the poem is founded, are too well known, and too sublime and affecting of themselves, to admit of dilatation or embellishment, without diminishing the impression made upon the mind by the simple and unadorned recital.

Glover has been recently brought forward as a candidate for the credit of the *Letters of Junius*. The hypothesis is not without some plausibility; and there are certainly circumstances in his character and situation, which give considerable support to his claim. But the presumptive proofs, we think, have not yet been arrayed in such order, or stated with such force, as to make the conjecture assume the appearance of probability. See *Memoirs by a celebrated Literary and Political Character*, London, 1814; and, *An Inquiry concerning the Author of the Letters of Junius, with reference to the Memoirs*, &c. London, 1814. (z)

GLOW-WORM. Several of the smaller animals are endowed with the remarkable property of emitting light from their bodies as night advances, which becomes imperceptible on the approach of day: the creature can no longer be distinguished from the myriads of beings around it Eight genera of insects are known to be luminous in the dark, in which is included the genus *Lampyris* of Linnæus; the male, a winged animal of the coleopterous order, but the female is in general a worm, entirely destitute of wings, and so unlike the other, that nothing less than the sexual congress has been required to establish its kindred. This is the common glow-worm, to which our attention shall be briefly directed.

The Lampyris noctiluca, or glow-worm, is about three quarters of an inch long, when full grown; dark-brown above, and yellowish-white below. It crawls on six feet, and its body is divided into eleven segments, of which the last eight constitute the abdomen. The head, which is very small, round, and black, is concealed by the thorax, while in a state of repose. The eyes, also black, are large; and the antennæ, which are filiform, to the naked eye consist of eleven articulations, separated by white rings. Neither wings nor their rudiments exist, and the animal advances with a very sluggish motion, frequenting humid places, and living among the grass. Naturalists conjecture, from its conformation, that it is carnivorous. The male of this species, which is exceedingly rare, and which some of the most industrious entomologists have never seen, is said to have brownish elytra covering the wings; but the female is not only more numerous, but well known, from depositing a cluster of eggs on twigs or straws; and the young animals pass through the state of a larva and nymph, between which there is less difference than among insects in general.

The glow-worm, remaining in concealment through the day, crawls abroad at night, when it appears surrounded by a beautiful radiant light of considerable intensity, and of a greenish colour. It is most brilliant two or three hours before midnight; and an elegant and interesting spectacle is presented by collecting several together in a glass vessel. More powerful emanations illuminate the animals; sometimes the light is suddenly extinguished, sometimes it shines at protracted intervals, while the motion of the insects produces perpetual variety: but it always grows fainter and fainter, and at last it almost totally disappears. The observer, in the course of his examination, discovers, that the exhibition and intensity of the light are partly under the controul of the glow-worm; that the place from which it emanates is in the last three rings of the abdomen; and that it ceases entirely with the death of the animal, though a severed portion will continue to be illuminated, and after extinction the light will at a moderate interval be renewed.

The three rings, while illuminated, are of a pale yellowish colour, and their internal surface is spread over, with a layer of a peculiar soft yellow substance, whose consistence resembles paste. The whole interior, however, is not covered, as it is more or less deficient along the inner edges of the rings, where it forms an irregular waving outline. We compare this substance to paste; but, when magnified, it is found to be organised like the common interstitial matter of the animal's body, except that it is of a closer texture and paler yellow; and the segments of the abdomen, behind which it is situated, are thin and transparent, on purpose to expose the internal illumination. Several years ago, Count Razoumousky, a learned Polish naturalist, discovered that, besides the rings, there were luminous points in the abdomen, giving out a more permanent light; and the ingenious experiments of Mr Macartney prove, that two minute bodies, endowed with this property, are lodged in two slight depressions in the shell of the last ring. By the microscope, these are found to consist of two sacs, containing a substance similar to that lining the inner surface of the rings; and the membrane composing the sacs is so strong and elastic, as to resume its figure after the contents are discharged. The light thence proceeding is less under the controul of the insect than that of the luminous substance disseminated over the rings: it is rarely distinguished even through the day, during the season that the glow-worm gives out light. The presence of these two bodies seems alluded to by Mr Waller, in the Philosophical Transactions, so long ago as the year 1684, when speaking of those species of lampyrides, both male and female of which are winged; and Thunberg mentions one found in Japan with two vesicles on the extremity. The former describes their site as under the termination of the tail; and observes, that the winged insects are extremely rare in England.

The luminous substance, when extracted from a dead glow-worm, gives out no light, though the sacs, when cut from the living animals, shine several hours after separation; and, if put into water, they will emit light uninterruptedly for forty-eight hours. Whether they contain greater heat than the other parts of the animal, as a sufficient number have never yet been accumulated to prove the fact by experiment, is not altogether free of doubt. John Templer, one of the earliest English observers of the nature of the glow-worm, says, "If my senses fail me not, she emits a sensible heat in her clear shining." Mr Macartney also thought, that, when shining brilliantly, the luminous rings communicated the sensation of warmth to the hand; but, from remarking that the heat of the surrounding atmosphere, 69°, was not raised more than to 75° or 77°, on introducing a very sensible thermometer among several glow-worms, he concluded, that the actual difference of heat was insufficient to warn him of its presence. Sometimes, however, the luminous portion of the tail seemed to raise the thermometer more quickly than other parts of the body; and on cutting it off several animals, he found, that if the thermometer were immediately applied, it would rise one or two degrees; but that no effect whatever was produced after these parts were dead, though they continued to give out light. It ought to be kept in view, that many erroneously believe insects are entirely destitute of heat, whereas its presence is sufficiently demonstrated by accumulating a number together in a limited space.

Besides the glow-worm properly so called, an insect wanting wings, there are several of the genus provided with them, and then generally denominated *fire-flies*. In the hot climates, thousands shoot across the eye, and sparkle in the woods and bushes during night, with the most beautiful and brilliant illumination. Some, resembling so many specks, are not larger than the common house-fly; others are above half an inch long; and several collected in a glass vessel, emit sufficient light for reading a book. All are of the coleopterous tribe: both sexes have wings, and the emanations proceed from the last segments of the tail.

Some general conclusions have been drawn regarding the nature of luminous animals, most of which apply to the glow-worm: and first, that this property is not constant, but exists only at certain periods, and in particular states of the animal's body. The site of its emanations, also, resides in a particular substance, compared to paste; and the light is differently regulated while that substance is in the animal's living body, or separated from it. In the former case, it is intermitting: it is commonly produced or augmented by a muscular effort, and is sometimes absolutely dependent on the will of the insect. In the latter case of separation, the luminous exhibition is usually permanent, until becoming extinct, after which it may be restored directly by friction, concussion, and the application of warmth. No diminution of the substance follows the exhibition of light, however long it may be protracted. It does not require the presence of pure air, nor is it extinguished by other gases. The luminous appearance of living animals is not exhausted by long continuance, or frequent repetition, nor is it accumulated by exposure to natural light. From these principles, it is inferred, that this property not being dependent on any foreign source, is inherent in a peculiarly organized animal substance, and is regulated by the same laws which govern all the other functions of living beings.

Many conjectures have been indulged regarding the use of the light exhibited by luminous animals. Some have boldly declared, that it is for no specific purpose; others, more prudently, affirm, that it is utterly unknown: while a third class, substituting opinion for experiment, at once decide that, in the glow-worm at least, it is a wise provision of nature for promoting the concourse of the sexes. Undoubtedly this reason at first sight is plausible; but it ought to have been previously ascertained, that the male, while flying through the air, is sensible of the luminous emanations from the body of his grovelling mate. We know little of the different senses of insects; hearing seems altogether denied to certain species, and others are void of any external organs of sight: but what is more extraordinary, neither the number nor size of the eyes apparently increase the acuteness of vision. It ought constantly to be preserved in remembrance, that the beautiful structures of the bee are erected, and all its complicated operations performed, in the dark; but that other organs, and especially the antennæ, are constantly resorted to by them as a guide. Emanations undoubtedly proceed from the bodies of females at certain periods, which produce a lively impression on the sensations of the male, and we should be inclined to admit that there might be some analogous concomitant of the luminous exhibition of the female glow-worm; but the probability of this hypothesis is greatly diminished, on considering, that the emanations of light belong to the earliest period, even when the insect is in the larva state. We must therefore necessarily conclude, that naturalists have not yet discovered the real uses of this remarkable property.

See Bartholinus *de luce Animalium*; *Philosophical Transactions*, vol. vi. p. 2178; vol. xv. p. 841; De Geer, *Memoires sur les Insectes*, tom. iv. p. 29; Aldrovandus, *De Insectis*, p. 494; Geoffroy, *Mem. sur les Insect.* tom. i. p. 166. (*c*)

GLUCKSTADT, a word signifying the *Fortunate Town*, is a town of Germany, in the Duchy of Holstein, and belonging to the King of Denmark. The town, which is situated on the Elbe, where it receives a small river called the Rhu, is regularly and neatly built; and the principal streets run into the market-place. The town is intersected by several canals, the principal one of which passes near the market-place, and is there joined by another, which divides the town into two parts. From the marshy nature of the surrounding country, the road from the town towards Krempe, passes over a stone causeway, nearly three-quarters of a mile long. The town, therefore, can be easily laid under water on the land side. As there are no springs here, every good house is provided with a cistern, and the poor are supplied with water from the harbour in the new moat. There is a free grammar school here, a Calvinist church, a Roman Catholic chapel, and a Jewish synagogue.

The foundations of this town were laid in a waste called the Wilderness, in 1617, by King Christian IV.; who, with the view of making it a commercial town, granted it particular privileges. Frederick III. increased these privileges, and made it the entrepot of all the merchandize of Iceland which came into the Elbe. The vessels of Gluckstadt carried their merchandize to Altona and Hamburg. In 1738, Christian VI. founded a commercial college here; and in 1739 a house of correction and a workhouse were founded. In 1750,

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Glue. Goa.

Frederick V. instituted a commission for clearing and repairing the harbour. The King of Denmark declared Gluckstadt a free port, and abolished the duties which vessels had formerly paid in passing the town. In 1782, a commercial company was formed, to which the king granted an octroi for 30 years. Its capital was 200,000 rix-dollars, and it was chiefly engaged in the coasting trade and the whale fishery. Distance from Hamburg 28 miles north-west.

GLUE, is a tenacious cement, principally used by cabinet-makers, joiners, book-binders, case-makers, and hatters.

The substances from which glue is made, are the shreds or parings of hides; the ears before they are immersed in the tanner's vats; the cuttings and raspings of horn, from the comb-maker, the button-maker, and the horn lanthorn-maker; and the hoofs and horns of oxen, calves, and sheep from the butcher; the pelts of the hare, rabbit, beaver, &c. from the hat makers, beaver-cutters, and furriers; and the parings of vellum and parchment from the white leather dresser, glover, &c.

English method of making glue.

These substances are indiscriminately mixed together, and are purified from all grease and dirt by digestion in lime water, the greatest care being taken to remove every piece that is in the slightest degree putrescent. The materials are next steeped and washed in clean water, with frequent stirring, and are afterwards laid in heaps, and the water pressed out. They are then boiled in a large brass kettle with clear water, the fat and dirt being constantly skimmed off as they rise, and when the whole is dissolved, a little melted alum or finely powdered lime is added. After the skimming has been continued for some time, the whole is strained through baskets, and suffered to settle, in order that the remaining impurities may subside, and the fat rise to the top. The impurities and fat being removed, it is then returned into a clean kettle, and suffers a second evaporation and skimming. When it acquires a clear darkish brown colour, and a sufficient consistence, which is known by the appearances during ebullition, it is lifted out by a scoop, into frames or moulds, about six feet long, one foot broad, and two deep, where it is allowed to cool gradually. It is then cut by a spade into square cakes, and each of these is afterwards divided into three pieces, by an instrument like a bow, having a brass wire for its string. The pieces thus cut are dried in the open air, on a kind of net-work, (generally old herring nets,) fastened in moveable sheds of four feet square, each containing six or eight rows of net-work. When the glue is dry, each piece is rubbed gently with a wet cloth, to give it that glazed appearance which the London glue always possesses. The different pieces are then packed carefully up in separate rows in barrels or hogsheads, and are ready for sale.

The best glue swells considerably, without melting, by three or four days immersion in cold water, and recovers its dimensions and properties by drying. When glue looks thick and black, or has got frost in the drying, it should be melted over again with a sufficient quantity of fresh glue. Good glue is distinguished by its having a strong black colour, and by being free of cloudy and black spots, when held between the eye and the light.

French method of making glue.

In France, glue is made from whole skins, which, when fresh, are steeped 24 hours in large tubs; but a longer time when they dry. They are then placed upon hand barrows, formed of strong basket work, to allow the water to drain off, and are afterwards well washed in a running stream, where they are shaken in baskets with a long toothed rake, till the water runs through them quite clear. The materials are now steeped in weak lime water, the liquor being refreshed every 15 days with a bucket of fresh lime water, and the skins being occasionally turned. By this process, the grease is removed, and the skins converted nearly into the state of parchment. The parts of the materials that still retain the hair, require a stronger lime water. The skins are again steeped and drained in hand barrows, and sometimes the water is squeezed out of them by a press. The skins are now thrown into the kettle, which has sometimes stones at its bottom, and sometimes a wooden grate to prevent the skins from sticking to it. The boiling is carried on very cautiously and gradually, and the evaporation is known to have been sufficiently great by dropping a little upon a plate, and finding it of the proper tenacity. The glue, when hot, is then filtered through a bed of long straw, into a tub, the operation being performed in a warm place, in order to prevent the glue from congealing. In this tub the glue is left to refine for two or three hours, and when still fluid it is run off by stop cocks, at different heights, into wet wooden boxes, where it congeals. The glue which flows from the different stop cocks, has different degrees of fineness, the uppermost being the purest. After lying 24 hours in the boxes, the cakes are taken out, divided, dried, and packed up for sale.

Glue from bones.

Glue has also been successfully prepared from the bones of animals. Parmentier found that 6 pounds of buttonmaker's raspings yielded a pound of glue not inferior to the English glue. Glue from ivory was less transparent. See *Annales de Chimie*, vol. xii. p. 292.

GLUTEN. See CHEMISTRY, p. 113.

GMELIN. See BOTANY, *History of*, p. 20, 22, 26, 31.

GNEISS. See MINERALOGY.

GNOMON. See ASTRONOMY, p. 720. and DIALLING.

GNOSTICS. See ECCLESIASTICAL HISTORY, p. 307.

GOA, the principal Portuguese settlement in the East Indies, is situated in 15° 28′ North Latitude, and 72° 45′ East Longitude; and is built upon an island, called by the natives Tissoari, about 25 or 30 miles in circumference. This island is separated from the continent by a navigable river, about three miles broad at its widest part; and, though generally barren and hilly, it contains many level and fertile spots. At the entrance of the harbour is the new city of Goa, where the viceroy and principal Portuguese inhabitants reside, and is defended by several fortresses, particularly one called the Alguarda, which stands close to the shore, and is so situated that every ship sailing up the river must pass near its walls. About eight miles beyond this castle, is the old city of Goa, the seat of the inquisition, and the residence of the ecclesiastics, built in the form of an amphitheatre on several eminences, and almost surrounded by hills, finely clothed with wood. The harbour is a noble basin, presenting on every side the richest and most magnificent scenery. The city of Goa was first taken from the Hindoo Rajahs by the Bhámenee sovereigns of the Deccan, about the year 1469; and was reduced under the power of the Portuguese by the celebrated Albuquerque in the year 1510. It soon became the most flourishing European settlement in India, but the Portuguese never possessed any considerable extent of territory in its vicinity. Its walls inclosed a compass of nearly twelve miles; and few cities in India or Europe were better built, or more strongly defended. It was crowded with monasteries; and at one time, not less than 30,000 ecclesiastics are said to have resided within its district. These, however, soon began to apply themselves more

Goa.

ardently to the acquisition of wealth, than to the instruction of the natives; and established in the place the tribunal of the Inquisition, which continued till very recently to exercise all its cruelties upon the Hindoo converts.* The town has been rapidly falling into decay since the middle of the last century, and presents a most striking instance of ruined grandeur. The banks of the river are still covered with country houses, and many of these, especially the monasteries, from their elevated situation, make a magnificent appearance. The streets are straight and regularly built; the houses are large and handsome; and the number of its churches, palaces, and public buildings, excites, at a distance, the idea of an imperial residence; but a nearer approach disappoints the expectations of the stranger, and exhibits a melancholy picture of wretchedness and ruin. The churches and monasteries, the office of the inquisition, and a few other public structures, are still kept in good repair, particularly the church of San Caitan, which is a beautiful specimen of Italian architecture; the convent of the Augustine monks, which is a handsome edifice; the Jesuits college, which is very large and conspicuous; the church of Francis Xavier, the chapel of which, containing the monument of the saint, is uncommonly splendid, and the tomb is ornamented with basso relievos composed of the choicest marbles by European artists, representing his history and miracles. But more than one half of the houses and adjacent country seats are void of inhabitants; the most magnificent palaces mouldering into ruin; the streets faintly traced by the remains of forsaken mansions; the squares and market-places depopulated and silent, and actually filled with noxious reptiles. The few human inhabitants are priests, monks, half-starved soldiers, and low mechanics; and so great is their poverty, that women of the best families earn their subsistence by working lace or muslin, and making artificial flowers One of the most celebrated productions of Goa is the Alphonso mango, a delicious fruit, superior to all others of the same species. It has long been famed also for its arrack, which is made from the juice of the palm-tree, and for its cocoa-nut oil. Rice, arrack, and oil, indeed, form the principal articles of its now limited commerce. Two or three ships arrive annually from Portugal with military stores, and other articles; and carry back printed cottons from Surat, a few spices, &c. Two or three trading vessels take in cargoes for China; and a few coasters collect the produce of the Malabar ports, in order to supply the ships from Portugal with their home cargoes, and to answer the demands of the inland trade from Goa. There are a few armed vessels for the protection of the traders. Goa is 292 miles from Bombay, 1300 from Calcutta, 575 from Madras, and 325 from Seringapatam. See *Mod. Univ. Hist.* vol. ix.; Parson's *Travels in Asia and Africa*; Forbes's *Oriental Memoirs*; Hamilton's *East India Gazetteer*; and Buchanan's *Christian Researches in Asia.* (q)

GOAT. See Mammalia.

GOBELINS, *Tapestry Manufacture at*, See France, Vol. IX. p. 718.

GOBIN, St, *Glass Manufactory at*, See France, Vol. IX. p. 718.

GOD. See Theology.

GOITRE. See Medicine.

GOLCONDA, a province of Deccan, a district in India, comprehends the tract of country between the rivers Kistnah and Godavery in 17° North Latitude; and extends about 200 miles from north to south, and 220 from west to east. It is bounded on the north by Berar, on the south by the kingdom of Mysore, on the west by Visiapour, and on the east by the northern circars. It was formerly a portion of a very extensive empire, which comprised all the peninsula from the north extremity of Orissa to Cape Comorin. It was anciently called Tellingana; and it is some evidence of its original extent, that the Tellinga language is at present in use from the river Pennar in the Carnatic to Orissa along the coast, and to a considerable distance inland. It was reduced under the power of Aurenzebe in 1687; and now forms the principal possession of the Nizam or Soubah of the Deccan. Its ancient capital was Warangole or Oringal, about 400 miles from Madras, the site of which is indicated by an old rampart of great extent, within which a modern fortress is erected; but the present metropolis is Hydrabad, about 50 miles to the south-west, a large walled town, situated in a delightful plain on the banks of the river Moussy, 902 miles from Calcutta, 352 from Madras, and 480 from Bombay: (See Hydrabad.) About six miles north-west from this town stands the celebrated fortress of Golconda, which gives name to the province, and is deemed impregnable. It occupies the summit of a hill, of a conical form, and is of such extent as to deserve the name of a city. It was anciently the residence of the kings of Golconda; and the tombs of many of them are still to be seen in the midst of gardens at a short distance from the fortress.† The country of Golconda is extremely fertile, and produces abundant crops of rice and other grain. Vines are very plentiful, and a white wine is made of the grapes, which are ripe in January. The wet or winter season begins in June, and continues till January; when the great heats commence. But it is chiefly celebrated for its diamond mines, which are generally adjacent to the ridges of rocks running through the country. The principal of these mines are in the neighbourhood of Raolcondo, and Culloor, the last of which places is about 110 miles east of Hydrabad, and is situated in the midst of barren, rocky plains. The diamonds are sometimes found scattered in the earth, within two or three fathoms of the surface; and in other places they are bedded in the body of the rock, at a depth of 40 or 50 fathoms. For a particular account of these mines, see *Philosophical Transactions*, vol. xii. or of the *Abridgment*, vol. ii. See also *Mod. Univ. Hist.* vol. vi; Rennel's *Mem. of a Map of Hindustan*; and Tavernier's *Travels.* (q)

GOLD. See Chemistry, p. 17, Gilding, Gold-Beating, Mineralogy, Money, and Wire-Drawing.

Goat, Gold-beating.

GOLD-Beating is the art of reducing gold to extremely thin leaves, for the purposes of gilding. The gold employed for this purpose must be pure. It should be melted in a crucible, with a small quantity of borax, and cast into small bars, or thin flat ingots, about $\frac{3}{4}$ths of an inch wide, and weighing two ounces each. These are extended to long plates, by rolling them in a flatting-mill, until they become lengthened out like ribbands, and very thin. To effect this, the ingot must be passed between the rollers a great number of times; and to correct the hardness which the repeated rolling at length produces, the metal must be occasionally annealed, by heating it to redness, and suffering it to cool gradually.

Casting the ingot.

The rollers employed for this process should be of a most perfect cylindrical figure, and have a highly po-

Laminating.

* See *Relation de l'Inquisition de Goa*, par Dellon; and Buchanan's *Christian Researches in Asia.*

† Within the fort itself, the principal inhabitants and bankers of Hydrabad are permitted by the Nizam to possess houses, to which, upon any alarm, they retire with their treasures and families.

lished surface. They should be of a large size, that they may not yield or bend; for the ultimate perfection of the gold leaf depends very materially upon the precision with which every part of the ribband is reduced to an equal thickness. Formerly the reduction was wholly effected by hammering: in course of time, a small hand flatting-mill was used to finish the work, after a considerable extension had been produced by the hammer; but at present the most improved practice is to have the rolling done at a flatting-mill, where, by following a similar process to that which we have described under the article COINING, a ribband can be produced which will contain very nearly the exact weight required for a given surface. The gold-beater generally orders this to be at the rate of very nearly 6½ grains to a square inch; and the workman who conducts the rolling, shews his care in coming as near to this as possible. Still much depends upon the goodness of his machinery, and also upon the regularity of the ingots in the first instance.

The moulds for casting the ingots should be made of cast-iron, and the internal surface rather concave, because, in cooling, the metal contracts more in thickness at the centre than at the outside. The moulds are heated, and rubbed with linseed oil, or tallow, on the inside, previous to pouring in the metal.

The ribband being thus prepared, the gold-beater cuts it up with shears into small squares of an inch each, and having previously divided it rather accurately by compasses, the pieces will all be very nearly of an equal weight, which is about 6½ grains for the ordinary gold leaves, but is more or less as the leaves are intended to be thicker or thinner. In order to beat out these squares to greater extent, they are made up into a parcel of about 150, with a leaf of fine calf-skin vellum interposed between each square, and about 20 leaves extra at the top and bottom of the parcel. The vellum leaves are about four inches square, and the plates of an inch square are carefully laid in the centre. In order to retain the packet together, it is thrust into a case of strong parchment, which is open at each end, so that it is only a belt or band, but sufficiently broad to cover the whole packet, except the two ends; and to secure these, a second case is drawn over the packet in the opposite direction. By this means the packet is rendered sufficiently firm and compact to bear beating with a large hammer of 15 or 16 pounds weight, the face of which is circular, nearly four inches diameter, and so much convex as will make it strike more forcibly upon the centre of the square packet, and extend the small square plates regularly.

The beating is performed upon a very strong stool, or bench, framed to receive a block of marble, or other hard stone, which is about nine inches square on the surface, and as heavy as can be procured; the wood-work is carried up round the stone in the form of a ledge, rising on the two sides and at the back; and to the front edge is nailed a kind of apron, which the workman takes before him, to preserve any fragments of gold which may come out of the packet. The handle of the hammer is very short, and the workman manages it with one hand: he strikes fairly upon the middle of the packet, which he frequently turns over to beat the opposite side, but this he does in the interval between two strokes, without losing his blow. He keeps up a constant beating, and when fatigued with one hand he dextrously changes the hammer to the other, whilst the hammer is elevated in the air, and without any loss of time or force. The packet is occasionally bent, or rolled between the hands, to loosen the leaves, and render the extension of the gold more free; and the packet is sometimes taken to pieces to examine the gold, and the centre leaves put at the outside, by which means the spreading of the gold will be equal throughout the packet. The beating is continued until the gold plates are increased to nearly the same size as the pieces of vellum; they are then taken out of the packet, and each cut into four squares, by a knife drawn across them in two directions. This reduces the plates to about the same size as at first, and they are again made up for a second beating, in a packet of about the same thickness as the former; but instead of vellum, skins about five inches square, prepared from the intestines of an ox, are interposed between each. The packet is made up in cases in the same manner as before described. The second beating is performed with a smaller hammer, of about ten pounds weight, and is continued until the leaves are extended to the size of the skins. The folding of the packet must be frequently repeated during this beating, to leave the gold as free as possible between the skins; because the leaves begin now to be very delicate, and are easily broken if the beating is not very carefully performed. The leaves are spread upon a cushion, and again divided into four, by means of two pieces of cane cut to very sharp edges, and fixed upon a board crossing each other at right angles. This cross being applied upon each square leaf, and pressed upon it, will divide it into four equal portions, which are made up into a third packet of convenient thickness, and once more extended to the size of the intended leaves, which is about three inches, or three and a half square. In this state the leaves will be extended to 192 times the surface which the plates had before the beating was begun. As these plates were each an inch square, and 75 of them weighed an ounce, the surface of the ultimate leaves will be $192 \times 75 = 14400$ square inches, or 100 square feet per ounce. This is by no means so thin as they may be made, for it is very practicable to extend an ounce to 160 square feet; but the waste arising from the great number of broken leaves, and the increase of labour, renders it of very little advantage to the gold-beater to reduce them to a greater thinness; and to the gilder such thin leaves are less valuable, both because they make less durable work, and are so liable to break and waste in laying them on.

Second beating between skins.

Third beating.

Thickness of the leaves.

The leaves when finished are put into small books made of single leaves of soft paper folded, but without sewing, and the surface of the paper is rubbed with red chalk to prevent the leaves adhering. Before putting the leaves into these books, they are taken one by one, with a pair of delicate pincers, out of the packet of the last beating, and spread out upon a cushion of leather, by blowing them flat; then to cut them all to the same size, a piece of square board is applied, which has four sharp edges of cane glued upon it. These edges being pressed upon the gold, cut it to the size desired, which is generally 3¼ inches square. The books are made up to contain 25 leaves each, and in this state they are ready for the gilder.

Cutting the leaves.

The extension of the gold during the latter beating depends greatly upon the nature of the membrane or skin, which is interposed between the leaves. The preparation of these skins is kept a secret by the few individuals who furnish them to the gold-beaters. Dr Lewis describes them as being made from the skins of ox-gut, stripped off from the large straight gut cut open. A number of these membranes are laid with the smooth sides together whilst in a moist state, and will adhere together: they are then stretched in a frame, and the fat and loose skin carefully scraped off, so as to leave

Preparation of the skins.

Gold-beating || Goldoni.

only the fine exterior membrane of the gut. Afterwards they are beaten between leaves of soft paper to absorb the grease, moistened with infusions of strong spices, and are lastly dried and pressed flat. Before being used, they are rubbed over with a pounce, composed of plaster of Paris, which is rubbed strongly with a hare's foot, to prevent the gold from adhering to the membrane, which is very thin but tough, and so transparent, that small print may be read through it. The skins will serve for beating seventy or eighty times; but at length the gold will not extend well between them. It is said in the French *Encyclopedie*, that their virtues may be again restored, by placing them between papers wetted with vinegar or white wine, beating them for a whole day, drying them, and then rubbing them again with the pounce. It is also recommended to dry and press the skins every time before they are used.

Gilt-leaf. The Dutch manufacture a false gold leaf, which is made of brass covered with gold. The brass is reduced to a fine thin ribband, by laminating in the same manner as we have described for the gold. The ribband is then gilded by the wash gilding process, and afterwards cut up into pieces, which are beat out into leaves, by the same means that are used for gold beating; but the extension is not carried so far, because there is less inducement to make the leaves thin.

It is difficult to distinguish this Dutch leaf from true gold when new, but it very soon tarnishes and wholly loses its colour, which renders it unfit for any other kinds of gilding than those which are to be varnished over. (J. F.)

GOLD Coast. See Guinea.

GOLDONI, Charles, an eminent Italian dramatic author, was born at Venice in the year 1707. He displayed an early disposition for study, and could both read and write when only four years old. The perusal of the comic writers of his country was his favourite occupation. Of these, his father's small library afforded him a considerable fund; and he made it a practice to transcribe those passages which gave him most pleasure. At the age of eight, he ventured to sketch a comedy of his own invention.

His father having been called to exercise his profession of a physician at Perugia, he placed his son at the college of the Jesuits there, where he studied grammar and rhetoric; and his preceptors were so highly pleased with his proficiency, that when he was about to leave the college, they offered him a situation in their Society, which he, however, thought proper to decline. He thence went to Rimini, to pursue his philosophical studies at the college of the Dominicans. But the dry dogmas of the scholastic philosophy had no attractions for the lively mind of Goldoni, who thought himself much more usefully and agreeably employed in perusing the works of Plautus, Terence, and Aristophanes, and in attending a troop of comedians, who were then performing at Rimini. At the end of their engagement, the players prevailed upon him to accompany them to Chiozza, where his mother resided. His father was a good deal irritated at this foolish step, but soon became pacified; and intending that his son should embrace his own profession, he took him occasionally to visit his patients. The son, however, showed no inclination for the medical profession; and it was then resolved that he should study law. With this view, he was placed for some time as a clerk with his uncle, M. Indric, a respectable practitioner at Venice, and was afterwards removed to the papal college in the university of Pavia; but in the third year of his studies, he was expelled from the college, in consequence of a satirical effusion which he had been prompted to circulate against some of the inhabitants of the town, who had given him offence. After several changes of fortune, he at length engaged in practice at the bar of Venice; where he published an Almanack for the year 1732, and composed a lyrical tragedy, entitled *Amalasonte*, which he afterwards suppressed. Having been obliged to leave Venice in disgust, he removed to Milan, where he became attached to the suite of the Venetian resident. Here he composed a short comic opera, called *The Venetian Gondolier*, which was performed, and afterwards printed among his works. He afterwards returned to Venice, where he employed himself in composing pieces for the theatres. His *Belisarius*, a tragi-comedy, was represented, for the first time, on the 24th of November 1734, and experienced a most brilliant reception, having been repeated every day until the 14th of December.

Goldoni, Goldsmith.

In the spring of the following year, he accompanied the comedians to Genoa, where he married a lady of that place. From this period, he continued to compose dramatic pieces for several of the Italian theatres. In the year 1742, however, he was induced to settle as an advocate at Pisa, and he appears to have practised for some time with considerable success; but the theatre at length seduced him from his legal pursuits, and he again attached himself to a company of comedians. He accordingly returned to Venice, and continued to compose for the theatres of that and other cities of Italy, until the year 1761, when he received and accepted an invitation to Paris. Here he furnished a number of pieces for the Italian opera; and even ventured, although a foreigner, after a nine years residence, to compose comedies in the French language. One of these, *Le Bourru bienfaisant*, experienced a very flattering reception, and was admitted among the number of stock plays. He also attended some of the French princesses in the capacity of Italian teacher; and besides some presents in money, he obtained the grant of a yearly pension of four thousand livres. At the period of the revolution his prospects darkened; his pension was withdrawn; and after passing some years in poverty and distress, he died in the beginning of the year 1793, at the age af 86.

In private life, Goldoni appears to have been amiable, chearful, easy, and artless. As a comic author, he ranks high among the writers of his age and country. Like Lope de Vega, he seems to have possessed an almost miraculous fertility of conception, and rapidity of execution. In one theatrical season at Venice, he furnished no less than sixteen new comedies, besides other pieces. He also composed a great number of operas, both serious and comic; but of these he was not vain, and indeed never thought them worthy of publication. His admirable comic opera, however, entitled *La Buona Figliuola*, set to music by Piccini, and first performed in London on the 9th of December 1766, established the reputation both of the author and composer in this country.

The works of Goldoni are very numerous. The most complete edition, it is believed, is that printed at Leghorn in 1788-91, in 31 volumes 8vo. See *Memoires de Goldoni*, Paris and London, 1814; and *Monthly Magazine*, vol. v. (z)

GOLDSMITH, Oliver, was born in the parish of Forney, and county of Longford, in Ireland. He was the second son of the Rev. Charles Goldsmith, a respectable clergyman of the established church. His early education was limited to reading, writing, and arithmetic, such as could be acquired from the schoolmaster of

Goldsmith.

his native village, and might fit him for some mercantile employment. But having shewn some marks of genius, it was at length resolved to send him to the university; and accordingly having gone through the preparatory studies, he was admitted a sizer of Trinity College, Dublin, in June 1744. While here, an unfortunate quarrel with his tutor, occasioned by the imprudence of the one and the harshness of the other, blasted his hopes of distinction. He engaged in a tumult, and escaped expulsion only by making a humble confession. Nor did he atone for such follies by diligence and progress in learning. He was habitually indolent: he neither stood candidate for the usual premiums, nor did he obtain a scholarship; and it was not till February 1749, two years after the regular time, that he was admitted to the degree of Bachelor of Arts. Having lost his father, he was taken under the protection of his uncle, the Rev. Thomas Contarin, who had all along, indeed, shewn him the utmost kindness, and who persevered in his friendship towards him, notwithstanding the most provoking conduct on the part of young Goldsmith. He was at length, by this worthy relative, sent to Edinburgh about the end of 1752, to study physic. His attendance on the medical classes there was very irregular; his habits of heedlessness and folly grew upon him; and his health, as well as his finances, was greatly injured, by the dissipations in which he freely engaged. Having gone through the usual course of study, he set out for Leyden with the consent of his uncle: after having, by the generosity of two friends at college, been freed from an arrestment for debt, contracted by his thoughtlessly becoming surety for a fellow-student. At Leyden he continued for a year, studying chemistry under Gaudius, and anatomy under Albinus; but more heartily engaged in gambling, to which he was now unhappily addicted, than in the pursuits of science. Stripped of all his money, he determined to quit Holland, and to make the tour of Europe. He supported himself by various means. Sometimes he had recourse to his musical skill, playing on his flute for what the people would give him; sometimes his classical learning procured for him entertainment at the monasteries; and sometimes, by engaging in those public disputations, which were maintained in the universities and convents, he was so successful, as to be allowed a donation of money, a dinner, and a bed for the night. In this manner he travelled through Flanders, some parts of France and Germany, Switzerland, and Italy. It was while in Switzerland, that he first cultivated his poetical talents, part of his beautiful poem the Traveller having been written there, as he himself tells us. When he was in Italy, he received accounts of the death of his uncle; and the pecuniary remittances failing him in consequence of this, he was obliged to travel homeward on foot. He landed at Dover in 1756, having spent about twelve months in this strange and adventurous peregrination. He first became usher in an academy; then assistant in a chemist's laboratory; and at length commenced business as a physician, which procured for him plenty of patients, but almost no fees. In 1758, through the kindness of Dr Milner, a dissenting clergyman, he was appointed physician to one of the factories in India. To equip him for that situation, (into which, after all, he never entered) he composed "The Present State of Polite Literature in Europe." This work was printed in 1759. Before it appeared, he laboured as a contributor to the Monthly Review. His contract with the editor was favourable to Goldsmith; but it was dissolved by mutual consent at the end of seven or eight months. His circumstances continued to be narrow. While under arrest for debt, he produced that inimitable novel, the Vicar of Wakefield, for which he received £60. On May 31st 1761, he received his first visit from the celebrated Dr Johnson. Besides correcting and revising many publications for Mr Newbery, he wrote his Letters on English History, in 2 vols. 12mo, which have been by mistake attributed to Lord Lyttleton, and other noble authors; conducted a Lady's Magazine; contributed to the "Bee;" and produced a periodical paper called "The Ledger." This last work was afterwards collected into 2 vols. 12mo, and entitled the Citizen of the World: It is characterised by fine sentiment, and exquisite humour. But his chief attention was bestowed on The Traveller, which he brought out in 1765, on which he intended to build his poetical fame, and which did procure for him both high reputation, and considerable patronage. His charming ballad the Hermit, recommended him to the Duchess of Northumberland. In 1764, the famous Literary Club was established; Goldsmith was one of its first members, and continued in it till his death. In 1768, his comedy of "The Good-natured Man" was first represented at Covent Garden, and kept possession of the stage for nine nights. And in the year following, he produced his fine and popular poem of the "Deserted Village." While preparing these pieces for the press, he undertook and completed his "Roman History," in 2 vols. 8vo, and his "History of England," in 4 vols. 8vo,—works intended for the perusal of the young, and certainly written in an interesting manner, but almost always superficial, and frequently inaccurate. The History of England was finished in two years, and he received for it £500. He was employed all this time in literary efforts of an occasional and inferior kind; such as prefaces, introductions, and prospectuses. It was one of these that led to the publication of the "History of the Earth and Animated Nature," a production entertaining and well written, but unfortunately abounding in errors. He also wrote a "Life of Parnell," of which Johnson speaks in terms of high approbation. In preparing his "Beauties of English Poetry," he introduced, inadvertently, an indecent tale from Prior, which blasted the success of the selection, as it was chiefly intended for the use of boarding schools. The life of Lord Bolingbroke, prefixed to that nobleman's Dissertations on Parties, was the production of Goldsmith's pen, though his name was not affixed to it in the first edition. When the Royal Academy was established, Sir Joshua Reynolds procured for him the appointment of professor of ancient history,—an appointment without salary or trouble, but in other respects honourable and useful to him.

On the 15th March 1773, his second comedy, "The Mistakes of a Night, or She stoops to Conquer," was produced at Covent Garden, was received by the audience with great applause, kept possession of the stage as a stock play, and increased his literary reputation. A scurrilous paper, occasioned by his success, and inserted in a London paper, so provoked him, that he went to the editor and assaulted him; but the Doctor got himself severely bruised in the scuffle. He was led into this quarrel by the officiousness of a pretended friend. About this time, he wrote "The Retaliation," "The Haunch of Venison," and some other small pieces, which did not appear till after his death. A great project now entered his mind; it was "An Universal Dictionary of Arts and Sciences." He had engaged his literary friends to assist him, and had actually prepared a prospectus of the work. But his plan was interrupted by a fever, which terminated his life on the 4th of April 1744. He was privately interred in the Temple burial ground. A marble monument was afterwards erected to his memory in Westminster Abbey, between those of Gay and the Duke of Argyle, in the poet's corner. The inscription was written by Dr Johnson, and contains a very just though concise delineation of his merits. As a man, he was constitutionally kind, but exceedingly improvident, and acted according to impulse rather than principle. As a writer, he must be regarded as standing in the very foremost rank of the British classics. In both views, simplicity may be considered as his leading characteristic. (τ)

GOLF, is an ingenious field game, played with bats or clubs, and balls, and a favourite amusement in Scotland. When or by whom it was first introduced, is not ascertained; but we find, that as early as the fifteenth century, it was so much in vogue as to be an object of attention to the legislature. The parliament of Scotland, assembled under James II. in 1457, passed an act prohibiting golf and foot-ball, as being found to interfere too much with the acquisition of dexterity in archery, an accomplishment in those days of such consequence to the safety of the state. "It is decreed and ordained," says the act, "that the foot-ball and golf be utterly cried down, and not to be used, and that the bow-marks be made at ilk (*each*) parish kirk a pair of butts, and shooting be used. And that ilk man shoot six shots at the least, under the pain of being raised upon them that comes not, at the least two pennies, to be given to them that comes to the bow-marks to drink." This shows that golf was at that period known and much practised. And as in the former reign, viz. of James I. anno 1424, we have a similar act of parliament, prohibiting foot-ball, without any mention being made of golf, we think the probability is, that golf was not then known:—certainly it was not much practised.

In both the subsequent reigns of James III. and James IV. we have similar acts of parliament against foot-ball and golf. Under the first of these monarchs, in 1471, it is enacted, "that foot-ball and golf be abused, (that is disused) in time coming; and that the buts be made up, and shooting used, after the tenor of the act of parliament made thereupon." In the reign of James IV. 1491, it is statute and ordained, "that in no place of the realm there be used foot-ball, golf, or other such unprofitable sports," under the penalty of forty shillings. All these statutes were evidently framed, not from a conviction that there was, in the manly and athletic exercises of foot-ball and golf, any thing injurious either to the health, the morals, or the loyalty of the subject; but because they drew the attention too much from the attainment of skill in martial exercises, at a time when the situation of the country so eminently required it.

The ground over which golf is played, is in Scotland called links, and is usually a particular sort of sandy soil in the neighbourhood of the sea-shore, its surface mostly covered with short close grass, here and there interrupted by breaks, pits, and inequalities. These interruptions are necessary to impart interest to the game.

The track along which the players proceed, is denominated the course, and may be either rectilinear, or a figure of any number of sides. Holes are made in the ground of about four inches diameter, and at the distance of four hundred yards, or a quarter of a mile from each other; and the object of the game is to strike a ball from one of these holes into the next with as few strokes as possible. A game may be said to terminate at each of these holes, and their number is not limited, but depends on the nature of the ground.

Balls are used of about $1\frac{1}{4}$th of an inch in diameter, and weighing from 26 to 30 drachms avoirdupois. They are made of strong alumed leather, and stuffed with feathers. The feathers are forced in at a small hole left in the covering, by a blunt pointed iron instrument, which the maker applies to his shoulder, and the operation is continued till the ball acquires a surprising degree of hardness and elasticity. A good workman makes about nine balls in a day. When dry, they are painted with white oil-paint, to exclude the water, and render them easily seen. In playing, they are struck with a bat or club, four feet in length, having a small tapering elastic shaft, with a crooked head, into which is run a quantity of lead to render it heavy, and it is fortified by a piece of horn before. A good player, with one of these clubs, will strike a ball to the distance of 180 or 200 yards. Every golfer has a variety of clubs, differently formed, and adapted for playing in different situations of the ball, and in different stages of the game. A set consists of four at least, viz. the common or play-club, the spoon, the putter, and the iron; but most golfers have ten or a dozen different sorts. The common club is used when the ball lies fair on the ground; the spoon, when in a hollow; the iron, when among sand, gravel, or stones; and the putter, when near the hole.

A match may consist of two or more players; but no proficient at golf every plays in one exceeding four, that number being allowed to be the most elegant and convenient. Each party has a ball, and the rule is, that at the beginning of a hole or game, the player may elevate his to what height he chooses for the convenience of striking, and this is done by means of a little sand or earth, and is called *teeing*; but after the first stroke has been made, the ball must be played from the spot where it chances to lie. And whichsoever of the balls lies farthest back, or at the greatest distance from the hole to which the players are proceeding, must be always played till it get before the other.

Thus, suppose A and B to be engaged in a match. A plays off, and then B. A's ball lies farthest behind, and therefore, by the rules of the game, he is obliged to play again. This is called playing *one more*, or *the odds*. But A misses his ball, or sends it only to so short a distance, that it is not yet so near the mark as B's. A must therefore play a third time, and this is called playing two more; and should it so happen, that, even at this stroke he does not get his ball laid nearer to the hole than that of B, he must then play three more, and so on.

When B then plays, he is said to play *one off three*; and if he plays a second time in order to get before A's ball, he is said to play one off two; and if a third time, one off one, or *the like*. Then whoever of the two plays first, again plays the odds. But if when B played one off two, or one off three, A had been to play next, he would then have played two more, or three more, respectively. If the party consists of four, the rule is the same, except that the two partners on each side play alternately. If the ball be struck into the hole at *the like*, or an equal number of strokes on both sides, the hole is said to be halved, and goes for nothing.

To play this game, will require more dexterity and practice than is commonly imagined. But an idea of its difficulty may be formed by considering the smallness of the object struck, compared with the largeness of the circle described in the swing round with the club; the accuracy required to keep the course, and to measure the force applied in such a manner as to avoid hazards and over-driving the ball when approaching the end of the range; also the judgment requisite to determine the most advantageous club to be used in any given situation of the ball; as well as the allowance to be made for the force and direction of the wind when there happens to be any, and the nature and inequalities of the ground. (*)

GOMBROON, or Bender Abassi, the Harmozia of the ancients, is a town of Persia, in the province of Kerman. It is situated in a barren country, on a bay of the gulf of Ormuz. The town is large, and the houses more commodious than in other parts of Persia. It is fortified with double walls, and is defended by the fort of Minah, which stands partly on a hill, and is divided into the upper, the centre, and the lower, forts. A small river breaks through the hills, and forms a pass from the east, and its water, diffused by means of canals, serves as ditches to the fort. The country, for about 45 miles round, is covered with villages, and supplies all the neighbouring districts with grain and dates. The cattle of the adjoining districts are sent here in great numbers to feed during the hot season.

Gombroon was formerly the first sea-port in Persia, and it is still a place of considerable trade. The English settled here in 1613. In 1620, the Dutch followed their example; and, upon the taking of Ormuz, in 1622, merchants flocked here in great numbers. In 1759, it was taken by the French; but though the English factory was afterwards re-established, yet, from the heaviness of the expence, and the unhealthiness of the climate, it has long ago been withdrawn. Gombroon is now subject to the Imam of Muskat. The customs amount to 20,000 rupees annually; and for this, as well as the tribute of Minah, the Imam is accountable to the King of Persia. East Long. 56° 12′, North Lat. 27° 81′. See Milburn's *Oriental Commerce*, vol. i. p. 131; and Kinneir's *Memoir of the Persian Empire*, p. 201.

GOMERA, one of the Canary Isles, is situated about six leagues S. W. from Teneriffe, and is about 20 miles long, and 10 broad. The chief town in the island is St Sebastian, or La Villa de la Palma, which stands upon the shore in the bottom of a bay on the south-east side of the island, where shipping is secure from all winds except the south-east. Ships of any burthen may heave down and repair at the cove, hauling close to the shore, which is a high and perpendicular cliff. A battery, with several pieces of cannon, are placed on the summit, for the defence of the harbour. At a short distance from the beach the town commences, the principal street running straight inland. The houses, to the number of 150, are small and mean; the only public buildings are a church and a convent. It is supplied with good water. An account of the trade, &c. of this place, will be found under our article Canary Isles. Population 7000. West Long. of the harbour 17° 7′ 45″, North Lat. 28° 5′ 40″.

GONDAR, the capital city of Abyssinia, is situated in 12° 34′ 30″ North Latitude, and 37° 33′ East Longitude from Greenwich. It is placed upon a hill of considerable height, the top of which is nearly plain, and which is surrrounded on every side by a deep valley. The river Kahha, which comes from the Mountain of the Sun, runs through the valley on the south side of the town, and the river Angrab, falling from Woggora, surrounds it on the north and north-east. These two rivers unite their waters at the bottom of the hill, about a quarter of a mile south of the city. The houses of Gondar are constructed chiefly of clay, and the roofs are of a conical form, covered with thatch. The principal public building is the palace, at the west end of the town, which is said to have been built in the time of Facilidas, by masons from India, and by such Abyssinians as had been instructed in architecture by the Jesuits. It had been originally a square building, four stories high, and flanked with square towers; but having been burnt at different times, great part of it was in ruins during Mr Bruce's residence in Abyssinia. Some of the apartments, however, still exhibited proofs of their ancient magnificence. In one chamber the walls had been covered with plates of ivory, stained with stars of various colours; and in another the skirting was finished with ivory, four feet from the ground; and over it were arranged, around the room, three rows of Venetian mirrors, fixed in frames of copper, while the roof was formed of split painted cane, disposed in Mosaic figures, in the gayest style. There was still ample lodging in its two lowest floors, and the audience chamber alone was above 120 feet in length. Successive sovereigns have built apartments by the side of the original edifice, which are formed of clay, and according to the fashion of the country; but the whole structure, and these contiguous buildings, are surrounded with a substantial stone wall, 30 feet high, and the four sides of which are above an English mile and a half in circumference. There are battlements upon the outer wall, but no appearance of embrazures for cannon; and a parapet roof between the outer and inner wall forms a gallery, by which a person can go along the whole, and look into the street. In times of peace, Gondar contains above 10,000 families, or 50,000 souls. One of its principal manufactures is a kind of coarse carpet made of the wool of the sheep and hair of the goat dyed red or light blue. See Bruce's *Travels in Abyssinia*, vols. iv. and v. 8vo; Valentia's *Travels*, vol. ii. and Salt's *Travels*. (*q*)

GONG, is the name of an instrument used among the Chinese for producing loud sounds by percussion. It is a large circular instrument, somewhat resembling a tambourine. It is entirely made of metal, and has its face somewhat convex. The metal, which resembles bronze, bears numerous marks of the hammer in every part. A string passes though a hole in the rim, and when the gong is suspended by this string, it is beaten on the centre by repeated gentle strokes of a spherical mallet, covered with folds of woollen cloth. When it is properly struck, it emits an overpowering sound, which may be heard at more than the distance of a mile. Gongs are manufactured openly in Canton; and the largest kinds are made in one of the interior provinces of China. They are generally carried on a pole by two men, and beaten by the hindmost, and are commonly used at processions and at festivals, and also for the purpose of regulating the steps of the soldiers.

The metal of which the gong is composed is brittle, and very elastic, and has a granular texture. Dr Wollaston found it to be quite malleable at a temperature considerably below that of red heat. He determined the composition of the metal, and having made a quantity of similar alloy, he mended a crack in a gong belonging to Sir Joseph Banks, and restored the tone of the instrument. Klaproth found that the specific gravity of the gong was 8.815, and that it consisted of

Copper	78
Tin	22
	100

Dr Thomson found that its specific gravity was 8.953, that its thickness varied from one-fifteenth to one-twentieth of an inch, and that it was composed of

Copper	80.427
Tin	19.573
	100.000

Mr Murdoch has recently discovered not only the proper composition, but also the mode of manufacturing gongs; and in the course of his investigation has obtained several interesting results, which we hope to be able to communicate in a subsequent article. See Gehlen's *Journal, Second Series*, vol. ix. p. 408; and Thomson's *Annals of Philosophy*, vol. ii. p. 208. 315, 316.

GONIOMETER, from γωνια *an angle*, and μετρειν *to measure*, is the name of a class of instruments for measuring the inclination of one plane surface to another. As the principal use of these instruments is to measure the angles of crystallised bodies, they were first introduced, and are now principally used, by mineralogists; although those which depend on the principle of reflexion, are of the most essential utility in many branches of physics, particularly in optical experiments.

Common goniometers.

In our article CRYSTALLOGRAPHY, p. 454, we have already described the goniometer used by Romé de Lisle, and M. Hauy, and invented by M. Carangeau, (see Plate CCXXIII. Fig. 34.) and in the same article we have given drawings and descriptions of the new reflecting goniometers invented by Dr Wollaston and Dr Brewster. See Plate CCXXIV. Figs. 1. and 2. The present article will therefore embrace some additional remarks on the applicacion of the principle of reflexion, and an account of some other goniometrical instruments which could not with propriety have been introduced under the head of CRYSTALLOGRAPHY.

The reflecting goniometers of Dr Wollaston and Dr Brewster were invented nearly about the same time, without any communication between their respective authors; but though these instruments resemble one another in so far as they both make use of the principle of reflexion, yet they differ very widely in the application of that principle, and in the mode of measuring the angles of crystals.

Reflecting goniometers by Wollaston and Brewster.

Plate CCLXXVII. Fig. 1, 2, 3.

One of the advantages which Dr Brewster's goniometer possesses over that of Dr Wollaston's, is, that the former is capable of measuring a hollow angle, such as *a b c*, represented in Plate CCLXXVII. Fig. 1. and 2. or one in which the crystal *a b c*, Fig. 3. is imbedded in a stony mass from which it cannot easily be detached. The case represented in Fig. 2. is one which actually occurs in measuring the angle which the edge of the interrupting stratum, or crystallised vein of some specimens of Iceland spar, forms with the surfaces of the rhomboid. The determination of this angle is of the utmost importance, and is incapable of being measured by any goniometrical instrument with which we are acquainted, excepting that of Dr Brewster's. See *Philosophical Transactions* for 1815, p. 277.

This goniometer will measure the angles of crystals with great accuracy, and little trouble, if the surfaces are moderately smooth, and reflect the smallest quantity of light. When the surface has the appearance of being perfectly rough and irregular, the oblique reflection generally gives a very distinct image of a vertical bar, when the image of a horizontal line or of any other object could not possibly be obtained. It frequently happens, however, that the crystal does not reflect sufficient light to form an image, or is so irregular in its surface, or is so inconveniently placed in the specimen, that a variety of different contrivances must be adopted for measuring its angles. In a specimen of Allanite, for example, belonging to Mr Allan, the crystals are situated in such a manner, that their angles could not be measured by any goniometer without breaking off some of the projecting parts of the mineral.

Brewster's goniometer.

Plate CCLX[illegible] Fig. 4.

When the planes of the crystal are smooth, but unpolished, a small piece of parallel glass AB, Fig. 4. or any other reflecting substance, with parallel sides, is successively placed upon the surfaces of the crystal CDE; the coincidence of the direct image of a rectilineal object with the image reflected from the piece of glass, is observed as before, and the angle found in precisely the same manner. If the two surfaces of the reflector should not be parallel, the aberration will be corrected by reversing its position on the second surface of the crystal.

Fig. 5.

When the planes of the crystal are covered with asperities which prevent the piece of glass from lying parallel to these planes, we must make use of the reflector AB, Fig. 5. supported by three slender feet, and so formed that the reflecting plane *m n* is exactly parallel to the plane *o p*, passing through the extremities of the three feet. The three feet are then placed upon those points of the surface where there are no asperities, and the coincidence of the images is observed in the reflector: It is then transferred to the other surface of the crystal, the coincidence of the images again observed, and the angle of the planes measured as before. As the surface of the crystal may always be brought into a horizontal position when the coincidence of the object and its image is observed, the reflector will stand steadily on the planes of the crystal; but, in order to secure it from sliding, a drop of varnish or melted bee's wax may be placed round each of its feet. It might be proper to have two or three of these reflecting tripods of different sizes, and with their feet at different distances, in order to accommodate themselves to the smooth parts of the crystal. One of the reflectors might be fixed on each surface with bee's wax, in the way represented in Fig. 6. where C is the crystal, and A, B the two reflecting tripods. If the position of the crystal should prevent us from adopting either of these methods, which was the case in the specimen of Allanite already mentioned, we must have recourse to the goniometrical microscope, which is intended to measure the angles formed by two lines when the eye is perpendicular to the plane of the angle.

Fig. 6.

If we conceive the two surfaces of a crystal to be cut by a plane perpendicular to their common section, the apparent angle contained by the two lines which form the boundary of the section, when the eye is perpendicular to the section, is evidently the inclination of the planes. But if the cutting plane is not perpendicular to the common section, the apparent angles of the lines which form the boundaries of the section when viewed by an eye perpendicular to it, is evidently greater or less than the real angle of the crystal, according to the position of the cutting plane. If the observer, however, places himself in such a manner, that the common section of the planes is parallel to the axis of his eye, then the apparent angle formed by the bounding lines of the section, whatever be the position of the cutting-plane, is the real angle of the crystal. By placing the crystal therefore, in this position, in the focus of the goniometrical microscope, which shall be hereafter described, and measuring the apparent angle formed by the bounding lines, we obtain, by a very simple process, the inclination of the planes.

Fig. 7.

This will be understood from Fig. 7. in which ABCDEF is a crystal, ABC a section of it perpendicular to AD, and A *b c* an oblique section. Now, though BAC is the real angle of the crystal, yet, when the oblique section A *b c* is viewed by the observer at O, its bounding lines A *b*, A *c* are apparently coinci-

Goniometer. Brewster's goniometer. PLATE CCLXXVII.

dent with the lines AB, AC, whose inclination is the real angle of the planes; and therefore, if we measure by a proper instrument, the apparent angle contained by the oblique lines A b, A c, we obtain a measure of the real angle of the crystal.

The angles of the crystal may also be advantageously deduced, from the plane angles by which any of the solid angles is contained. The plane angles are first measured with great accuracy by the goniometrical microscope, or the angular micrometer adapted to a microscope, and the inclination of the planes is deduced from a trigonometrical formula. Whatever be the number of plane angles which contain the solid angle, we can always reduce the solid angle to one which is formed by three plane angles, and determine by the formula the inclination of any two of them. Thus, if the solid angle at A, Fig. 8. is contained by five plane angles, and if it is required to find the inclination of the planes ABC, ACD, we first measure the plane angles CAB, CAD, and also the angle contained by the lines AB, AD; so that we have now reduced the solid angle contained by five plane angles, into one contained by three plane angles, CAB, CAD, BAD.

Fig. 8.

Legendre, in his Elements of Geometry, has given a very elegant solution of this problem by a plain construction; and it is easy, from his solution, to form an instrument for shewing the angles of the planes without the trouble of calculation. Thus let the angles BAC, CAD, DAE, Fig. 9. be made equal to the three plane angles by which the solid angle is contained. Make AB equal to AE, and from the points B, E let fall the perpendiculars BC, ED on the lines AC, AD, and let them meet at O. From the point C, as a centre with the radius CB, describe the semicircle BFG. From the point O draw OF at right angles to CO, and from F, where it meets the semicircle, draw FC. The angle GCF is the inclination of the two planes, CAD, CAB. In order to construct an instrument on this principle, to save the trouble of projection or calculation, we have only to form a graduated circle BHEG, with three moveable radii, AC, AD, AE, and a fixed radius AB. The moveable radii must have vernier scales at their extremities, that they may be set so as to contain the three plane angles which form the solid angle. Two moveable arms BG, EO, the former of which is divided into any number of equal parts, turn round the extremities B, E; and, by means of a reflecting mirror on their exterior sides, they can be set in such a position as to be perpendicular to the radii AC, AD. When this is done, the number of equal parts between C and O, divided by the number between B and C, is the natural co-sine of the angle GCF; and therefore, by entering a table of sines with this number, the inclination of the two planes will be found.

Fig. 9.

In order to obtain a more accurate result, however, we must have recourse to a trigonometrical formula. Let A, Fig. 10. be the solid angle, and let it be required to determine, by means of the three plane angles, the inclination of the surfaces ACB, ACD. Draw AM, AN in the planes ACB, ACD, and perpendicular to the common section AC; join BM, DN. Then it is obvious, that the angle MAN is the inclination of the planes required, and that the angle BAD, which is an oblique section of the prism BM, will be equal to MAN when it is reduced to the plane AMN. By considering that the inclinations of the bounding lines of the oblique section of the prism, to the bounding lines of the perpendicular section, are measured by the angles DAN, BAM, the complements of the two given plane angles CAD, CAB, we shall obtain, by spherical trigonometry, the following formula:

Fig. 10.

$$\text{Sin.}\,\frac{\text{MAN}}{2} = \frac{\text{R}\sqrt{\left(\text{Sin.}\,\frac{\text{BAD}+\text{CAD}-\text{CAB}}{2}\,.\ \text{Sin.}\,\frac{\text{BAD}+\text{CAB}-\text{CAD}}{2}\right)}}{\text{Sin. CAB. Sin. CAD}}$$

Or, calling φ the angles of the surfaces of the crystal, B, C the plane angles at the vertex of these surfaces, and A the other plane angle, then we shall have

$$\text{Sin.}^2\,\frac{\varphi}{2} = \text{Rad}^2\frac{\left(\text{Sin.}\,\frac{\text{A}+\text{B}-\text{C}}{2}\,.\ \text{Sin.}\,\frac{\text{A}+\text{C}-\text{B}}{2}\right)}{\text{Sin. B. Sin. C.}}$$

a formula from which the value of φ may be obtained by a very simple calculation.

Let the angle BAD, for example, be 62° 56′, the angle CAD = 100° 2′, and the angle CAB = 106° 10′, then we shall have, by the preceding formula,

$$\text{Sin.}^2\,\frac{\varphi}{2} = \text{Rad.}^2\,\frac{\text{Sin. } 28^\circ\, 24'\ \ \text{Sin. } 34'\, 32''}{\text{Sin. } 106^\circ\, 10'\ \ \text{Sin. } 100^\circ\, 2'};$$

Now we have,

Log. sin. 28° 24′ . .	9.6772640
Log. sin. 34° 32′ . .	9.7534954
	19.4307594
Add 2 Log. of Rad. .	20.0000000
	39.4307594
Log. sin. 106° 10′ . .	9.9824774
Log. sin. 100° 2′ . .	9.9933068
	19.9757842
From	39.4307594
Subtract	19.9757842
2 Log. sin. $\frac{\varphi}{2}$ . . .	19.4549752
Log. sin. $\frac{\varphi}{2}$ . . .	9.7274876

Hence $\frac{\varphi}{2} = 32^\circ\, 16'\, 18''$

and $\varphi = 64^\circ\, 32'\, 36''$

the angle of the surfaces of the crystal.

A goniometer, upon another principle, has recently been invented by the Rev. E. J. Burrow, fellow of Magdalene College, Cambridge. The following is the description of it given by himself:

Burrow's goniometer.

"BG (Fig 11.) is a steel bar, of about $\frac{1}{12}$ of an inch square, chamfered off to the point B. On BG is taken exactly an inch, BA, and A is made the centre of motion of the legs DE and de, of which DE is also brought to a point at D to correspond with B. To the other end of these legs is attached by the pin F, a moveable quadrant, passing through the bar BG at C, and graduated to read towards the side of the shorter leg de. The handle GH is made to project on the opposite side to that on which the legs move, that it may not interfere with the use of a brass degree divided into minutes, to be attached to the centre A upon longer radii. The leg AB is divided accurately into tenths, and the two nearest the point B into twentieths, and these again into fortieths. The whole instrument is about four inches and a half long.

Fig. 11.

Now if the crystal, the angle of which is to be mea-

Goniometer. Burrow's goniometer. PLATE CCLXXVII. Fig. 11.

sured, be detached, it is obvious, that, if an acute one, by applying it to the angle BAD, the vertical and equal angle EAC will be given on the quadrant; if obtuse, by applying it to the angle E and B, we obtain its supplement EAC. But if the crystal be imbedded in the matrix, so that with the common goniometers having the moveable vertex, it is difficult to procure a mechanical measurement of the protruding angle, we take any distance from the vertex of the crystal measured upon the scale of tenths, &c.; and placing one point of the instrument, (*ex. gr.*) on x (Fig. 12.) and the other on z, so as to make the triangle $x\,y\,z$ isosceles, we get upon the quadrant the angle which the base $x\,z$ subtends at the radius one inch; and we have the side $x\,y$ measured. As, therefore, when the object is given, the angle it subtends, and $\frac{1}{\text{rad.}}$, we have the proportion $x\,y$: AB : : angle found : angle sought. And as the whole radius is one inch divided into tenths, this proportion is easily made in the head.

Fig. 12.

The short bar is added for the better carrying of the quadrant, and renders the instrument useful in geological observations, to ascertain the inclination of strata. This is done by hanging a small plummet to a hook at A, and having made the angle which it forms at BC a right angle, and moving the outer bars, till their upper line coincides with the stratum, the angle of inclination will be given on the quadrant."

We shall now conclude this article with the description of a goniometrical telescope, and a goniometrical microscope, invented by Dr Brewster, and described in his *Treatise on New Philosophical Instruments.*

Brewster's goniometrical telescope. Fig. 13.

This instrument is represented in Fig. 13, where TT is the eye-tube of the telescope, which carries the graduated circle AB, divided into 360 degrees. By means of the milled head which surrounds the eye-glass at E, this circle has a motion of rotation about the axis of the eye-tube. The vernier V has likewise a motion round the axis of the instrument, and may be set to the zero of the scale, when the level L, fixed to the plane surface of the graduated circle, is adjusted to a horizontal line. On the same surface, parallel to the axis of the level, there are fixed two screws, (one of them is seen at s,) on which the arm DF may slide to or from the eye-glass E. This arm is bent into a right angle at D, and carries a frame, in which the small reflecting plane O, made of black glass, is fitted so as to have a rotatory motion about the axis $a\,b$.

When an angular object appears in the field of the telescope, the arm DF is pushed backwards or forwards, till the mirror O is near the centre of the eye-glass, and it is then turned round its axis $a\,b$, by means of the lever h, till the observer, by looking through the eye-glass, and into the mirror at the same time, perceives a distinct reflected image of the field of view, and the angular object which it contains. The graduated circle AB is then moved round its centre, till the reflected image of one of the lines which contains the angle is continuous with the line itself, and the degree pointed out by the index is noted down. The circle is again made to revolve till the image of the other line is continuous with the line itself, and the place of the index is again marked. The arch of the circle intercepted between these positions, is the measure of the angle required. To save the trouble of reading off a second line, the vernier may be placed at the zero of the scale, when the first coincidence has been observed.

In order to explain the theory of this instrument, let ABC, Fig. 14. be a plane angle seen in the field of the telescope, and MN the section of a reflecting mirror, which moves along with the graduated circle. When the side BC is in the same straight line with its image CE, BC is perpendicular to MN; and when, by the motion of the divided circle, the mirror MN is brought into a position $m\,n$ perpendicular to the other side AB, the arch described by the moveable circle is evidently a measure of the angle formed by the lines AB, BC. The angular motion of the mirror, in passing from the position MN to $m\,n$, is not measured by the angle AOC, formed at the centre O by AO and CO, but by the angle FOG, which is equal to ABC. This will be evident from considering, that the lines AB, CB are parallel to FO, GO, and that the same angle would have been obtained, by taking the reflected image of the lines FO and GO.

Goniometer. Goniometer. PLATE CCLXXVII. Fig. 14.

When the instrument is required to measure the apparent angle which any right line makes with the horizon, the index of the vernier should point to zero when the level is adjusted to the horizon; and then, by turning round the graduated circle till the coincidence between the direct and reflected image of the right line is observed, the index will point out the angle required.

Goniometrical microscope. Fig. 15.

The goniometrical microscope is represented in Fig. 15, and is nothing more than the application of the preceding contrivance to a microscope. See Nicholson's *Journal*, Jan. 1809, vol. xxii. p. 1. and Brewster's *Treatise on New Phil. Instruments*, p. 97—106, 110.

GONORRHŒA. See MEDICINE and SURGERY.

GOREE, is an island in the Atlantic, on the west coast of Africa. It is about 30 leagues from Senegal, about 1 league from the Terra Firma of Cape Verd, and about 3 leagues from that Cape itself. The island is about 800 yards long and 240 broad, and is surrounded on all sides by inaccessible rocks, excepting in one small place to the east-north-east, contained between two points, one of which is high and the other flat, and covered with a bank of sand. This place forms a natural and secure harbour. A late director of the island, M. de St Jean, erected a new fort, and several buildings, discovered springs of good water, and planted a variety of vegetables and fruit trees. The air is cool and temperate during the whole of the year; and the inhabitants are refreshed by alternate breezes from the land and sea.

This island was ceded to the Dutch in 1617, by Biran, king of Cape Verd. It was immediately strengthened by Nassau Fort on the north-west, and afterwards by Orange Fort, a little nearer the shore. In 1663, Admiral Holmes took it from the Dutch. In 1665, it was retaken by Ruyter; but in 1677 it was taken, after some resistance, by the French under the Count D'Estrées. The English took the island from the French in 1692, and restored it in 1693. Since that time, it continued in the possession of the French with a few interruptions, and was guaranteed to them by the treaty of 1783. It was taken by the British in the late war. West Long. 17° 24′ 45″, and North Lat. 14° 40′ 10″. Those who wish for very particular information respecting Goree, may consult Prelong's *Memoire sur Goree*, in the *Annales de Chimie* for 1793.

GORITZ, GORZ, or GORITIA, is a town of Germany, situated in a district of the same name. The town is handsome, and is picturesquely situated on the river Lisonzo. A great number of the houses are good, and belong to noble families. It has seven convents, nine chapels, and a college. The opera-house, though not very neat without, is elegant and commodious within. The fort commands an extensive view over the surrounding country. On the north side of the town are eminences of moderate height, affording all the characteristics of the finest Swiss scenery; while on the south, the plain country exhibits all the beauties of an Italian climate.

The district of Goritz contributes annually along with Gradisca, an insignificant town, 41,502 florins to the maintenance of the army. The country produces wine, fruits, silk, and corn. Population 12,000.

GORLITZ is a town of Germany in Upper Lusatia. It is situated on the river Neisse. Besides the cathedral, there are two churches within the walls, and three without. The organ is reckoned the finest in Europe, next to that of Haarlem. The great spire, the chapel of St George cut out of the rock, the public library, and the collections of the Society of Sciences of Upper Lusatia, are worthy the notice of strangers. The mountains of Gorlitz near the village of Konigshayn, about 4 miles from the town, are composed of vast masses of granite; on one of which, a lofty granite column has been erected to the memory of M. Von Schachman, the proprietor of Konigshayn. Numerous fragments of granite are scattered around these mountains. On the road from Gorlitz to Konigshayn, is situated the once celebrated holy sepulchre. It is an exact representation of that which was shewn in Palestine in the 15th century. The baths of Liebwerda, about five miles from Gorlitz, are generally visited by strangers. Gorlitz has long been celebrated as a flourishing manufacturing town. Cloth is fabricated here in great quantities; and during the last 20 years, considerable improvements have been made, particularly in the quality of that article, by the attention which is paid to the breed of sheep, and the importation of Spanish rams. Linen and cotton stuffs are also manufactured here. Population 8500.

GOSPORT, is a seaport town of England, in Hampshire, situated on the west side of Portsmouth Harbour. This town, which flourishes particularly in times of war, consists of a principal street extending westward from the harbour to the fortification, with the obstruction only of the market-house, and of other streets parallel to the principal one, and crossed by various streets of a smaller size. Different ranges of buildings stretch also along the shore and near the fortification. Gosport is fortified on the land side by a line of bastions, counterscarps, &c. which extend from Weovil to Alverstoke Lake. The king's brewery and cooperage, with storehouses for wine, malt, and hops, are within the works on the Weovil side. The new barracks are also on the Weovil side. Gosport is a chapelry to the village of Alverstoke. The chapel stands to the south of the town, in a well-wooded cemetery. It is a large building, neatly fitted up. There is also here a Roman Catholic chapel, and a meeting-house for the Dissenters, who have an academy for the education of young clergymen, under the management of Dr Bogue. There are at Gosport several charity-schools, an alms-house, and a large and airy work-house for the poor. The principal manufactures here are an iron foundery, and several breweries. A neat theatre has been erected at Gosport.

This town communicates with the sea by means of a large bason and canal, with extensive quays, where vessels of considerable size can take in their stores. Ferry-boats are constantly passing and repassing across the harbour between Gosport and Portsmouth.

Near Gosport is situated the royal hospital at Hasler, for the reception of sick and wounded seamen, which was erected between 1746 and 1762. It stands within 400 yards of the extremity of the point of land which lies to the west of the entrance to Portsmouth harbour. The front is about 567 feet long, and it has two wings, each of which is about 552 feet long. It can accommodate 2000 patients, and has an annual expenditure of £5000. The following is an abstract of the population of the town of Gosport for 1811.

Inhabited houses	1439
Number of families	1614
Families employed in trade	385
Males	3483
Females	4305
Total population	7788

See Warner's *Topographical Remarks relating to the South-western parts of Hampshire;* and the *Beauties of England and Wales*, vol. vi. p. 310.

GOSSLAR, is a large town of Westphalia, situated on the river Gose. The magnitude of this town forms a very singular contrast with its population, which does not exceed 6000, the number of houses being no fewer than about 1500. The cathedral church of Gosslar is the only remarkable building which the town contains. It possesses the altar of Crothos, one of the deities of the ancient Saxons, who sacrificed to it infants. It was brought from Harzburg, and is considered as a genuine piece of antiquity by the antiquarians of the town. It is a brass chest, perforated on every side, so that the flames could strike through to consume the victims which lay upon it. There is also here a Christian altar, encircled with large metallic columns. It was found at Harzburg, and is regarded as a monument of the heathen ages in Saxony. This town is celebrated for its excellent beer called Gose. There are seven different species of it, the best of which is called Beste-Krug. It is a very spirituous drink, and tastes more of wine than of beer. There are here also manufactories for vitriol, paper, and fishing-nets.

GOTHA, anciently *Grimmestein,* and afterwards *Friedenstein,* is a town of Germany in Upper Saxony, situated on an eminence near the Leine, which supplies the town with water, conveyed to it in stone canals. Gotha is one of the handsomest towns of Thuringia. The Ducal Palace stands on a height above the town, and contains a museum of natural history, a library, a cabinet of medals, and a splendid collection of prints, paintings, geographical charts, and mathematical and physical instruments. This excellent collection, which has been recently enlarged by that of M. Lichtenberg, has been long ago minutely described by Keysler. At that time the Ducal library consisted of about 80,000 printed volumes, and 2000 manuscripts. The cabinet of medals, which is particularly valuable, has been long ago described by M. Liebe, in his *Gothæ nummaria,* and more recently by M. Schlichtegroll, in his *Historia Numothecæ Gothanæ.* Gotha, 1799. The Ducal Palace has recently undergone great improvement, particularly in the grand terrace, which has been compared to that of Windsor The English garden of the Duke is worthy of being visited, and the small island, planted with weeping willows and birches, which contains the tombs of Ernest and Charlotte, the children of the reigning Duke. A column of granite, surmounted by an urn of white marble, is placed near the tomb. The garden of the Duchess, containing the monument of Madame de Buchwald, and busts of Newton, Leibnitz, and Kepler; the buildings of the Orangerie; and the hotel of Prince Augustus, the brother of the Duke, are also objects of some interest. The other public buildings are the arsenal, the two churches, called *Kloster und Neumarkts Kirchen,* the last of which contains the tombs of several of the Saxe-Gotha princes; an hospital for soldiers, two schools for the children of soldiers, a public college, a gymnasium with a good library, the public library, the house of correction, and an hospital for widows, and another for orphans.

The principal manufactures in Gotha are those of woollen goods, ribbands, muslin, and porcelain. There are no fewer than six periodical papers published in this town. Near the village Siebeleben, about half a league from Gotha, upon the insulated mountain of Seeberg, is an excellent observatory, under the charge of Baron Zach, an able and active astronomer. Population of the town, 11,500.

GOTHA. See SWEDEN.

GOTHARD, ST, Mount. See ALPS, p. 575, 576, and 579.

GOTHIC ARCHITECTURE. See CIVIL ARCHITECTURE, p. 534, 652.

GOTHLAND. See SWEDEN.

GOTHS. See CELTS, DENMARK, SWEDEN, ROME, &c.

GOTTENBURG, or GOTHEBORG, is a sea port town on the west coast of Sweden, and the second town in the kingdom. This town is situated on the banks of the most easterly branch of the Gotha, a large river which issues from the lake Wenner. About ten miles from Gottenburg it divides into three branches, two of which are soon reunited, after passing a rock upon which the old fort of Bohus is situated. The other two branches discharge themselves, by separate mouths, into the sea, and form a large island called Hisingen. The town is nearly three miles in circumference, exclusive of the suburbs called Hoga, and is regularly fortified with a ditch and wall.

Gottenburg consists of a principal street, called Great Harbour Street, consisting of houses three stories high, built of stone or brick, resting upon piles, and covered with white plaster, the roofs being in general concealed. A canal on the river Ham, crossed occasionally by wooden bridges, two of which only are for carriages, runs along the middle of this street. This street is crossed at right angles by North Harbour Street and South Harbour Street, and a few others; and parallel to it there are other streets of inferior note. These streets are ill paved with round stones, and have no side pavement. At the west end of the town is a hill about 100 feet high, upon which are several streets. This part is called the upper town, and the other part the lower town. In the upper town, the rows of buildings rise above one another like the seats of an amphitheatre. The exchange, and the extensive building belonging to the East India company, stand in the principal street. There are in this town two Swedish churches, and a German church. In 1812, a very magnificent church was building with stones brought from Scotland.

The harbour of Gottenburg is about one-fourth of a mile in breadth, and is formed by two chains of rocks. Its entrance is defended by the small fort of New Elfsborg, situated upon a rocky island, and garrisoned with 250 men.

Gottenburg formerly carried on a very great commerce in herrings, but, for several years past, they have entirely left the coast, and the fishing has of course declined. Formerly, they obtained about 600,000 barrels of herring annually, of which they salted 200,000; train oil being obtained from the remainder, at the rate of one barrel from 15 barrels of herring. In the year 1790, there was exported from Gottenburg 104,797 schips of iron in bars; 9,033 schips of other iron; 1142 schips of steel; 36,900 planks; 195,482 tons of salt herrings; and East India commodities, consisting of tea, silken stuffs, cinnamon, rhubarb, sago, fans of bamboo, porcelain, &c. to the amount of 599,471 rix dollars. A Royal Society of Sciences and Literature has been established here, and has published some volumes of its memoirs in 8vo.

The population of Gottenburg was in

1791	15,000
1804	17,760
1811	24,858

The country about Gottenburg consists of low precipitous ridges of naked rocks of gneiss, stretching in various directions. They vary in height from 100 feet to 310, which was the highest, as measured by Dr Thomson. Tolerably cultivated vallies, about a mile wide, separate these ridges. The west side of the island of Hisingen is composed almost entirely of naked rocks; and it protects the town against the north sea, and the west winds. See Coxe's *Travels in Sweden*, vol. iv.; Catteau de Calleville's *Voyage en Allemagne et en Suede*, vol. ii. p. 300; Kuttner's *Travels through Denmark, Sweden, &c.* sect. vi.; Thomson's *Travels in Sweden*, chap. i.; and INLAND NAVIGATION, for an account of the great canal of Trolhatta.

GOTTINGEN, or GOETTINGEN, is a city of Lower Saxony, in the electorate, (now kingdom,) of Hanover, and principality of Calenberg. It is situated on the small river Leine, in longitude 9° 53′ east, and latitude 51° 32′ north.

The university was founded by George II. in the year 1734, and soon became one of the most celebrated and best frequented seminaries on the continent. It is believed to have suffered considerably during the oppressive occupation of Hanover by the French, and the military operations in the north of Germany, subsequent to the disastrous battle of Jena; but it will probably recover, in some degree, its former prosperity, under the present favourable circumstances. The university possesses a noble library, consisting, it is said, of more than 150,000 volumes, a museum of natural history, an observatory, and other institutions for the advancement of science. Connected with the university, are the Royal Society, the Philological Seminary, and other scientific and literary institutions. Gottingen boasts of having cherished many individuals, eminent in different departments of learning; among whom may be reckoned Mosheim, Michaelis, Mayer, Lichtenberg, Kästner, Bürger, Beckmann, Pütter, Heyne, Blumenbach, Martens, and many others whose names are familiar to those who are conversant with continental literature.

The town contains about 12,000 inhabitants, including the garrison and university. It was formerly a place of some strength; but the fortifications have been demolished, and the rampart converted into a public walk. The woollen and hat manufactures are, besides the university, the principal support of the inhabitants.

Those who wish for a more particular description of Gottingen, and more minute information on the subject of its literary history, may consult Pütter's *Versuch einer Academ. Gelehrten-Geschichte von der Univ. zu Gottingen*, 2 vols. 8vo. 1788; and Rintel's *Versuch einer skizz. Beschreib. von Gottingen*, Berlin, 1791, 8vo. (z)

GOUDA, or TERGOUW, is a town of Holland, advantageously situated on a branch of the Rhine, called the Issel, where it receives the Gouw. The town is well fortified, and has five gates; but it is principally celebrated for the painted windows of its magnificent cathedral. These paintings were executed principally by Theodore, and Walter Crobeth of Gouda, and they have been preserved with singular care. The principal trade of the place consists in cordage, and tobacco pipes, and cheese. In the neighbourhood of the town great quantities of bricks and tiles are made. Peuchet informs us that there were once in Gouda 350 breweries, which supplied with beer Zealand and a great part of Flanders. This trade is now greatly diminished.

GOVERNMENT, in political science, sometimes signifies the act of carrying the national affairs into execution; sometimes the person or persons who, as a separate branch of the constitution, are lawfully charged with that function; and sometimes it imports the whole frame of the civil polity. In this latter and more comprehensive sense, it is synonymous with *constitution;* and it is in this sense we purpose here to employ it.

In endeavouring to simplify a subject so infinitely varied and complex, Aristotle and other ancient writers have reduced all systems of government to the primary and elementary forms of Democracy, Aristocracy, and Despotism. Under the first, the whole body of the people are at once the sovereign and the subject; laws are enacted by them alone, and the whole business of the commonwealth, whether it be the command of armies, the judiciary and ecclesiastical functions, negotiations with foreign states, or any other department of affairs, is transacted by officers appointed by them, and responsible to their authority. Under the second form, the many are subject to the few,—on whom superior wealth, talent, and, it may be, virtue, have originally conferred power, and in whose descendants a still further accumulation of wealth,—ambition,—and the popular sentiment in favour of illustrious birth, even where talent and virtue have no place, have, by a natural and easy transition, confirmed it. Under a Despotism, no orders are issued, no measures adopted, no affairs transacted, but with an exclusive reference to the personal gratification of the prince, or the security of his power. Laws which, under a Democracy, are enacted by the people themselves, and, under an Aristocracy, by the nobles, as the rule of public and private conduct, and the measure of public and private right, have no existence under a Despotism. The will of the tyrant is the sole law,--which, therefore, fluctuates every moment, and the people, their children, and their property, exist only in subservience to his passions, his caprices, and his crimes.

Modern writers, and particularly the President Montesquieu, have regarded this arrangement of the elementary forms of government as inaccurate. According to the well known division of that eloquent philosopher, these forms are, in like manner, *three;* the Republican, the Monarchical, and the Despotic. Under the first, he comprehends the Democratical and Aristocratical of the ancients; his description of which, as well as of the Despotic form, corresponds with theirs. The description of the Monarchical form differs in nothing from that of the Aristocratical, except that, in the latter, the supreme power is exercised by a combined plurality, but, in the former, by a single individual. As in the Aristocratical too, the administration of the nobles is controlled by the laws which they have themselves enacted; so, in the Monarchical, that of the prince is restrained, however imperfectly, by the rules of his own sovereign appointment; and this, as in both the Republican forms, constitutes the elementary difference between it and the Despotic.

But, according to this distribution, the ancient arrangement is not so properly inaccurate, as *incomplete.* The arrangement of Montesquieu is precisely that of the Greek philosophers, with the addition of the Monarchical form. The inaccuracy, it would seem, is rather chargeable upon him, since, in his enunciation of the elementary or simple forms of government, he limits, after the ancients, the number to three, whilst, in his description, he enumerates, (as they appear to us,) four essentially different systems. For though he has combined the Democratical and Aristocratical forms under the general term *republican*, it is difficult to perceive in what sense the latter is more republican than the Monarchy of his enumeration. The characteristic difference, according to his own description, between an Aristocracy and such a Monarchy, consists in the individuality in the one case, and, in the other, in the plurality of persons by whom the sovereign power is exercised. The people are absolutely excluded alike under both, from all share in the public authority; alike under both, the concerns of the state, its interests, its property, and its rights, are in no respect subject to their control or interference. In what sense therefore can these rights, interests, and concerns, or (which is here the same thing) the power by which they are regulated and controlled, be denominated *republican*, when applied to the Aristocratical form, which will not be equally applicable to the Monarchical?

Whether this enumeration of the elementary governments, as enlarged by Montesquieu, be complete, we shall not at present stop to inquire;—that it is chargeable with the inaccuracy we have alluded to, can scarcely, we think, be questioned. We rather proceed to observe, (what must likewise be well known to most of our readers,) that the same writer, besides describing the *nature* of the different simpler forms of government, has, with no less elegance than, as it appears to us, sound philosophy, indicated the *principle* upon which they chiefly depend for their respective support.

Under the Democratical form, *public virtue*, pervading the hearts and conduct of the whole body of the people, is the animating and sustaining principle. Every selfish and exclusive purpose must be relinquished by the individual; and his country, its glory, and its happiness, must take entire possession of his breast. Proud distinction for popular government! and happy the people among whom it is established, if the principle were a sure consequence of the form!

Under an Aristocracy, (and as a distinct principle is ascribed to it, we have here a further indication that it constitutes a *fourth* form, altogether different from a Democracy with which the celebrated writer we have alluded to, had classed it,) *moderation*, as well on the part of the few who govern, as of the many who obey, is the principle. If, among the former, any individual aspire to an over-ruling share of power, a tendency to the Monarchical or to the Despotic form, immediately arises; and if, among the latter, a sense of public rights, a spirit of patriotism, a disposition to interfere with the government, should appear, a tendency emerges in favour of Democracy.

Under the Monarchical form, the preserving principle is said to be *honour*. The word is abundantly vague and illusory, because the thing signified is commonly so also; but here it seems to import, that each individual of a numerous nobility, (for a Monarchy, in the sense of Montesquieu, implies a nobility,—*no nobles, no king,*) as well as the whole order considered as a separate body, and even each individual of the people, as well as the separate classes of which they may be composed, are constantly actuated by a jealousy for their respective and exclusive interests and consequence. Ever jostling in the pursuit of these objects; ever suspicious of mutual encroachments; and, at the same time, alike intent upon securing a portion of the royal favour, through one or other of the many channels in which, in a Monarchy so nearly absolute, it always abundantly flows, they become at once the vigilant instruments of their own controul, and the vain-glorious yet submissive dependants of the sovereign. Without a suffrage in the enactment of laws, and deriving from the constitution little power of restraint over the direction of affairs, they are almost necessarily unconscious of any principle of a pure and disinterested patriotism. The envied distinction of the prince's approbation,—preferment, emoluments, honours, become the chief incitement to their public exertions: and if thus they are not the legitimate objects of moral approbation, they often achieve deeds at once illustrious in themselves and beneficial to their country, as the proper means of acquiring the royal distinctions to which they aspire.—The government which has been so lately annihilated in France, as well as the more ancient monarchy, and several of the other governments of the continent of Europe, sufficiently illustrate and justify this description.

Fear, on the part of the people, is the dismal principle by which a Despotism must be maintained: nor need any thing further be added to indicate that system of sanguinary and incessant cruelty, which, on the part of the prince, becomes necessary to uphold his unhallowed empire.

These observations, as well on the primary forms of government, as on the principles on which they chiefly depend for their maintenance, are elementary, and could not with propriety, in a work of this nature, be passed over in silence. But, in contemplating the subject further, we are at a loss to determine under what particular aspect to regard it. When the various combinations of which these primary forms are susceptible, both with one another, and with their respective principles, are considered; the infinite varieties in the modification of the most simple as well as complex system of government,—arising from a narrower or more extended territory,—from insular or continental, maritime or inland situation,—a thinly scattered or crowded population,—the religious ceremonies and dogmas of the people, and the nature of their ecclesiastical establishment,—the constantly progressive or retrograde state of their morals, manners, and intellectual habits,—their warlike or peaceful, commercial or agricultural genius,—the character of the political institutions of the neighbouring states with which they have their principal intercourse,—the accidents of talent or imbecility, disinterested purpose or selfish emolument and aggrandisement, which may influence alike the conduct of the executive and legislative members of the government,—and the innumerable other circumstances which conspire to the same infinite variety of modification,—thought is bewildered in the complexity of the subject, and finds all attempt at detail utterly overwhelming and impracticable. To deduce, with any degree of exactness, the particulars which truly and accurately characterize even the most celebrated governments of ancient or of modern times, would be an undertaking sufficiently appalling from its magnitude, and sufficiently hazardous from the obscurity in which the information to be derived on such subjects seems inevitably to be involved. Nay, to attempt a clear and satisfactory delineation of our own government, on the nature of which full and accurate information might be supposed to be the most accessible, would be bold, perhaps presumptuous. For how has it fluctuated, by a thousand minute or more extensive gradations, throughout the greater period of its history! and though, since the days of William III. it has acquired a more balanced motion, and assumed an infinitely more regular and majestic form, yet how great the diversity of parts of which it is composed! how varied, and often delicate, the machinery by which it is impelled! and how numerous the interfering considerations necessary for giving it a safe and steady direction! *

But amidst a speculation so complex and embarrassing, some general views present themselves of a more manageable nature, and of a universal and paramount interest. Of these, an investigation of the rule by which *the legitimacy of all governments shall be tried*, which shall serve at once as the measure of lawful authority on the part of the sovereign, and of obedience on that of the people, seems the most important. It is a subject unquestionably of some delicacy, but infinitely less so than, in some countries, the mercenary partizans of usurped power,—and, in others, the mistaken and narrow-sighted zeal of many sincere friends to order,—would represent it; whilst the advantages to liberty of preserving it constantly in the public view, are incalculable. Under arbitrary governments, such discussions (when, indeed, they can be avowed at all) are justly alarming to the existing authorities; but under a constitution like that of Great Britain, they are its worst enemies, and but little acquainted with its real nature, who would regard the subject as dangerous.

In pursuing this inquiry, we will avoid, as much as possible, the metaphysical abstractions of mere general reasoning. We will endeavour, rather, to consider the subject through the medium of some of the principal events in the history of our own government; and with these we will at the same time combine, (whilst we shall take care to indicate sufficiently our own sentiments,) the opinions which the nation at large, as well as some of the most distinguished individuals in it, have from time to time entertained on a topic so interesting. We shall thus, besides blending historical fact with the less edifying deductions of bare general discussion, present also the outlines, at least, of the political branch of our literary history.

Except the close of the eighteenth century, no period in the British history appears to have been more productive of political discussion than about the time of the civil wars, in the reign of Charles I. Before that period, political inquiry had made little progress among the people. Opposite claims to the crown had divided their efforts in favour of the different competitors, and changes in the religious establishment had very deeply engaged their attention; but no question had arisen calculated to lead the public mind, by an easy and obvious connection, to an investigation of the original principles upon which all government is founded, or to a comparison of one species of government with another. The two Houses of Parliament were the only place in which political discussion was at all to be found; and, even there, it had scarcely ever dared to trespass the safe boundaries prescribed to it by the executive authority. A few speculative and learned men alone had indulged in inquiries of this nature To them exclusively the fragments of political science which the general ruins of antiquity presented, were accessible; and, fired with the seemly ideas which these had excited, they were naturally led to emulate their own conceptions of the superstructure. The performances, however, which some of these men thus produced, were

* We could not with propriety, under this general article, have introduced even the outlines of our own goveroment, the theory of which, the more it is studied cannot fail to be the more admired. The reader may coosult the more appropriate article, ENGLAND, p. 25. and, for still more detailed information, Blackst. *Comm.* b. i.; Montesq. *De L'Esprit des Lois,* l. xi. c. 6. &c; and De Lolme. For other individual governments, see their appropriate articles, SPARTA, ROME, &c.

either expressed in a language with which the people were utterly unacquainted, or conceived in so subtle and scholastic a manner as was little fitted to engage public attention.

But in proportion as the disputes between Charles and his parliament drew to a crisis, in proportion were the minds of the people directed to a bolder range of political discussion. At first, *the limits of the prerogative* formed the only subject of inquiry. By degrees, as the fortunes of Charles darkened, *the circumstances which constituted a total forfeiture of the throne* began to be examined. And at last, when the sovereign was destroyed, and the peers voted useless, the question assumed the broadest form of which it was susceptible. The inquiry now was into the *best form of civil polity*; and in this enquiry, the whole extent of political science was developed to the people.

That all lawful authority was derived from them, and was co-existent only with the just and impartial administration of it, were considerations of no mean importance, and accordingly received a share of the public attention; but the opportunity was now arrived when the British people, freed from their ancient government and all its deformities, might, as they conceived, erect a new superstructure which, while it secured their own and their descendants felicity, might for ever serve as a model to the rest of mankind. On this wider subject, therefore, every mind was occupied. All other conversation was naturally without interest. Every press was employed in furnishing the various publications which might inform the ignorant, convince the doubting, or excite the enthusiastic. The blemishes of the former government needed no exaggeration from the pen of the political writer, to create a general abhorrence of every form of polity which bore any resemblance to it. The people themselves had too recently felt its imperfections, even while its administration was yet unexasperated by opposition, and had smarted too severely under the consequences it admitted when its chief magistrate chose to be offended. The most opposite form, therefore, was the most favourite. Every publication, accordingly, consisted either of arguments in support of a democracy, or detailed some new and rival plan of government for the approbation and choice of the people. Nor in this competition of speculative politics, then deemed so glorious, do we find such names only as are ever ready to serve the purposes of ambition, or of avarice. Warmed with the love of ancient liberty, and proud to avow their admiration of it, the fairest schemes of republican government, and the strongest arguments in support of it, which the minds of a Harrington and a Milton could devise, or their energetic eloquence recommend, afford interesting specimens both of the manner in which the public mind was then occupied, and of the ability employed in giving it a direction.

But these delusive prospects soon disappeared. The hope of establishing a republican government became daily fainter and fainter; and with it, those schemes which had been so eloquently detailed, and so fondly contemplated, quickly fell into neglect. The views of Cromwell, which had always been suspected by some, now began to be understood by many; and the vigorous administration by which he confirmed his usurped power, by and by convinced the people that they still possessed a monarchy in every thing but the name. The death of the Protector, and the incapacity of his son, replunged the nation in all the miseries of anarchy. The partizans of the royal family were not slack to improve the opportunity they so much desired. By their efforts, and the concurrence of a full tide of circumstances, the proscribed monarch was received into the bosom of the kingdom, without any limitation of his authority, and with an ardour of popular affection, proportionate to the interruption it had suffered, and to the calamities and confusion to which the nation had been exposed.

It was accordingly during the reign of Charles II. that the public mind seems to have been disposed to admit the exercise of the royal prerogative in as unlimited and dangerous an extent as had ever been possessed by any former monarch. Still smarting under the desolating consequences of the civil wars, and still remembering the odium with which they had regarded the tyrannical, though energetic, administration of the Protector, it is not surprising if the people began to indulge the opinion, that an uncontrolled prerogative in the crown was necessary to order and good government.

The court does not seem to have been insensible to this favourable state of men's minds for promoting its views. The nation, it was easy to perceive, had now acquired a taste for political speculation which it would be more practicable to lead in a safe or advantageous course, than altogether to obstruct. And though the reigning monarch had little reason to apprehend any immediate opposition to his power, yet a theory in support of it, would at once gratify the public mind, and might lessen the chance of future resistance. There was now no demand for plans of government. These had had their day. They had fallen into neglect with all, and contempt with many. Monarchy, the resumed, uncontrouled monarchy, was the idol; and nothing was wanting but a systematic detail of the justice and rationality of the principles upon which it rested.

About this time, accordingly, several writers appeared who, either hired immediately by the court, or impelled by general hopes of reward, endeavoured to perform so acceptable a service. Among these, the most celebrated was Sir Robert Filmer. His book, entitled *Patriarcha*, seems to have been by far the most daring and specious attempt to assign a legitimate and rational origin to absolute monarchy. It was daring, not so much because it was an express and avowed endeavour to establish that form of government in exclusion of every other that had ever been set up in the world, but to establish it upon the basis of *a divine appointment*; and it was specious, because the mode of argument, and the style of writing adopted, were such as, in those times, were likely to make considerable impression,—the former being chiefly, or altogether, founded in texts of scripture, and the latter made up of expressions sufficiently vague and unmeaning to elude detection in an age when literature was yet but little diffused, or accurately studied. If not the first to assert the *jus divinum* of kings, Filmer seems to have been the first, at least, who ventured to account for its origin, to develope its nature, and to establish it avowedly and expressly, upon the basis of argument.

Aware of the futility of that sort of reasoning which, while it founded the legitimacy of the sovereign power in the general or providential arrangements of the Supreme Being, would at the same time have justified every form of government, and even every species of crime, (since these also fall out, or are permitted in the general arrangements of Providence), Filmer had recourse, if not to a more logical, at least to a more specious, mode of argument. Texts of scripture, he conceived, could be found, in which might be traced the legitimacy of modern kings to the appointment of God himself at the creation of the world. If so, his object was accomplished—infidelity in that age not having yet dared to erect his unhallowed standard among the people.

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Filmer accordingly maintained that God, at the creation of Adam, endowed him with a right of fatherhood, (as he termed it), absolute and unlimited; or, in other words, with a right of arbitrary dominion over all his offspring. *Second,* That he was endowed in like manner with a right of absolute dominion over Eve: "Thy desire shall be unto thy husband, and he shall rule over thee:"—in which text he seriously assures us we have very expressly, the original grant of monarchical government. *Third,* That the whole material globe, with all the brute creation, was his property by right of donation from the same Almighty Being And, *fourth,* That these rights, upon Adam's death, descended to his next heir; that thence they descended, in direct succession, to the patriarchs; and from them, in similar succession, to modern kings. These principles he partly asserted, and partly endeavoured to prove, sometimes by producing garbled passages of scripture, and sometimes by giving to other passages an unlimited, or, as it would seem, a sophisticated meaning.

It would be frivolous to occupy much time in examining a theory so ridiculous. It could scarcely, one would think, have drawn the attention of the Sidneys and the Lockes to its refutation. Yet however easy the task, it will not appear unworthy even of such men, when we consider the bias of the times, and the impression which Filmer's book appears to have made upon the public mind. The philosopher and the patriot felt alike indignant at the insult which had been offered to their country; and the employment of their talents upon a subject so far beneath their powers, they deemed a sacrifice well due to public virtue.

As Filmer had found it expedient to have recourse to the standard of public faith for the arguments by which he had supported his system, so the writers to whom we have just alluded, found it necessary to resort to the same standard for the arguments by which they were to overturn it. They denied that there was any text of scripture that asserted a right of absolute fatherhood, or unlimited paternal jurisdiction in Adam; but, on the contrary, maintained, that neither Adam, nor any other man, ever had a right to any further paternal jurisdiction than was necessary for the protection, improvement, and welfare of his children, during those years of minority when they were unable to protect, improve, or provide for themselves; and that this paternal jurisdiction was more properly termed *parental,* since it implied duties that belonged equally to Eve, and every other mother, as to Adam, and every other father,—the nature of the duties requiring such common jurisdiction. *Second,* The jurisdiction granted to Adam over Eve, could not be understood to mean a *political* jurisdiction, or the right of life and death; but merely such a right of control as, in matters regarding their common interest and property, would enable the husband, in the event of opposite opinions, to decide, and so prevent that endless contention which would arise had no superior authority been conferred upon either. *Third,* As the donation which God is said to have given to Adam of the earth, with all the animals upon it, is nowhere to be found in scripture, so, had it been given, it could not have been absolutely and exclusively, but only so far as his own use might require,—it being absurd to suppose, that God would give to one man an exclusive right to what, from its extent, was infinitely beyond his power of enjoyment, and would, at the same time, call other rational beings into existence, who should be at this favoured person's mercy for a foot of ground to stand upon, or a morsel of food to support life. But *fourth,* Although Filmer had succeeded in establishing these premises, it did not follow that such absolute rights were to descend to his *next heir.* If it did so follow, who was his next heir? for God has neither by scripture, nor by human reason, pointed out a natural and invariable line of succession in the person of any individual. Granting however this also, it was still incumbent on Filmer to shew, not only that the patriarchs possessed this absolute authority, and that they possessed it from Adam through this invariable line, but that it has also come down from them to modern kings through the same invariable line,—an attempt, which only requires to be stated to evince its extravagance. But still granting even this extravagance, there must be only one legitimate monarch in the world, only one king who reigns *jure divino* derived in this direct line from Adam, and all the rest must be usurpers and interlopers, against whom every honest man and sound Christian should raise his arm, never to be pacified till all the nations of the globe should be reduced to the arbitrary and exclusive dominion of this lineal descendant, and true heir of Adam!

These writers having thus demonstrated the absurdity of this theory *jure divino* of Sir Robert Filmer, they conceived it necessary to substitute another, more friendly to liberty, and more consistent with truth. They proceeded, accordingly, to point out what they regarded as the only foundation and just limits of *legitimate* government; and this, they maintained, was the *consent of the people.**

That the *consent of the people,* they contended, is necessary to all legitimate government, seems not to admit of argument; for the very notion of such a government implies the notion of a contract between those that govern and those that obey. By what other right, or upon what other foundation, can any form of government which is to be regarded as *legitimate,* that is, binding upon the people to preserve and obey it, be either originally established, or afterwards exercised? Various other foundations of legitimate government indeed, have been pointed out and defended; but all of them appear to be sufficiently irrational. The doctrine of the right of conquest, where such conquest has been occasioned by the repeated and aggravated hostility of the party conquered, is perhaps the least exceptionable. But besides that the arbitrary form of government established in consequence of conquest, involves the innocent with the guilty, it is a punishment disproportionate to the crime. The victor, in such a case, has no other right than to indemnify himself sufficiently for the injury he may have sustained, either by former provocations, or the actual war. He can only demand *compensation for the past, and security for the future.* And this he may, in most instances, sufficiently obtain, by making it a losing bargain to his enemies to offer him injury. This

* As Filmer appears to have been the first, if not to suggest the doctrine of absolute monarchy *jure divino,* at least the first avowedly and systematically to explain and argue it; so Mr Locke, if not the first to suggest the consent of the people, as the only foundation of lawful government, seems to have been the first who entered, at any length, into a developement and defence of the principle. For although the celebrated Discourses of Algernon Sidney were written previously to Mr Locke's Treatises, and embrace the same principle, yet they were not given to the public by Mr Toland till after Locke's Treatises had appeared, and accordingly do not seem to have been known to that philosopher.

We may here observe, that the opinions of the Tories approximated to the extravagance of Filmer's system; those of the Whigs consisted, it would seem, of most of the reasonings and inferences of Mr Locke's.—We may add, that, by *the people,* Locke and his followers evidently meant the nation at large, in contradistinction to the sovereign magistracy, of whatever nature that may be;—not that needy and desperate class of men, who, in every country, and most of all under the freest constitutions of government, are always found opposed to the orderly, industrious, and fortunate.

loss indeed, must be proportionate to the circumstances of the case; but no case can be figured, where it ought to amount to *absolute authority* on the part of the conqueror; that is, to *slavery* on the part of the people. A few captives taken in actual war may be reduced to that unhappy state, where the law of retaliation, and only where such law demands it; but no *national* offence can infer the punishment of *national* slavery. It is possible to imagine cases, where *security for the future* may require the conquered to submit to the government of the conqueror; but such government cannot be *legitimate*, unless it be as free as is compatible with that security.

It would seem, therefore, they argued, that the doctrine of the *consent of the people*, as forming the only foundation for legitimate government, requires only to be sufficiently explained, in order to be acknowledged.

This consent they conceived to be of two kinds. First, that which is *implied* in consequence of certain acts of the people; and, second, that which is *direct*, and *expressly conventional*.

First, The greater part of the governments, as well ancient as modern, to which the epithet of *legitimate* can with any propriety be applied, have been of the first description. They have all been originally constituted, and afterwards exercised, in consequence of the implied consent of the people; an implication by no means doubtful in its nature, or feeble in its conventional effects; but, on the contrary, more generally, as well as more powerfully binding, perhaps, than that consent which is direct and express.

These governments have been the same in their origin, and similar in the first periods of their progress; but, for the most part, sufficiently varied in the subsequent and concluding eras of their history. At first, the savage who roamed the desert, was at once the father and supreme civil governor of his family. Convenience, and the ties of blood, soon united a certain number of families into a tribe, village, or horde. The same natural sentiment of confidence and respect, which had impelled the children of a family to admit the father's authority, impelled the several families of the same tribe or village to admit, *in time of peace*, the authority of those individuals amongst them who were most celebrated for wisdom and experience; and, *in time of war*, of that single individual who was most renowned for his martial skill and achievements. But as war among rude nations (alas! in more civilized periods also) ever occupies much more of the public attention than peace, and as, from its nature, there can be only one supreme leader at a time, sufficient opportunity is then afforded him of acquiring a greater share of public respect, and of being regarded as of greater national importance, than those individuals in whose authority he is only a sharer in time of peace. Hence the consideration which the leader or king, in civilized as well as in rude periods, acquires over the other individuals of the civil administration, whether that consist of a senate, (as it comes afterwards to be termed,) a popular assembly, or both. This leader or king, as well as the other members of the civil administration, are not, in the earlier periods of the history of political government, expressly elected by the concurring voice, by the majority, or by any other avowedly conventional act of the people. Their experience, their wisdom, and their virtues—such virtues as men in those ruder periods can understand and admire—invest them with authority, and render them the natural objects of respect and obedience. The people soon perceive the beneficial effects of submission, and, by a thousand different acts, testify their concurrence in a government so naturally formed, and so advantageously administered. As the king, or any of the other rulers, dies, or from any other cause becomes unfit for discharging the duties of his station, another, of similar accomplishments, succeeds him by the same natural means, and receives the same natural obedience. For obvious reasons, the successor is commonly the immediate descendant, or intimate friend, of the deceased, unless a striking deficiency of capacity disqualify him. As the ideas, however, of property extend and improve, and as other alterations take place in the progress of society, men come to acquiesce in that *hereditary* succession to civil authority for which kings and rulers now begin to struggle. The people perceive its tendency to exclude rival and tumultuary pretensions to power, and, in this respect, soon actually experience its advantageous consequences. Their original acquiescence is confirmed by their voluntary obedience, and their acknowledgment of the legitimacy both of the constitution, and of the administration, of the government, is sufficiently declared by their reiterated acts of co-operation, as well in forming as in executing the laws, and in modifying, when necessary, the form itself of the civil polity.

But this natural and just order of things is too often interrupted and broken. Usurpation may either occupy the place of those rulers, whether supreme or subordinate, whom alone the people acknowledge as lawful; or tyranny may characterise the conduct of those rulers themselves. In both cases, the administration of government, and, as an usual, or rather almost necessary consequence, the form of government itself, have undeniably become *illegitimate*; and the people, if they can yet command sufficient force, or whenever they choose to risk the attempt, may, with perfect justice, endeavour to displace and punish the usurper and tyrant. Should they neither command sufficient force, nor choose to risk the attempt, the government of the *usurper* may *become* legitimate, by the justice with which it is afterwards administered, and by reiterated acts of sufficiently implied consent on the part of the people; but that of the *tyrant* can never become so. He may hold his people in a precarious subjection, if they choose to remain in his territory, by the principle of fear; but none of his enactments, or of their involuntary compliances, can ever render his authority legitimate, or deprive the people of the right to displace and punish him when they can, and to substitute another governor, as well as to appoint another form of government more equitable and friendly to liberty.

Second, That consent of the people, they further maintained, which is *direct* and *expressly conventional*, although by no means of such frequent occurrence in the history of civil government as the former species of consent, is yet sufficiently frequent to prove its existence, and give an idea of its nature. Among rude tribes, we find instances of general assemblies of the people, met for the express purpose of electing their rulers by a majority of suffrages. The great civil magistrates of several of the states of Greece, and particularly the archons and other civil officers of Athens, together with the consuls and most of the other magistrates of Rome, were appointed periodically by the act of the people. Most of the ancient colonies also, whether they originated from Greece, Rome, or Carthage, were left at liberty to establish such a form of civil polity, and to choose such rulers, as the colonists themselves thought best; the respective mother countries claiming no authority over them, but only soliciting from their

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friendship, consanguinity, or bounty, assistance in times of general difficulty and danger. The government established by the United Provinces in the reign of Philip III. of Spain, by America in 1782, and, proud reflection! by Great Britain herself in 1688, may be quoted as further examples, in which this *direct* and *expressly conventional* consent of the people was exercised.

But as the theory of Filmer was fated to fall before the opposition of Sidney and Locke, so the system which these distinguished men had set up in its stead, was, in its turn, exposed to an attack, which, if less efficacious, proceeded notwithstanding from a quarter not less respectable. About the middle of the last century, Mr Hume and some other writers undertook to shew, that the doctrine of the consent of the people, as the only basis of legitimate government, was altogether erroneous and visionary.

If it be meant, said they, that the contract, implied or direct, between the sovereign and the people, is the agreement by which men in a savage state form the social union, and from which every community is originally derived, we admit the accuracy of the fact, but deny its obligation on men in the advanced stages of society: Every government that has endured for any period, has undergone the most entire changes since its first establishment; nor can a consent or voluntary acquiescence, which was given some centuries ago, be binding under a totally different aspect of the political arrangement.

Again, in those instances, they further observed, which seem the most favourable to the doctrine of the consent of the people, the real exercise of the right has been altogether imperfect or illusory. In the most perfect and extensive republics of antiquity, not a tenth part of the people voted either for the original establishments, or on the enactment of any subsequent law; and even at the boasted Revolution of 1688 itself, the Prince of Orange was brought over, and seated on the throne, by a mere junto of the English people. But, it was further said, if, even in these instances, the principle has in fact no place, how much less shall we find it realized in any of the other governments, which either actually exist, or which history has recorded? In perhaps all of them, it is not difficult to trace the sovereign authority to conquest, usurpation, donation by testament, or some other mode of fraud or violence. Hereditary descent prevails the most generally; yet it would be bold to affirm that none of these governments were lawful, or that the people were never sensible of any obligation to submit to their authority. In fine, "though an appeal," says Mr Hume, in the concluding part of his Essay on the Original Contract, "though an appeal to general opinion may justly, in the speculative sciences of metaphysics, natural philosophy, or astronomy, be deemed unfair and inconclusive, yet in all questions with regard to morals, as well as criticism, there is really no other standard by which any controversy can ever be decided; and nothing is a clearer proof that a theory of this kind is erroneous, than to find that it leads to paradoxes repugnant to the common sentiments of mankind, and to the practice and opinion of all nations and all ages. The doctrine which founds all lawful government on an original contract, or consent of the people, is plainly of this kind; nor has the most noted of its partizans, in prosecution of it, scrupled to affirm, *that absolute monarchy is inconsistent with civil society, and so can be no form of civil government at all, and that the supreme power in a state, cannot take from any man by taxes and impositions any part of his property, without his own consent, or that of his representatives.** What authority," continues Mr Hume, "any moral reasoning can have which leads into opinions so wide of the general practice of mankind in every place but this single kingdom, it is easy to determine."

In the remarks which we have already made, when detailing what we conceive to be the just and fair state of the doctrine of the consent of the people, we have already, perhaps, anticipated the proper answer to some of these objections. We shall, therefore, only very briefly take further notice of them.

1. It would be improper to say, that so candid a mind as Mr Hume's is represented to have been, has intentionally sophisticated the doctrines of Locke, or that so great a philosopher was not always eager to discover truth, whether it agreed with his own political opinions or not. Yet we cannot but think, that the careful peruser of Mr Locke's book, can have no difficulty in reconciling the passage in question to the "general practice of mankind." For it is most obvious, as well from the whole scope of the work, as from the undeniable and notorious nature of the facts themselves, that Mr Locke could never mean to deny the *actual existence* of absolute monarchy in the world, or that the supreme power in a state did not often *actually take* part of a man's property without his own consent, or that of his representatives. It is plain that he only meant to affirm, that absolute monarchy was inconsistent with such a state of society, as, from its internal security, and the innumerable advantages thence arising, might with propriety be termed *civil*; and that the supreme power in a state could not *lawfully* take any part of a man's property without his own consent, or that of his representatives. Indeed, the opposers of this doctrine seem always to have taken it for granted, that its advocates maintained its applicability to all the different governments which have ever actually appeared in the world. Neither was Locke nor Sidney so little conversant with the history of mankind, as not to know the various sources of fraud and violence from which political establishments had, *in point of fact*, too often proceeded. All that they meant to affirm was, that no government could be regarded as *lawful*, that is, exercising its functions upon any obligatory principle, where the unequivocal, though it might be tacit, consent of the people actually existing under it, was not interposed.

2. It is true, that in none of the instances in which the consent of the people was most directly exercised, did it arise from the universal suffrage, or even, perhaps, from a fair and totally unbiassed majority of the people. It is sufficient if this conventional consent was given in as perfect a manner, or as nearly so, as the nature and structure of human society will admit. An abstractedly perfect expression of the popular consent is impossible. Nor can they be accused of supporting an illusory principle, who would rest the legitimacy of government upon that consent of the people which is expressed by such a majority as, from the very nature of society, it is reasonable to expect, or practicable to obtain.

3. We grant that it is impossible, in every instance, to ascertain the precise period when this consent of the people may be considered as fully and unequivocally expressed, or to distinguish between that apparent consent which a tyrant or usurper may exact, and that which is voluntary and free. But the principle is not, therefore, the less real. Pirates, or banditti, may seize

* "Locke on Government, chap. vii. sect. 90."

a man's person, and carry him into captivity. In that situation he may find it his interest to serve his masters with alacrity and zeal. Yet nobody would thence infer, that the authority exercised over him was lawful, or that the assent which he gave to it was voluntary and free. None will deny, that those unhappy men who, in different parts of the world, exist in a state of slavery, have a right to revolt whenever they can; yet, from the circumstances of their birth, and the manner in which they have been brought up, this right is but imperfectly understood by many of them, and perhaps, for the most part, not recognised at all. But that it belongs to them, is not the less certain. The case is the same in reality, though not in degree, with any people whose government exists otherwise than by their consent alone. The neutral observer may be uncertain, whether or not they are a free people, and they may themselves have employed little thought upon the matter; but that *the right*, notwithstanding, to adapt the government to their own views of national felicity, is inherent in them, seems unquestionable.—Again, though it be impossible, in most instances, precisely to fix the period when the national consent may *first* be regarded as fully and unequivocally expressed in favour of the government, yet, when it is once actually interposed, little doubt of its reality can exist. It may safely be affirmed, that the government of the American States is free; that is, *that the people are sensible* that it is co-existent only with their consent, and that the obligatory nature of its acts proceeds from the same source. The like, for a similar reason, may be confidently affirmed of our own government. That the governments of Spain and Turkey are not free, may as safely be affirmed, since it is impossible that this consciousness of consent can, in these instances, exist on the part of the people. We may add, that it is precisely for this reason that these governments seem ready to receive any new form, and that so many of the governments of Europe lately expired without one popular effort to save them.

It will not, we apprehend, be alleged, that, after all, this principle of the consent of the people is of little influence in the actual conduct of nations, and that men, for the most part, submit to their respective governments, and regard them as lawful, from habit, prejudice, or education. It would be difficult, we readily admit, to estimate, with any precision, the effects which the principle has produced, either in ancient or modern times. But from what source, we would inquire, did all the energy of the Greek and Roman character, in the best days of these states, proceed? Whence was each individual conscious of a degree of political importance of which most modern nations seem to have little conception? It obviously arose from the conviction with which every man was impressed, that not only each act, but the very existence of the government, depended, in some measure, upon his individual concurrence. It was this conviction that made him proud of his country: it was the principle that incited him to every effort for her prosperity, or exposed him to every danger for her glory. Nor in modern times has the principle been altogether inefficient. The policy, indeed, has prevailed of discountenancing it as much as possible; and as most of the feudal governments of Europe arose in utter violation of it, so their subsequent aim has been to suppress it as seditious and criminal. Yet it is to this sentiment chiefly, as the unfailing and copious fountain of all her exertions, that our own country has so long owed, and still so eminently maintains, her splendid distinction among nations. The latter periods also of the history of America and of Europe afford eventful instances of its more general diffusion, and seem yet to support the hope of its further progress. It does not appear idle, therefore, to speculate upon this principle. Let us, besides the example of our own political institutions,—of which when it ceases to be the actuating spirit, they will cease to be worth preserving,—expressly divulge its nature and effects. Let us impress it on the general mind. We shall thereby create a perpetually living motive to liberal action, which, in proportion as it is diffused, will control despotism, and extend the triumphs of liberty.*

But as those philosophers who overturned the system of Filmer erected another in its place, did Mr Hume and his followers offer, in their turn, a substitute for that which they had opposed? We think not. In comparing the History of that great writer with his Political Essays, it is not easy, we believe, to discover any distinct and consistent principle by which he would try the lawfulness of any form of civil government. At one time, he would seem to have regarded as legitimate every government which was once established, and, *from whatever motive*, acquiesced in by the people; a doctrine which appears to lead, without any circuit, to the encouragement of usurpation, and the exercise of tyranny. At another time, he appears to have reposed in the very principle he had been combating. "The observation," says he, "of our general and obvious interests, is the source of all allegiance, and of that moral obligation which we attribute to it. What necessity, therefore, he continues, "to found the duty of allegiance or obedience to magistrates, on that of fidelity, or a regard to promises; and to suppose, that it is the *consent of each individual* which subjects him to government, when it appears that both *allegiance and fidelity* stand precisely on the same foundation, and are both submitted to on account of the apparent interests and necessities of human society." The interests which are here meant, must be those advantages which appear to the mind of the people as well worthy of preservation; and, consequently, their adherence and consent to the government from which these advantages proceed, or by which they are protected, is implied; since, were they to withdraw this consent, the government would become precarious, or actually perish, and with it, consequently, those interests for whose sake alone they had formerly supported it. The question, therefore, in this case, seems to resolve itself into the mere propriety of the appellation by which the principle has been distinguished;—a point of too little importance to merit consideration. Call it the consent of the people, or *a sense of their own interests*, it is of no consequence, provided they be made sufficiently sensible that there can be no legitimate government that is not established for their good, and co-existent only with their opinion that it is so.

The philosophical scepticism in which Mr Hume indulged, necessarily arose, perhaps, from the very nature of several of the subjects upon which he employed his exquisite powers; yet we need not extend the remark to the principle we have been considering. It would seem to lie too near the surface, to elude a penetration much feebler than that of Mr Hume. In fact, at the time that philosopher wrote, † a coalition of parties was the wish of every good man in the commu-

* Any endeavour to fix *prospectively* the exact amount of disorder in the constitution, or actual administration, of a government, which would warrant a renunciation of the national allegiance, would be sufficiently absurd, nor is here contemplated. All we mean is, an unceasing recognition of *the principle*.

† The first part of Mr Hume's *Political Essays* was published in 1742, and the second in 1752.

Government.

nity. The friends of the exiled family were still numerous in the nation. A junto favourable to their interests had recently been discovered in the cabinet itself; and a rebellion, countenanced and supported by the power of France, had actually broken out for the purpose of restoring them to the throne. It is not therefore to be wondered, if such men as Mr Hume, who might be supposed capable of influencing, in some measure, the public mind, should endeavour, if not by reconciling, at least mitigating, the principles by which the opposite parties were actuated, to moderate their passions, and encourage unanimity.—Philosophy may sometimes preserve silence in the cause of truth; but can she, consistently with her obligations to the moral interests of mankind, ever actually raise her voice in opposition to her real sentiments? Can she ever delight to sacrifice the sternness of her dictates, even on the altar of public peace? (J. B.)

Government ‖ Grace.

GOUT. See MEDICINE.

GOZO. See MALTA.

GRACCHUS. See ROME.

GRACE. See THEOLOGY.

GRADUATION.

Graduation.

GRADUATION is the name given to the most delicate, difficult, and important branch of mathematical instrument making: it gives to the instrument the means of ascertaining the dimensions of objects, or their distance from each other, according to its nature, whether linear or angular measure is required.

History.

The substance of this article was intended to have been placed under the equally appropriate title of DIVIDING, and was partly written with that intention. Our having indiscriminately used both these terms, is owing not only to this circumstance, but also because the latter is exclusively used by the workmen.

Graduation first practised amongst clockmakers.

We believe that in every country in Europe, clock-making was the earlier art, and that clock-makers were the first who fabricated mathematical instruments. But as the excellence of the time-piece depends not at all upon the accuracy of the division of its dial-plate, we may suppose that instruments, the perfection of which rests principally upon the correctness of division, came from their hands in a very rude state.

As clocks, however, must at first have raised clock-makers out of brasiers, smiths, or other workers in metal nearest allied to the nature of the work; so instruments must have made instrument-makers, and for this purpose the clock-maker was more than half formed. One would think, indeed, that makers of compasses, dials, rules, astrolabes, &c. from the great usefulness of these instruments, must have existed prior to clock-makers, and of course the graduation of them; but however that might be, if there was about the middle of the 17th century any such distinct trade in this country, those who practised it were little thought of by men of science; for the instruments invented by Hook were made by Tompion; and both Tompion and Graham in succession made instruments for the royal observatory.

Abram Sharp.

It was the opinion of the late Mr Smeaton, that Mr Abram Sharp, the assistant of Flamstead, was the first who cut accurate divisions upon astronomical instruments: he having, about the year 1689, constructed and graduated for the royal observatory, a mural sextant of $6\frac{1}{2}$ feet radius, which in the hands of Flamstead rendered essential service to astronomy. Whether Mr Sharp was bred up to any mechanical business, or whether the whole was the effort of his own genius, is now unknown.

There were, however, instrument-makers in the early part of the 18th century, who, in the art of dividing, might at least have equalled those celebrated clock and watch-makers, whose names have been mentioned. Some of the works of Rowley are still extant, and bear such evident proofs of neatness and accuracy, that many a workman of the present day might be proud to own them. The elder Sisson, contemporary with, or a little later than Rowley, like him, constructed and graduated large instruments with success; but neither the manner of performing the work of graduation, when beyond the limits of their dividing-plates, nor the method pursued by Sharp, has been recorded. It was in the workshop of Sisson, that the eight feet mural quadrant, several large zenith sectors, &c. of Graham, were executed. That the latter should be employed in the construction of them, rather than any one who was exclusively an instrument-maker, was owing, no doubt, to his superior abilities as a general mechanician, his knowledge in astronomy, and his proficiency in making observations, as well as to his sound judgment, and nice execution of the most essential parts of whatever he undertook to construct.

Rowley. Sisson the elder. Graham.

Bird.

About the year 1727, the late Mr Bird, then a rustic lad of Bishop Aukland, observing the unequal divisions and coarse-engraving of a clock dial-plate, determined upon doing one himself. The success of this attempt was the first step that led to the developement of powers, which, during a long life, proved beneficial to science, and rendered his name an honour to his country. It was from the elder Sisson, to whom he served a short apprenticeship, and his acquaintance with Graham, that Bird learned every thing that was not derived from his own resources. Bird and the younger Sisson were contemporaries and rivals for fame, were both men of considerable abilities and application. But the superior ingenuity of the latter lost its effect with the best informed, when brought into competition with the accurate execution and sound judgment of the former.

Sisson younger.

Ramsden.

Mr Ramsden followed the next in time; and perhaps gained greater credit in his line of business, than any preceding artist. The dividing-engine, which he invented, by rendering small instruments almost as accurate as large ones had been before, will shed lasting and well-merited honour upon his name. In his larger works, however, he was not so happy, although they were graduated better than any previous to his day. Too vain of invention, he despised the patterns left by his predecessors, and gave to his works complex and unsteady forms.

Mr John Troughton.

The late Mr John Troughton, about twelve years younger than Ramsden, was equal, if not superior, to him in the graduation of instruments. But his chief works, performed in his own attic, were destined to shed honour upon the names of the first mathematical instrument sellers in London; and by the time his merit became known to the public, his younger brother had taken the lead. But we must close these short biographical sketches with the labours of the dead.

We are aware that these desultory remarks will ill supply the place of a regular history of the art; a thing which we cannot attempt, and which is perhaps impossible. To describe things as they are, and to give the methods as hitherto practised by eminent men, will certainly be more useful: and in doing this, as often as ommon Graduation.

they have written upon the subject, their different modes of practice shall be given in their own words.

Of those numerous contrivances, which have neither ingenuity of conception, nor have been found useful in their day, we shall say nothing; for it would be idle to obstruct their natural passage to oblivion.

ision of subject.

For the sake of perspicuity, we shall divide this article into three Sections, containing, 1. *Common graduation*, 2. *Engine graduation*, and 3. *Original graduation.*

Sect. I. *Common Graduation.*

mon duation.

In this Section of our article will be shewn the method of taking copies from a pattern, which has already been laid down originally; or, as indeed is now generally practised, taking copies from a copy. This part also includes original dividing, in cases where the usual patterns do not apply, and where the utmost degree of accuracy is not required.

 divid- plate.

It will here be necessary to describe the apparatus or tools used by the person who divides in common. And first the dividing-plate must be noticed. Its dimension varies from 14 to 30 inches in diameter. It is either an entire plate, or a broad rim, connected with the centre by four or more radii, and rendered inflexible by circular rings, or edge bars underneath. The extreme border is divided into degrees and quarters; and just within this another circle, into degrees and third parts. Within are usually put such numbers as are required for the dial of the perambulator; Gunter's line of numbers arranged in a circle, and other logarithmic lines, are sometimes inserted. There are also often to be found tangents in hundredth parts of the radius, and the difference of the hypothenuse and base, as applied to the theodolite; also the equation of time for dialling; the points of the compass, &c.

There is always in the centre of the plate a circular hole, which should be truly perpendicular to the surface. Into this is nicely fitted a pin or arbor, which also fits the centre hole in the circle or arc to be divided; and while the operation is carried on, is the principal connexion between them. Fig. 1. Plate CCLXXVIII. shews the dividing plate, and its connection with a compass ring; also a pair of *holdfasts* for keeping the work from turning round. One of these fastenings would be sufficient, were it not necessary to remove one of them, when its position obstructs the work. An index of tempered steel, usually made of a saw blade, has one of its edges made very straight: At one end a plate of brass, as at A, is rivetted fast to this index, having at its extremity a right angular notch, reaching a little beyond the blade: the angular point should be exactly in a line with the edge of the index. This notch receiving the arbor of the plate, will always direct its edge to the centre. The length of the index should be equal to the radius of the plate. To the exterior end, and below it, is fixed a secondary index B, reaching as far inwards as the original lines of the plate extend, which also must have its edge directed to the centre; but it need not be exactly in the line of the other, and will be better seen if it is placed a little to the right. The figure shews this, and also an arrangement of nuts and screws, by which the distance of the two parts is to be adjusted, according to the thickness of the work, so that the secondary one may be flat upon the plate. The generality of dividers, instead of this contrivance, bend the index to suit the different planes of the work and plate; but this is a very bungling method; indeed, when the borders of instruments are required to be divided on feather edges, as is the case with protractors, bending is necessary: a very flexible index should, in such cases be employed, in order that the pressure of the hand may bring it in contact with the inclining plane. But even here a secondary index might be employed to advantage, having its position adjustable to the plane which is to receive the divisions.

ATE CLXXVIII. Fig. 1.

The dividing-knife. Fig. 2.

The dividing-knife must next be described. This little implement is represented, in full size, by Fig. 2. It consists of a blade and handle; the former should be made of the very best steel, and the latter of beech-wood. The cutting edge should be exactly of the same thickness that the divisions are intended to be; it should be quite straight, and in a line with the handle. This edge must not be sharp like that of a common knife, but rounding, so as to present to the surface to be divided a small semicircle, whose radius is equal to half the breadth of the line it is to make. At the back the blade should be about a fifteenth of an inch in thickness. The left side, which is the front and downwards in the figure, should be ground flat; but the opposite side must be chamfered in a faint curve from back to edge. The extreme end of the blade makes with the line of the edge, an angle of about 70°. A small chamfer on the side to the right, broad at the back, but vanishing at the edge, reduces the end to an equal thickness. A semicircular recess is made in the edge of the blade, near the handle, which affords a relief when the tool is sharpened, and is farther useful by receiving the inner side of the end of the middle finger. For the accommodation of this finger also, a part of the ferrule of the handle is cut away, as represented in the Figure. There is a convenience in the back of the blade being formed into a curve so as to make it narrow at the point, for without diminishing its strength, it enables the operator to see his work better. Such is the form of the dividing knife, an important tool in every branch of the art, as in the hands of the best workmen it has continued unaltered since the time of Bird. Had we, indeed, been inclined to describe it as found in the workshop of an ordinary divider of the present time, we should only have had occasion to say, that it exactly resembles the butcher's cleaver; and, perhaps, we might add, is commonly directed with about equal science.

Mode of using the dividing-knife.

The action of the dividing knife is directly the reverse of the graver; the latter being pushed outwards, cuts away a fibre in the line of its course, leaving the rest of the surface of the metal undisturbed; but the former is drawn inwards, and without producing chips, ploughs a furrow, and the metal displaced rises in a bur on each side. The knife is held very much like a pen, only the handle must be quite home between the thumb and fore-finger, which being placed upon the ferrule, directly over the back, is, by its pressure, the chief agent in giving depth to the divisions, the thumb and middle finger acting as supporters, while the other two fingers, as in writing, prop the hand. The knife is held at an angle of about 45° with the plane to be divided, and is used with the flat side in contact with the index before described. If it has an inclination of its own to deviate either to the right or left, it is not in a condition fit to be used; for in the former case it would require too hard a pressure of the hand to keep it in contact with the index, and in the latter would undermine it, and in either case it would make crooked lines. It is therefore necessary to try it in this respect, before the commencement of dividing. If, on drawing a line without an index, it deviates to the right, then is the vertex of the semicircular edge too near that side; but when that vertex is too near the left, the knife will deviate the contrary way. The use of the small chamfer before described is to make the two sides of the knife exactly similar at the point; were it not for this

Common Graduation.

contrivance, the bur would not rise equally on both sides, and the strokes, where they meet the bounding lines, would have an appearance of crookedness.

Method of drawing the circular line.

Preparatory to making the divisions, the circular lines must be drawn for limiting the length of the strokes: these are made with the well known apparatus called a beam-compass; but it is only necessary to trace the lines with it. They are to be made of sufficient breadth and depth by the dividing-knife, which, when sharpened as above directed; and guided by the hand alone, will aptly follow the slightest mark.

Scraper.

The bur is generally taken off the lines with a tool called a scraper, and then cleared with the knife. After this the surface is rubbed with charcoal (that from the willow is best) and water, which leaves the surface smooth, without producing a gloss that would be unpleasant to the eye.

Having been thus minute in the description of the tools, that of their application will be short indeed.

Method of dividing circles.

A compass ring, for instance, as before mentioned, is attached to the dividing plate, for the purpose of being graduated; its *zero*, or N, being placed so, that the index, when set to it, may agree also with the *zero* of the plate. In this position of things, the operator must drop the point of the dividing knife into the line on the plate, and, pressing the index to prevent its moving, cut the corresponding stroke upon the ring. He must be careful to hold the knife steady, and in exactly the same position, while he sets and cuts. His eye must be directed to the left side of the knife, in order that he may see that he holds it in contact with, and parallel to, the edge of the index. The index is now drawn forwards something more than the value of a division, and the knife being fixed in a second line, it is then pushed back into contact with it, and a second stroke cut as before; thus proceeding from right to left until the circle is completed. In dividing upon metals, this work is laborious for the hands, which will require frequent intervals of rest: during these the divider should examine his work with a magnifying glass. In cases where the hand has not power to cut the strokes deep enough at once, which does not unfrequently happen, instead of cutting twice, the operator will proceed with more ease and expedition, if he goes round by single cutting, and afterwards completes his work; for, in the latter part, he will not have occasion for either the dividing plate, or the index; the knife, if well set, will follow the former strokes with accuracy and neatness. The bur must be worn off the divisions by rubbing the surface with charcoal and water, as was before done with the circular lines; but the scraper must not be employed.

Method of dividing straight lines.

Plate CCLXXVIII Fig. 3. & 4.

Common dividing, as it applies to straight lines, is so similar to circular dividing, that little need be said about it. Figs. 3. and 4. represent the necessary apparatus; the dividing knife is common to both. AA is the pattern, and B is a scale to be divided into inches and tenths: CCC represents what is called the dividing square. This tool consists of a thin tempered piece of steel, extending, in the line of the pattern, about six inches, and at right angles somewhat more, and a stock about two-tenths of an inch shorter and narrower than the parallel part. This latter is formed of two pieces of brass; one above the steel, and the other below it, to which they are securely rivetted. The stock and blade are even with each other at the outside and left end; the projecting part of the steel, in the line of the pattern, lies upon the latter, preventing the square from tilting, and that at the end places the stock out of the way when the edge of the blade requires to be repaired. As it is, in some cases, necessary that the square should be used when placed upon the farther side of the work, the two parts of the stock should both be accurately at right angles to the blade; the best way to secure which property is this:—After having made the holes which are to receive the rivets, remove the steel, and pin the two branches of the stock together; then, with the *plane*, make the inner edges straight and even with each other. In order to prove that the blade is at right angles with the stock, take a broad scale of brass, having its edges truly straight and parallel, a thing by no means difficult to procure, and, first applying the square to one edge, draw a line across the scale with the dividing knife, and then, applying it to the other edge of the scale, with the same side uppermost, draw another line extremely near the former. If the parts are right, it is evident the two lines will be parallel to each other; but if they are inclined, half their inclination is the error of the tool, which must be altered by grinding the edge of the steel blade. It is almost unnecessary to observe, that the use of the square, in parallel dividing, is precisely the same as that of the index in angular dividing.

Beam-compass.

We omitted to describe the beam-compass, for tracing the circular lines which limit the length of divisions, on account of that apparatus being well known; for the opposite reason, we now proceed to give a description of the *gauge*, (See Fig. 4.) an implement which performs the same office in tracing parallel lines. It consists of a brass beam A, about six or eight inches long; a socket B, of the same material, with a steel front to the left, which, sliding along the beam, may be set fast on any part of it by the finger screw S on the upper side, and a tracer of tempered steel fixed to the end of the beam by a wedge and screw. The tracer has its point of action brought close to the inner edge, in order that it may draw a line extremely near to the edge of the scale; its great length, as shewn in the Figure, being in no respect incommodious, is designed for the purpose that it should be lasting. The steel front of the socket extends in the line of its action about two inches, which enables the operator to keep the beam without deviation at right angles to the edge of the scale; and there is a projecting part in the front, of the same length, which, bearing upon the surface, keeps the tracer perpendicular; this is discontinued in the middle, for the purpose of admitting the tracer to be brought into contact with the front. The tracing point should be so adjusted as to be a very small quantity below the projecting part. The end of the socket to the right is on every side chamfered to a thin edge, and the beam has divided upon its different sides many lines, suited to the most common work, such as drawing the parallel lines of diagonal scales, &c. By dropping the dividing knife into these, pushing up the socket into contact with it, and there fastening it, the operator places the steel front and the tracer at the proper distance for the performance of his work. In cases of less frequent occurrence, he clamps the socket by trial, so as to make the tracer pass through points previously laid down with the spring-dividers, a tool to be described presently.

Dividing gauge. Plate CCLXX Fig. 4.

The process of dividing from straight line patterns being exactly similar to that from the dividing plate, it must be quite unnecessary to repeat it. We may, however, observe, that in the former the errors go undiminished to the work, while those of the dividing plate are contracted in the ratio of the radius of the plate and work. Clockmakers pursue the contrary process; they fix a small dividing plate upon the centre of their dials, and transfer the divisions outwards. It is not, however, now uncommon for them, in their very best work, to send the dial plates to the instrument maker to be divided.

In straight line dividing, the operator has frequent occasion to divide lines to which none of his patterns will apply; but there is an expedient that he ought not to be unacquainted with, which will enable him, to a certain extent, to overcome this difficulty. Suppose he were required to set off French inches; that he knows the proportion they bear to English inches, which are shorter; and that he has marked off upon the scale to be divided, according to this proportion, the total length of French inches required: he may divide it from his English inch pattern. In this case his work must be placed at an angle with his pattern. The proper inclination is readily found by trial; and as the square must run along the pattern, its blade will not be at right angles with his work. On this account he will have to perform two distinct operations. In the first he is to go through his work, only making slight notches in the hypothenusal, or inclined line, with the dividing knife; in the second, with the square applied to the edge of the instrument which is to receive the divisions, he must, by seeing and feeling those notches, cut the corresponding perpendicular strokes.

Suppose, again, that Spanish inches were to be divided from the same pattern: These are shorter than English inches, and will require but one operation. In this case the square must be applied to the work, and the parts taken from the inclined pattern. We might here annex the rule for finding the angle of inclination, according to the proportion between the pattern and work to be divided, but we do not see its use. Those who handle the dividing-knife, especially in this department of the art, are seldom versed in computation; and as the lines upon the pattern, as well as those upon the work to be divided, are often remote from the edge, the angular point would seldom be found upon either, and would often fall beyond the limits of the room in which the work is to be performed. We have already said, that cutting divisions upon metal is laborious to the hand; but in ivory and wood it is not so; for in either of these a divider will keep pace with a dexterous seamstress, a division for a stitch, for any length of time. The common carpenter's rule is divided in this manner, and, small as is the price of the finished instrument, the dividing bears but a small proportion to it. As a farther proof of the celerity with which this kind of work is performed, it may be mentioned, that the writer of this part of our article being once in want of a good piece of boxwood, exactly similar to that of the common Gunter, but without slider or divisions, the artist who provided it charged sixpence more than he would have done for the finished instrument; and, upon being asked the reason, gave a good one: "the little order had put him out of his common track."

When box, or any other kind of wood, is divided upon, the bur is first well rubbed off the divisions, and then the whole surface brought to a polish with a dry rush; the surface is next burnished by rubbing it hard both ways, in the direction of the grain of the wood, with a clean piece of old hat, which produces an agreeable gloss; and, lastly, to blacken the divisions, a mixture of powdered charcoal and linseed oil being laid on quickly, rubbed hard and cleared away, finishes the process. In ivory, the divisions are, in the first place, filled with a composition of lamp-black and hard tallow, or, which is rather better, of bees-wax and olive oil: when this is hard rubbed into the strokes, the whole surface should be well rushed, and then polished with chalk and water laid upon a linen rag. It has already been said, that the bur of dividing on metal should be taken off with charcoal and water; but in brass, the surface will have a much better appearance if the finishing stroke is given with wet blue-stone, which is a very soft slate, or the same substance that slate pencils are made of. Divided gold and silver, however, look best when they receive their finish from the charcoal. The divided surface of all the metals is improved in appearance by being rubbed with the hand, after a little oil has been applied. No other blacking is required.

Division of diagonal lines.

In dividing diagonal scales, the beginnings and endings of the inclining lines are marked off with the dividing-knife from a pattern of equal parts, and afterwards those lines are traced by means of a straight edge, similar to the blade of the square. The knife being dropped into one of the marks, the ruler is brought into contact with it, and very nearly up to the other mark; the thumb of the left hand is placed exactly over the ruler at the former, and the knife being dropped into the latter, the ruler is brought into contact with it, being turned under the thumb as on a centre. Instead of drawing the diagonal lines by hand, some use the bevel; and as by this the whole is done at once from the pattern, it would seem to be the more methodical way, but it requires a very nice adjustment to make the bevel agree with the square which had been previously used to draw the perpendicular lines. But which ever method is used, to do it with sufficient exactness is one of the most difficult operations of this department of the art.

In the sector, and every other instrument, where the lines, which bound the length of the dividing strokes, are not parallel to the edge, so as to be traced with the gauge, the straight-edge and dividing-knife are used: The beginning and ending of the lines are set off in their proper positions by the spring-dividers: a tool so important in every branch of the art, that a description of it might have sooner claimed a place.

The spring dividers. Plate CCLXXVIII. Fig. 5.

This is a kind of compasses formed altogether of fine steel. It consists of a circular bow and two legs, all in one piece, as represented in full dimensions by Fig. 5. Plate CCLXXVIII. The bow is strong and well tempered, and, without danger of breaking, allows a motion of the points from the distance of about an inch to their contact. This is their range for use, but the elasticity is not exhausted until the points are separated nearly twice as far. At about three-fifths, reckoning from the bow, the adjusting screw has its place: It is at right angles with the legs when the distance between the points is small, because short lengths are most commonly taken. The screw, throughout its whole length, has a fine deep thread of about sixty turns to an inch; is fastened to one of the legs by a pin passing through it, and upon which it turns as on a centre, in order to obey the circular spring of the bow; and the other leg is perforated, in order that, at every distance of the points, it may pass freely through it. A nut, the female screw of which is nicely fitted to the former, by its action overcomes the expansive force of the bow, and regulates the distance between the points: But this nut does not come in contact with the leg; there is interposed between them a saddle-piece, which exterior to the screw is made conical, and this is received by a hollow conical part in the nut, which it exactly fits. The saddle-piece next the leg is formed into a knife-edge, or sharp angle, which, resting upon the sharp bottom of a notch in the leg, keeps the former from turning round with the nut, at the same time that it allows the angular change, as the distance of the points is varied. By this contrivance, freedom of action of the screw is preserved, and the possibility of its change

Common Graduation.

The spring-dividers. PLATE CCLXXVIII Fig. 5.

of place, and consequent alteration of the distance between the points, prevented. The legs are bored in the direction of their length, to a depth of about three quarters of an inch; they have each, near their extremities, a part which projects outwards. These parts, as well as the length bored, are cut open on the outer edge by a saw. A screw, in each of the projecting parts, passes freely through one-half, but acting in the other, brings the parts nearer together, and furnishes the means of securing the points firmly in their places. The points themselves are cylinders, exactly filling the bore of the legs, and their ends are worked to the requisite sharpness; and, in order that they may measure the shortest possible distance, are brought very near the inner extremity of the diameter. At the very point, however, they should be round, and in every direction the sides must make equal angles with the perpendicular; for, were they not so, a distance set off with them, it is obvious, would be altered by pressure.

In using this instrument, the fore-finger is pressed upon the bow, the thumb and middle-finger keeping it upright while the other fingers prop the hand; but where a distance is to be set off many times in succession, the dividers are to be twirled round in the same direction, making a dot at every half turn. This is the manner of handling the tool for common purposes; but for the accurate bisection of a distance, they must not be touched by any other part than the leg near the point, which is lodged in one extremity, while with the other a faint arc is described: the same thing being done from the other end of the distance, the middle point is secured by making a dot with a fine conical pointril. In every use of the dividers, a magnifying glass is to be held in the left hand.

Exemplification of their use in the division of common thermometers.

In *dividing* a common thermometer, several points, 12 or 15 degrees a part, are marked off, according with a standard one; these, always unequal, are filled up with equal parts. The use of the dividers cannot be better exemplified than in this case: Say the distance from one mark to the next is 15°, the operator knows the value of his time better than to do this at two operations; instead of first dividing the space into three or five, he guesses or estimates the distance of 1°, and running the tool over the space almost as quick as he can count its steps, sees how much he has erred; a second or third trial never fails to give him the proper distance. The dots in these trials, two of which should never be made in the same line, are barely to be seen by the glass, and he wants the last, that, by repeating the steps with a greater pressure, he may make the dots sufficiently large to receive the point of the dividing-knife. It may be mentioned, that the operator does not draw a line in the direction of his work: without such help, he learns by practice to plant his points in the direct course.

Division of sectors and plane scales.

Sector and plane scale patterns are divided from a diagonal scale, with the square and dividing-knife: the whole length of the scale is equal to the radius of the sector, and is divided into 1000 parts, and a lower subdivision is obtained by estimation. The value of each division is picked up among the diagonals, according to tables of natural or logarithmic sines, tangents, &c. Whoever wishes for full information upon this subject, may consult the *Select Mechanical Exercises* of the late celebrated James Ferguson; every table is there given, and not a figure more or less than what is required. The practical part of what is here referred to, Mr Ferguson learned from the first of the three Troughtons, to whom his youngest son James was apprentice, a youth of considerable promise, who died at the early age of 23 years.

If it should be thought that we have been unnecessarily diffuse in this department of the art, we would observe, that should any one, before he is fully acquainted with it, and habituated to the use of the tools, attempt to practise the higher branches, he will most probably find himself unqualified for the task.

Sect. II. *Engine Graduation.*

Engine Graduation. Hindley's dividing engine.

The late Mr Henry Hindley of York, about the year 1740, was the first who constructed an engine for graduating instruments, and which also served the purpose of cutting the teeth in clock wheels. We have it not in our power to give a particular account of this engine, but the late Mr Smeaton, in the *Phil. Trans.* for 1785, informs us that the plate was turned round by an *endless screw*, which having been cut with a tool that turned upon a centre at a distance equal to the radius of the plate, made it of smaller diameter in the middle, so that the screw throughout its whole length, acted in contact with the convex edge of the plate. Smeaton informs us, that both the screw and the teeth in the plate, were produced from the original graduation of the plate. Mr Smeaton's paper here alluded to, is replete with general information upon the graduation of instruments; but Hindley's method of original dividing, and his own improvements thereon, form the main subject. These will be briefly noticed in the next Section.

Hindley, far removed from the metropolis, and perhaps knowing little how, in his time, the useful arts were cultivated there, was, by dint of his own native powers, making considerable progress in the improvement of his double profession of clock and instrument making. In the latter, however, he must have wanted that constant employment which alone can ripen experience, and give full effect to execution. He died in the year 1771, at the age of 70 years.

The Duc de Chaulnes' dividing engine, 1768.

An account of the next attempt to make a dividing engine was published at Paris in 1768, by the Duke de Chaulnes; every part of which is described with the utmost minuteness, and illustrated by 15 folio plates, all full of figures. It will not, however, be to our purpose to give even an abstract of this ingenious work, on account of its having been superseded by better contrivances, a due attention to which will occupy as many of our pages as can be appropriated to this subject. We may however observe, that the wheel of this engine is not turned round by an *endless screw*; itself, together with the work to be graduated, is acted on by a clamp and screw for slow motion; by the latter, a divison of the limb is brought to be bisected by the vertical wire of a fixed microscope, and then the corresponding division upon the work cut with a point and frame adapted to the purpose. We do not know that any small instruments were ever divided by the Duke de Chaulnes' engine, or that any large ones were done according to the original method by which it was graduated. The method, highly interesting, and at that time altogether new, will find the notice it deserves in that Section of our present article to which it belongs.

Ramsden's dividing engine, 1766.

It is, however, to the ingenuity of the late Mr Ramsden, that the world is indebted for engine dividing in its full effect. That artist, about the year 1766, produced an engine which, although it fell far short of his expectations, exceeded, in accuracy, the best dividing plate. It was fully competent to the division of common instruments for surveying of land, &c. but was deemed insufficient to produce that accuracy which is required for the purpose of finding the longitude at sea. This engine, about 30 inches in diameter, after Ramsden had, about 1775, made another of nearly four feet, was sold to a nobleman in France for the purpose of being lodged in his cabinet.

Mr Ramsden, in his second effort to make an engine, was completely successful, insomuch that a sextant divided by it, being subjected to the examination of Bird, was by him reported to be fit for every purpose of nautical astronomy.* Ramsden's account of this engine, was in 1777 published by the Board of Longitude, who rewarded his ingenuity with the sum of £300. For a further sum of £315, he made over to the public the property of the engine itself, on condition, that at stated prices he should divide any instruments that might be sent to him by other makers, so long as the engine should be allowed to remain in his possession.

Previous to the account of Ramsden's being published, and before its construction was generally known, Messrs Dollond made an engine, differing materially we believe from the former; but as it was never used except in the graduation of instruments made by them, the only judgment we can form of its quality, arises out of the high respectability of that well known house.

In the year 1778, the late Mr John Troughton completed a graduating engine, which at the full stretch of his pecuniary means had occupied him for three years. In its general construction, this differs in no material respect from Ramsden's, though it is generally, we believe, thought to be superior in point of accuracy. The trade were so ill satisfied with Ramsden, on account of his keeping their work for an unreasonable length of time, as well as for the careless manner in which it was often divided by his assistants, that Troughton immediately, at augmented prices, found full employment for his; and he has been heard to say, that by the care and industry of himself and his young brother, he soon found himself as well remunerated for making his engine, as Mr Ramsden had been by public rewards.

It was about 1788, that Mr John Stancliffe finished a dividing engine. This accurate artist had been apprentice to Hindley of York, and for many years a foreman to Ramsden. The latter derived much information from him in the construction of his second engine, in which the cutting-frame of Hindley was adopted. In the first, the divisions were cut with the beam-compass, which, compared with Hindley's apparatus, is tedious and inaccurate. Mr Stancliffe's practice has almost exclusively been confined to making sextants, and their being held in the highest estimation, furnishes the most certain proof of the excellence of the engine by which they were divided.

It would be useless particularly to enumerate all the engines that have been made for angular dividing; perhaps there may be ten or twelve in London, generally copies of Ramsden's second engine. The greatest novelty that has appeared in this way, was given a few years ago by Mr James Allen, an industrious workman, which he stiles a *self-correcting method of racking the plate*, and which, with the usual good nature of the Society of Arts, &c. was honoured with their gold medal. Those who wish to know more of it, may, by consulting the journals of that Society, gain full information, and have an opportunity to examine whether or not it deserves its title.

As in our article, we have not room for more than the description of one circular engine;—as Ramsden's has been copied into more than one work similar to our own; and as that of the present Mr Troughton has not yet met the public eye, we give the preference to the latter, which at our request he has lately communicated, in the following letter to Dr Brewster:

"Dear Sir, I remember that in a late conversation between us, you gave me to understand, that a description of my circular dividing engine would be acceptable to you, in order to form a part of the article in your Encyclopædia to which it belongs. For that purpose, I have at length drawn it up, not to my own satisfaction indeed, for I wished it to have been done well; but such as it is I have the honour of presenting it to you.

The excellent engine of my late brother being fully four feet in diameter, gave to the operator, when at work near the centre, a position so painful, that it had done no good to either his health or my own, and had materially injured that of a worthy young man then my assistant; it was evident that, by making one of smaller dimensions, this evil would in a great measure be removed, and I foresaw that by employing my own method of original dividing from which to rack the plate, a considerable reduction might be effected without any sacrifice of accuracy. I also perceived, that by contriving the parts with more simplicity than Ramsden had done, I could get through the work at less than two-thirds of the labour and expence.

Such were my motives for making an engine, and the work was accomplished in the year 1793.

"The principal parts of this engine are represented by Fig. 1 a plan, and Fig. 2 an elevation, in Plate CCLXXIX. It is mounted upon a strong frame of wood, the upper part serving as a box to preserve it, and which at certain places opens for use. This stand does not, like those of engines hitherto made, form a part of the machine; it only serves to support it at a convenient height, and is not, excepting the platform EE, at all represented in the Plate. The lowest part of the engine is a heavy tripod of cast brass, nearly in the same state in which it came from the mould. Two of its branches are denoted at A, A, in the plan; the third is similar, but mostly covered by the work above. In Fig. 2. the tripod is also represented by AA, below which three finger-screws that support it upon the platform are seen. These screws, marked B in the elevation, serve the purpose of levelling the engine. They work in the tripod with their heads downwards, and are planted in the broad part where the two branches meet. At about two inches from the centre of the tripod, and at equal distances from each other, are fixed three conical tubes, extending downwards nearly three feet. Two of them appear at C, C, the other is hidden behind the axis of the engine plate. They are connected at the lower ends by a strong piece of brass F, forming together with the centre of the tripod a frame wherein the axis revolves.

The engine plate itself, represented by G*s* in Figs. 1, 2, and 5, was cast in one piece of brass, all except the circular limb. The form of the twelve radii respecting depth is seen in the elevation, and a central part of four inches diameter, equal in thickness to their greatest depth, connects them; but the broad circular centre-piece seen in the plan, as well as the circular ring shewn in the middle, are no thicker than the limb. The limb, three inches broad and half an inch thick, is formed without soldering of one piece of fine plate brass. It is rabbetted upon the extremities of the radii, so as to bring its upper surface into the same plane with them, and there by rivets made permanently fast.

The axis of the plate is a strong conical tube D, four inches in diameter at the upper end, and half as much below. Its length is determined by the three cones of the tripod. At the upper end it is immoveably fixed to the centre of the plate; the lower end terminates in an obtuse point of steel. There is fastened in the up-

Margin notes: Engine Graduation. — Dollond's engine. — Mr John Troughton's dividing engine, 1778. — Stancliffe's dividing engine, 1788. — Letter to the Editor, containing a description of Mr E. Troughton's dividing engine, completed in 1793. — Plate CCLXXIX. Fig. 1. & 2. — Fig. 5.

Description of Mr E. Troughton's circular dividing engine.

per end of the axis an arbour of hardened and tempered steel, which, having passed through the plate from below, stands full two inches above its surface, and ends in an obtuse point similar to that below. Upon the two points when revolving in the lathe, the surface of the plate was generated, and its outer edge made perfectly circular.

A screw for making the teeth in the limb had previously been made. It had 20 threads in an inch; and as it was intended that by one of its revolutions it should carry the plate through an angle of 10′, it followed, that the circumference of the plate should be 108 inches. From the measure of the screw, therefore, the dimension of the exterior border of the plate was derived, first by computation nearly, and afterwards by trial with the screw itself.

A strong collar of bell-metal had been soldered upon the axis, and, when the limb was turned, made concentric with it. The position of this collar is, respecting height, coincident with the body of the tripod. The centre of the tripod is hollow, in order that the collar should pass through, but does not form a socket for it to work in. Instead of that, two narrow pieces of steel are fixed vertically at an angle of 120° with each other. Against these, the collar is pressed by a steel spring planted at 120° distance from them. In this triangular bearing the axis is supported at top, while the piece F receives the point at the lower end, and supports the whole weight.

To that branch of the tripod which is in front, a strong plate of brass is screwed fast, as represented in the plan. It extends inwards half way to the centre, and outwards somewhat beyond the border of the wheel. Its breadth is rather more than the length of the screw arbor. Immediately above this, and in contact with it, is an exactly similar plate. To the under side of the latter are screwed three oblong pieces, the thickness of which is equal to that of the lower plate. These, one of them at the middle of the inner end of the plate, and the other two at the outer end near the edges, are received by slits cut in the lower plate, which are about one-eighth of an inch longer than the pieces, and allow a motion of the upper plate, in the direction of the radius equal to that quantity, but afford it no lateral play.

The dividing screw is fastened to the upper plate, and partakes of its motion, the use of which is occasionally to disengage the screw from the teeth of the limb. Two pieces, which connect the screw with the upper plate, are seen, one or both of them, in all the figures, and marked with H; they extend towards the centre, as far as the plate, and form edge-bars to strengthen it. The shape of these pieces is best shewn in Fig 4. especially as to the manner how they are brought from below, for placing the screw even with the edge of the wheel, and how the screw arbor is centered in them. The arbor of the screw is cylindrical; and a portion of each end forms a cylinder of smaller diameter. The shoulders, which near each end of the arbor, limit those parts, prevent lateral play in the pieces last described; for the smaller parts work freely in the holes of those pieces, the shoulders being in contact with their inner edges.

Plate CCLXXIX. Fig. 4.

The engine, so far described, is ready to receive the original graduation of its limb; and as this operation was done, while work to be described hereafter was preparing, I will here explain by what means this most important part of the work was accomplished: to do this, however, within moderate bounds, I must suppose that the reader is already acquainted with my method, as published in the *Phil. Trans.* for 1809, or that he will turn over to the last Section of this article, where it is fully explained.

In the first step, a roller was placed horizontally, in a frame attached to the tripod, having free and steady motion round its own axis; this was adjusted so as to be carried exactly 16 times round, while the engine plate made one revolution, and was itself near the edge upon its upper surface, divided into 16 parts. Now, upon turning the plate round, these 16 divisions 16 times told = 256, came in succession to the wire of a fixed microscope, and were, by a proper apparatus, transferred to the surface of the plate, in five dots, at a sufficient distance within the edge to prevent their being disturbed by making the teeth. To accomplish the next step, an index was made to revolve upon the arbor of the plate; it was composed of two branches, each of which carried at its extremity a microscope with a micrometer; these had a range of angular motion respecting each other, from a right line to a very small angle. By this index, and these microscopes, the 256 fine dots were examined by a certain bisectional process, from which their individual errors were investigated by computation, and formed into a table. By the help of the table of errors, the future work of racking the limb was prosecuted with as much certainty as could have been done, had the original divisions been inserted without error.

It has already been said that the value of a tooth of the limb should be 10′, and consequently their whole number will be 2160; now $\frac{2160}{256} = 8\frac{7}{16}$, and just so many revolutions and parts of the dividing screw will be commensurate with a mean space from dot to dot = an angle of 1° 24′ 22″.5. In order, therefore, that a comparison between the plate and the screw might be made at every original dot, it became necessary to provide means to ascertain the position of the former at every 16th part of a revolution. To this end a micrometer head, as large as could be admitted, divided into 16 equal parts, was fixed upon the left end of the screw arbor; and contiguous to this, was placed a fixed index bearing a fiducial line. For the purpose mentioned above, these were all that could be wanted; but as our dots were erroneous, in order from their apparent, to determine their true places, a lower subdivision of the head became necessary. Each of the 16 spaces, therefore, was divided into 10 by actual division, and as an eye, practised in such matters, can by estimation accurately obtain the value of the next decimal figure, it was into the last denomination of subdivision that the table of errors had been reduced, the value of an unit of which, in angular measure, is $\frac{3}{8}$ths of a second.

The roller was removed when the 256 dots had been transferred to the plate, as were the double index and microscopes from the central arbor, when the position of those dots had been ascertained. Now, the dividing screw was placed in its frame; a micrometer, with a moveable wire, fixed to the tripod for viewing the primitive dots, and a winch for turning the screw attached to its arbour on the right: this change of parts being effected, the screw with its frame having free motion in the line of radius, and capable of being, by the force of a spring, pressed into contact with the edge of the plate, or by a screw drawn backwards at pleasure; and the plate itself having free motion round its axis, the important operation of forming the teeth, or racking the circle, was commenced.

It should be premised, that to prevent mistakes, by beginning an interval at a wrong 16th of the head, which, by making false marks, would occasion much

Method of graduating the limb in Mr Edward Troughton's circular dividing engine.

trouble, those parts were numbered 1, 2, 3, &c. to 16, in the order of turning the screw forwards. Corresponding numbers were marked in ink upon the plate opposite to the dots, the order of which, from right to left, was 0, 7, 14, 5, 12, 3, 10, 1, 8, 15, 6, 13, 4, 11, 2, 9, which, repeated 16 times, completed the circle. These enabled me to proceed with confidence; for, in beginning any interval, it was only required that the number upon the head should be that, which distinguished the dot under the wire of the microscope. In the table of errors, I marked those dots, which were too forwards, with the sign —, and those that were too backward +, because it is evident that a + position of the screw will effect the correction of a — error of the dot, and the contrary.

The *zero*, or first dot, being without error in the table, is, by turning the plate round, to be brought exactly under the wire of the microscope, and the division of the head marked 0 made to coincide exactly with the fiducial line. The spring must now be allowed to press up the screw into contact with the edge of the plate, and then, by means of the winch, the screw is to be turned through $8\frac{7}{16}$ revolutions, which will make impressions upon the edge of the plate, and bring up another dot to the wire of the microscope. The screw must now be released, and the plate turned backwards, so as to bring that dot to the wire which precedes the one that the former interval began from, which dot is marked 9, and the division of the head marked 9 must be brought to the fiducial line, but not exactly; for in this, as well as in every future interval, the tabular error of the dot must be allowed for, according to the subdivisions of the head: the screw being again pressed up, and turned with the winch, as was done before, this interval will be indented. Thus proceeding in a retrograde course, from one interval to another, until the whole circle has been gone over, we shall have a slight impression of the screw at each of its 2160 revolutions.

The marks formed in the manner just described are laid on, as it were, in patches, the beginnings of which are agreeable to the original corrected dots, but at every other point subject to the error of mismeasurement of the screw, as well as to that of its uncertain action.

It is evident that the backward process in making the first impression, was to prevent accumulated error, which must have taken place, had the screw been turned forwards through successive intervals; but as the impressions already made are sufficiently deep for the screw in its future action to follow them, and by its own equalizing action to produce agreement, if necessary, between the beginning of one interval and the end of another, it would be useless to pursue that process any farther.

A continued forwards motion of the screw with the winch was therefore kept up, until the plate had made two more complete revolutions, when an examination at several places was made as to the agreement between the original dots and the impressions of the screw, which was highly satisfactory.

Hitherto the threads of the screw had not been made to cut; they indented the edge merely by their sharpness and pressure; and, without making either dust or chips, ploughed a furrow, on each side of which the metal rose in *bur;* and it was easy to see, that already four or five of the middle threads had been worn into action.

But to prosecute the operation of racking from these slight indentations to the full tooth, required that the screw should cut like a saw; and for that purpose, the spiral notches, which in opposite directions are represented in the Figures as crossing the threads of the screw, were made with a sharp-edged file; and, in order to preserve sharpness through long-continued action, those notches were from time to time filed deeper and broader.

In the account which Mr Ramsden gives of racking his engine, it is stated, that, after following step by step the retrograde process described above, through three or four revolutions of the wheel, without regarding any more the original divisions, he turned round by continued motion, until he had produced the full tooth.

I have, however, to give a very different description of a method of doing the same thing; an operation which occupied me nearly a month, and turned out one of the most troublesome I was ever engaged in: it was a continued process of *coaxing* from beginning to end. My brother, who had performed a similar task before, had, from his own experience, warned me of what I might expect; but, without that caution, I should not, any more than he had done, have trusted, without examination, to the blind operation of the screw. The chief cause of the embarrassment was, that the threads of the notched screw cut sharper with one edge than with the other, and consequently the indentations gained or lost upon the original divisions. By frequently sharpening the screw opposite various parts of the limb, the error arising from this source was sometimes + and sometimes —, and that to the amount of 7″ or 8″ in some parts of the circle. These errors were corrected from time to time, as they were found to exist, by pressing the wheel forwards or backwards, so as to force the screw, in its revolution, to remove more metal on one side of the indentation than on the other.

Those who dream of a self-correcting method of racking an engine, will do well to open their eyes to the above circumstance; and for their use it may be remarked, that, in mechanical matters at least, faith is but a poor substitute for good works, and ought never to supersede the use of the senses.

My brother had told me that he had experienced considerable inconvenience from having made the notches in the screw parallel to the axis, as Ramsden had done before; for the whole length of each cut, coming into action at once, and going out at once, caused an irregular jerking motion; this inconvenience I avoided by making the notches in spirals, which crossing each other at equal angles, gave in one set the preceding edge, and in the other the following edge the most advantageous cutting angle: this expedient was not only productive of dispatch, but also afforded an important advantage altogether unforeseen. In all the engines hitherto made, the racking screw, by frequent sharpening, had been completely cut up, and in every case a second had been provided for working with. I also had provided a duplicate; but the spiral cuts, by coming into and going out of action continually and imperceptibly, rendered its application quite unnecessary. The notched screw to be worked with, requires a much less pressure than that which would make it cut, but the working pressure is quite sufficient to cause the notches to rake off every impurity from the teeth of the wheel, and keep them perfectly clean: this last, together with the economy of using but one screw, constitutes the advantage above alluded to.

Fig. 3. is designed to shew in perspective the apparatus for carrying the wheel forwards by the screw, the manner how the latter is connected with the foot, Plate CCLXXIX. Fig. 3.

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Method of graduating the limb in Mr Edward Troughton's circular dividing engine.

Plate CCLXXIX.

and how it is stopped at every division. The chief parts of which this apparatus consists, are more or less seen in all the Figs.; but the manner of its being supported upon the platform of the stand by the intervening block I, is seen only in Fig. 2. The principal piece is a cock J, the horizontal part of which has two branches, (one shewn in the Figure,) between which the strings pass. The vertical part supports a cylinder of steel, which, when the screw is in action, forms a right line with its arbor; but there is left between their ends a space of about half an inch: this affords easy means of changing the ratchet-wheels, which are placed upon the screw-arbor, and move round or stop with it. A barrel about 2 inches long, and $1\frac{1}{4}$ diameter, is fitted upon the cylinder, but so as to admit of its being turned round and moved upon it with perfect freedom from end to end. The middle part of the barrel is formed into a spiral worm or screw, the groove of which receives a cord or cat-gut of one-tenth of an inch in diameter. There is a slight frame dove-tailed upon the horizontal branches of the cock, as shewn in front of Fig. 3. which has steady and free motion in the direction of the cylinder; to each side of this frame is attached a pallet, one of which enters in front, and the other behind into the spiral worm of the barrel, by which means, when the latter is turned round, rectilinear motion is given to the frame. The barrel to the right is large, and excavated, so as to admit the ratchet-wheel, which latter is driven by a catch and spring, planted in the edge of the cavity in the former. The end of the barrel to the left is embraced by a ring, which is capable of being turned round or set fast at pleasure. A stopping piece is fastened to the frame by a finger-screw, and by means of a slit, through which the screw passes from the ring of the barrel, varied through a considerable extent. The elevated part of the stopping-piece resembles an anvil, and the hither side of the ring of the barrel, a hammer: the contact of these determines the point from which divisions begin: each division is terminated by similar means; an anvil is found in the elevated part of the frame behind, and a hammer in a screw-head, projecting from the enlarged end of the barrel: a string occupying four or five turns of the groove of the barrel, at one end is attached to a treadle near the floor, and at the other, after passing over two pullies, to a weight behind. When the treadle is pressed down with the foot, the hammer in front leaves its anvil; and as the barrel is carried round, the frame is moved forwards by the pallets; so that in the second turn they pass clear of each other, and the motion is continued until the anvil behind is struck by the other hammer: during this time the catch, by the pressure of its spring, has hold of the perpendicular side of a tooth of the ratchet-wheel, carries the screw round along with it, and moves also the engine plate through the proper angle. On the pressure of the foot being gradually withdrawn from the treadle, so as to let the weight prevail, the barrel will be brought round in a contrary direction; the hammer and anvil on the farther side leave and pass each other, and then those on this side pass and meet as at first, ready for a second tread. During the time that the barrel runs backwards, the screw and engine-plate stand still; for the sloping sides of the ratchet-wheel allow the catch to escape freely over them. As things stand in Fig. 3. a tread gives only two revolutions of the screw, but the number may be varied at pleasure as far as six; for let the anvil in front be placed by its finger-screw so much to the right as will allow the hammer to escape it, the weight will then draw the barrel back through another revolution, and the parts will meet again. Parts of a revolution are obtained with equal ease. It was said before, that the ring of the barrel, to which is attached the hammer in front, might be turned round and fixed at pleasure; now it is evident, that if the hammer were brought down so as to meet the anvil sooner, the tread would be shortened; and, if shifted the contrary way, it would be lengthened. Thus, by changing the position of the anvil, we can vary the number of complete revolutions; and as parts of a revolution are obtained by shifting the hammer, we have the power of varying the angular value of a tread from six revolutions of the screw, down to a single tooth of the ratchet-wheel. The most useful number for the teeth in this wheel is 120, for it answers to the division of the vernier that gives 5″ of the usual degree, or 10″ in instruments of reflexion, as well as to many others. To divide the vernier of a reflecting one that shews 15″, requires a ratchet-wheel of 80 teeth; and this number, were it of any use, which it is not, would give the usual subdivision of the 96° arc. To divide the centesimal degree of the French, and its first decimal subdivision, requires a wheel of 100 teeth. To the division of odd and prime numbers, a near approximation may be made by an artifice contrived by myself, and I believe unknown to any except those who have been my assistants: an example will be the best way of teaching it to those to whom it may be useful. Let the number to be divided be 331, and let the ratchet-wheel with 80 teeth be chosen; if we divide 2160, the whole number of turns the screw makes in one revolution of the plate, by 331, we shall have a quotient of 6, with a remainder of 174, which latter being multiplied by 80, to reduce revolutions of the screw into teeth of the ratchet-wheel, gives 13920, and this also being divided by 331, quotes 42 with a remainder of 18; that is, a division will be equal to 6 revolutions of the screw, and 42 teeth of the ratchet-wheel nearly. But as we cannot at one tread exceed 6 revolutions, we must be content with half of it = 3.21, and tread twice for one division; but as in our arithmetical operation we had a remainder of 18 teeth, in order to *make ends meet*, these must, as we proceed, be disposed of in their proper places: now, as 18 is the 20th part of 360, if at every 20° of the circle we set the screw one tooth forward by hand, the thing will be accomplished, and no greater error than 1 tooth = 7″.5 will enter the work; a precision fully sufficient for any purpose that such numbers can require, and in my opinion greater than can be come at by any other means.

Fig. 5.

On the end of the screw arbor to the right, as exhibited in Fig. 5. is attached a milled-head and divided micrometer; the latter, like the rachet-wheel, is changeable at pleasure, and carrying the same number of divisions that the wheel does teeth; the micrometer turns round with the screw, and a cock, fixed to the frame, bearing a fiducial line, serves as an index for counting the divisions. By the help of this we are enabled at once to set the stopping apparatus to any part of a revolution of the screw, without the trouble of a second trial; and by it, in case of a false tread or other accident, we can adjust the parts again to due position.

Apparatus for cutting the divisions.

The frame and apparatus for cutting the divisions, and their connection with the engine, remain to be described. Upon the two remote branches of the tripod, and beyond the border of the wheel, are erected two pillars, the upper parts of which are formed into screws. Four screw nuts work, two and two, upon the screw part of these pillars, and embracing the ends of a strong bar of brass KK which they support, enable us to ad-

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just its height, to suit the thickness of the work to be divided.

Apparatus for cutting the divisions.

To the near branch of the tripod, a cross piece L, Fig. 2, nearly the length of the screw arbor, and parallel to it, is firmly fastened. This carries upon its extremities two pillars similar to, but smaller than, the others. Upon the strong bar KK, at equal distances from the middle, are two other bars fixed by finger screws. They extend from the strong bar to the pillars in front, to which they are secured by double nuts like the former. These two bars, marked M, M in the plan, are bound together by a cross brace at the remote end, and by another a little way beyond the centre. But in no other part can crossing pieces be admitted; for as they form the support for the apparatus that cuts the divisions, uninterrupted motion along the whole line of the radius is required.

The cutting apparatus consists of three principal pieces, marked in the plan *a*, *e*, *o*. The first is a bridge, which crosses the space between the bars M, M, and to which it is attached at either end by sliding sockets. The latter run along the bars, to any part of which the apparatus may be clamped, according to the length of the radius of the instrument to be graduated. Two steel screws having conical points, are tapped through the perpendicular ends of the bridge above the sockets, and by working in holes of the second piece, form an axis or joint, round which the latter has a free and steady motion. The third piece, the form of which, as well as that of the second, is seen in the plan, has, like the first, steel screws with conical points tapped through its ends, and these like the others act in the middle piece, forming another horizontal axis parallel to the former, and in every respect like it. In Fig. 1, the parts are extended, for the purpose of being more distinctly represented, into a position in which they cannot work. The best effect is produced, when the middle piece is vertical, and the third horizontal. Sufficient freedom of action, however, is found in this contrivance of Hindley's, to produce a rectilinear motion of the pointril of at least one-third of an inch, a quantity fully adequate to the purposes required. The part of the third piece next the centre, is that in which the pointril is placed. It is so contrived, that its length below the piece may be varied at pleasure, that it may be turned round upon a horizontal axis, so as to make any angle with the plane to be divided upon, and that its action may be viewed by a properly attached magnifying-glass.

There is one part, which might either have been mentioned sooner, or, as the performance of the engine in point of accuracy is not at all promoted by its introduction, might have been altogether omitted; but as it bears rather a conspicuous appearance in Fig. 2, it may as well be noticed. A bar attached to the same pieces that support the screw arbor, to which it is parallel, and placed below it, together with a cock behind, bear the axis of a vertical friction wheel N. This wheel is placed so, as to roll in contact with the under side of the limb of the engine immediately below the dividing screw. Without this, the action of the screw in the teeth of the wheel would occasionally produce a very harsh jarring sound, but which is rendered mute by this contrivance.

Fig. 2.

A hardened and tempered steel arbor rises full two inches above the surface of the plate, in the axis of which it is immoveably fixed. In other engines the axis is hollow, into which may be dropped differently sized arbors, suitable to the centre holes of the instruments to be graduated; but as I never intended with this engine to divide any other instruments than those of my own construction, and as it was easy to make them, whether great or small, to suit my arbor, by fixing it, I avoided one source of uncertainty and error. This arbor is the principal connection between the engine and work to be graduated, and requires the most exact fitting; and tapped holes, arranged variously through the length of the 12 radii, furnish the means of applying holdfasts, to prevent accidental circular derangement.

I will now conclude this long description with observing, that with this engine, and indeed the observation applies equally well to those of Ramsden's construction, the operator can cut about 24 strokes in a minute of time; for one single minute indeed, he will be able to make 30; but including short and frequent intervals of rest, the former rate may be kept up for hours together. The vast importance of this expedition, needs no comment with those who know the value of accurately graduated nautical instruments, and the great demand for them. Yours, &c. EDWARD TROUGHTON."

We are well aware, that engines for dividing straight lines, are of much less importance than those for graduating circles and arcs; yet we should not think that justice was done to our article, were we to omit an account of one for the former purpose.

Account of Ramsden's straight line engine.

Encouraged by his former success, and having in prospect farther rewards, of which he was not disappointed, Mr Ramsden constructed the first right-line engine, an account of which was published in 1779, by order of the Board of Longitude. Of this, the following is a copy, accompanied by reduced drawings of the original figures.

"Experience having evinced the great utility of the engine for graduating circles, it encouraged me to attempt a similar method, whereby lines of equal parts, sines, tangents, secants, &c. might be divided with equal ease and correctness.

By the engine hereafter described, any line of equal parts, &c. may be divided without an error of the $\frac{1}{4000}$th part of an inch; and, as this can be done by any indifferent person, and so very expeditiously, its uses for dividing all sorts of navigation scales, sectors, &c. must be obvious; especially when it is considered, that from the incorrectness of the present method of dividing, these valuable instruments are of less use than they might be.

This engine consists of a strong plate of brass, moveable on two edges of an iron frame. To facilitate its motion, the friction is considerably diminished by the application of three rollers to the under-side of the plate: the iron frame is supported on a strong mahogany stand.

One edge of the brass plate is ratched or cut into teeth, of which there are exactly twenty in an inch, and it is moved along the iron frame by an endless screw, having exactly the same number of threads in an inch; these threads fit into the teeth on the brass plate. Each revolution of the endless screw round its axis will move the plate $\frac{1}{20}$th of an inch along the iron frame.

A small wheel is fixed on one end of the screw, having its circumference divided into 50 parts, which are again subdivided into five parts by a vernier; therefore, when the screw is turned on its axis, one of the primary divisions, the plate will be moved $\frac{1}{1000}$th of an inch along the iron frame; if the screw be turned to the coincidence of one division on the vernier, the plate will be moved $\frac{2}{10000}$th of an inch, and so of the rest; and the line on the plate to be divided, which terminates the spaces moved by the brass plate, may be

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Account of Ramsden's straight line engine.

drawn on it, or on any instrument fastened on the plate, with the greatest accuracy, by a point or tracer fixed in a proper frame, whereby it has a rectilinear motion, without any lateral shake.

Sometimes it may be necessary to lay down lines on instruments which are not commensurable with English inches; such as are the feet, inches, &c. of most other countries: this is done by inclining the line to be divided to make an angle with the direction of motion of the plate, by an apparatus to be described hereafter; if the tracer be set to draw lines at right angles to the direction of motion, or to the side of the plate, then the line to be divided will be as much longer than the space the plate has moved, as the secant of the angle of inclination is longer than the radius; but if the tracer be set to draw lines at right angles to the line to be divided, then divisions on that line will be shorter than the space the plate has moved along the iron frame, as much as the cosine of the angle of inclination is shorter than the radius.

Plate CCLXXX. Figs. 1—5.

Fig. 1. Represents a plan of the dividing engine.

Fig. 2. An elevation.

Fig. 3. A section on the line AB.

Fig. 4. A section on the line DE.

Fig. 5. The underside of the plate A, represented in Fig. 1.

Note. Like parts are marked with the same letter in each of the Figures.

Fig. 1. A represents a strong brass plate, 27 inches long, four inches broad, and $\frac{7}{10}$ths of an inch thick; worked exceeding flat, and of the same thickness throughout, with its two edges exactly parallel.

B is a strong iron frame, 48 inches long, having two edges *a*, *b* rising half an inch above its surface; these two edges are made very straight, and in the same plane; the inside of the edge *a* is also made as straight as possible.

Fig. 5. The plate A slides on the two edges of the iron frame; beneath it are two springs *c*, *c*, each fastened at the extreme ends to the plate A by the screws *s*; at the other end of each spring is a roller *c* of tempered steel, turning on an axis in these springs; there is also a third roller *d* of tempered steel, let into the iron frame near where the threads of the endless screw act; this roller hath a long axis, one end turning in the iron frame at *g*, and the other in the lever *h*; this lever turns on a centre at *i*, and with it the roller *d* may be raised or depressed, by turning the capstan-head screw *o*, which presses on a strong spring.

Fig. 3. Figs. 2, 3.

The use of the rollers is to diminish the friction of the plate A, when moving on the iron frame B: for this purpose, the strength of the springs is regulated by turning the two screws *n*, *n*, and of the roller *d* by the capstan-head screw *o*, till the weight of the plate A be very nearly carried on these rollers.

Fig. 2. C is the endless screw, which is of tempered steel, and has its pivots formed in the shape of two frustums of cones joining each other at their smaller end by a cylinder, as shewn in the description of the circular engine, p. 5, Plate III. of that work. These pivots turn in half holes of the same form in the pieces of brass DD, which are firmly screwed to the iron frame; the half holes are kept together by the screws *m*, *m*, which may be tightened at any time to prevent the endless screw from shaking.

Fig. 1. On one end of the screw arbour is a wheel *h*, having its circumference divided into 50 parts, and numbered at every tenth division with 1, 2, to 5; and these divisions are again subdivided into five parts by the vernier *t*.

G, G represent two frames of steel; each of these frames turn on centres K, fastened to the under-side of the plate A, and equi-distant from the edge of it. In each frame is a roller *y* of tempered steel, turned very concentric to their pivots, and exactly of the same diameter.

Plate CCLXXX. Fig. 5.

The frames G, G are connected together by the brass plate E, which turns on a stud in each frame; the studs must be at equal distances from the centres K on which the frames turn, and the distance between the holes in the plate E in which the studs act, must be the same with the distance between the centres *k*, so that the plate E may always move parallel to itself, and that the circumference of the rollers may be always equidistant from that edge of the plate A, which is intended to be ratched. This apparatus serves to press the edge of the plate A, with a motion parallel to itself, against the threads of the endless screw.

Figs. 1. On the end of the plate A is a spring of tempered steel, which acts as a bent lever. The spring end of this lever has a ketch, which passes under the head of the stud I, that is on the end of the connecting piece E. While the other end of the lever is pressed gradually down towards the plate A, by turning the finger screw F, the connecting piece E is drawn forward, so that the steel rollers pressing against the edge *a* of the iron frame, may force the side of the plate against the endless screw.

Then having two screws of tempered steel exactly of the same diameter and number of threads, viz. 20 in an inch, one of these screws was notched across the threads, so as to cut in the manner of a saw; this screw was put in the half holes in the pieces D, D; on the opposite end of the screw arbor to that whereon the wheel is, there is attached a long rod, of such length, that the winch on the end of it, by which the rod and endless screw are turned round, may be clear of the iron frame. Fig. 2

Fig. 1. Z is a narrow slip of brass, having its edges exactly parallel, which is screwed on the plate A, and steady pinned.

The edge of this slip is parallel to the edge of the plate A; a distance of 25.6 inches was set off on a line on the slip parallel to its edge; this distance was bisected continually, till the distance between each bisection was $\frac{8}{10}$ths of an inch.

A brass cock was fastened to the iron frame, which passing over the endless screw, applied itself to the slip on the brass plate A, a small silver wire was stretched across a hole of half an inch diameter in the end of the cock. The coincidence of the bisections with this wire was examined by a small magnifier in a brass tube fixed exactly over it.

The plate A being on the iron frame, the bisection marked I, towards the right hand, was set to coincide with the wire, and the division numbered 50 on the wheel, was set to the first division on the nonius.

The plate A was then pressed against the endless screw, by turning the finger screw F; then, by means of the winch, the endless screw was turned towards the left sixteen revolutions, till the bisection marked *o*, was brought to the wire; this done, the plate was detached from the endless screw, by unturning the finger screw F, and the division numbered 2 was set to coincide with the wire, the division 50 on the wheel being previously set to its index, and the edge of the plate was pressed against the screw by turning the finger screw F; then, by means of the winch, the endless screw was again turned round its axis 16 revolutions

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Plate CCLXXX.

towards the left hand, till the bisection I was brought to coincide with the wire. The plate was again detached as before, and the bisection marked 3 was set to coincide with the wire, and in this manner the edge of the plate was ratched from end to end three or four times, till the threads had made a good impression, which afterwards was ratched from end to end, without ever disengaging the plate from the screw, till the teeth were entirely finished.

The notched endless screw, with the rod and winch, were then removed, and the plain screw was put in its place; having the divided wheel on one end of the screw arbor, and two sets of ratchet wheels on the other end. These sets are each composed of three wheels, having teeth round their circumference; one in each set hath 32 teeth, another 48, and the third 50. These two sets being one for turning the screw, and the other for stopping it, they have, for this purpose, their ratchet teeth cut in opposite directions.

Figs. 1, 2.

I, represents a cylinder of brass, having on one end two steel rings *a* and *b*, with their edges that are towards each other cut into ratchet teeth; these teeth are cut in contrary directions, so as to fit into each other; on one of these rings is an index, and the other hath its teeth numbered with 10, 20, up to 50. The other end of the cylinder is made hollow, and contains one of the sets of ratchet wheels. There are two slits opposite each other, pierced through the hollowed part of the cylinder W. In each of these slits is a click turning on an axis, and is pressed into the teeth of the ratchet wheel by a small spring. The clicks may be moved along their axis, so as to catch in any one of the three ratchet wheels, and may be fastened at that place, by tightening the small screw S.

Figs. 1, 2. 4.

The cylinder I, with the clicks, &c. turns on a steel axis X, firmly attached to the piece K, and in a line with the axis of the endless screw. Motion is given to this cylinder round its axis by a piece of cat-gut, which hath one end fastened to the ratchet ring *b*; and the other end, after passing four or five times round the cylinder, is fastened to a treadle; and on pressing the treadle downwards, the clicks S catch in the teeth of one of the ratchet wheels, by which means the cylinder I, together with the endless screw, are turned round their axis, which moves the plate along the iron frame, and at the same time winds up the spiral spring *u*. On releasing the treadle, the spring *u* unbends itself, the clicks quit the ratchet wheel, and leave the endless screw at rest, while the cylinder I turns in an opposite direction, and raises the treadle to where it was before.

Figs. 2, 4.

V is a small square bar of steel, having both its extremities cylindric. These cylinders move in holes lined with hardened steel, one in the piece D, and the other in the piece K. This bar carries three different pieces, which are of tempered steel; the middle one *t*, is made to lie in the interval between the threads of the screw cut on the cylinder, and passes nearly half round its circumference; it is kept in the threads by a spring *e*, which presses on a piece *q*, screwed to the iron frame. This piece being attached to the bar V, by the screw *p*, turning the cylinder I on its axis, will give a longitudinal motion to the bar V.

Fig. 2.

The upper end of the piece *f* is formed into a hook, and may be set to catch in the teeth of any of the ratchet wheels, and then fastened to the bar *v* by the screw *i*. Towards the other end of the bar is a piece *j*, which serves to stop the cylinder in turning back, so as to limit the number of revolutions or parts. It is fastened to any required place on the bar *v*, by the finger screw *f*.

When the engine is used, the treadle is pressed downwards, which, by means of the cat-gut string, turns the cylinder I round its axis; and the piece *t* moves along the thread, till a stud *r* on the cylinder, striking on the top of the curved piece *t* bends the spring *e*, till that piece rests on the piece *q*. By bending this spring, the square bar is turned a little on its axis, and pulls the hook *f* into the teeth on the ratchet wheel R. Then releasing the treadle, the spiral spring turns back the cylinder, till the piece *j* is brought under the stop on the ratchet ring *b*.

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Plate CCLXXX. Figs. 2, 4.

The parts of a revolution are regulated, by setting the number required on the ratchet ring *b*, to the index on the fixed ring *a*. Each of the teeth answers to a motion of $\frac{1}{1000}$ of an inch of the plate A; and the number of revolutions, each of which moves the plate A $\frac{1}{20}$ inch, is regulated by setting the piece *j* on the bar. Figs. 1, 2.

L represents the steel frame, in which the tracer is fixed. This frame turns between the conical points of two screws *n*, *n* of tempered steel, which are screwed in the frame Q. There are also two similar screws in the same frame at *m*, *m*. The points of these screws, which are also of tempered steel, turn in conical holes in the piece P. By means of this parallel motion, the tracing point, by which the divisions are cut, will always describe the same line without any lateral bending. The tracer is put in the hole in the axis *b*, and is fixed there by tightening the four screws *f*, which presses the piece *c* against the flat part of the axis. Figs. 1, 2, 3.

This axis, which hath its pivots formed in double cones, turns between the half holes at *d*, and may be fixed when the tracer is set to any required inclination, by tightening the screw S.

S is a brass ruler, having its edges very straight and parallel. It hath two thin pieces of steel *g* attached to it, which turn on joints at *h*, exactly equi-distant from the edges of the ruler. The interval between the pieces *g*, *g*, is exactly the same with the width of the steel frame L. There are angular notches on the lower edge of the pieces *g*, similar and equi-distant from their centres; so that when any two corresponding notches are put on the screws *n*, *n*, between the frames Q and L, the screws being on that part made cylindric, and both of the same diameter, then the edge of the ruler will always be at right angles to a line drawn by the tracer. The ruler S, in this manner attached to the cutting frame, may be set parallel, or to any required inclination with the edge of the plate A, by turning the handle T, which moves the piece P with the cutting frame and ruler on the centre *x*, and may be fixed there by tightening the nut P. Fig. 6.

From a centre J, on the plate A, are drawn two circular arcs. The outer one is divided into degrees, and numbered from 1 to 9. Each degree is again subdivided into six parts, or every ten minutes. The inner circle is divided in the proportion, that the cosines of the angles of inclination with the edge of the plate A bears to the radius, supposing the radius 10,000, and the divisions are numbered every 10th with 10, 20, to 140. But the use of this apparatus may be perhaps better understood by an example.

Let it be required to divide a line of the length of 9 $\frac{900}{1000}$, into the same number of divisions, and in the same manner as if it were 10 inches long. Put the ruler S to the cutting frame L, and turn the handle T till the same edge of the ruler cuts the centre J, and the first division from the O of the inner arc. Then screw the instrument to be divided firmly on the plate A, so that the line to be divided may be parallel to the edge of the ruler, which may be now removed. When the plate has moved 10 inches in its own direction, the

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whole length of the divisions on the line divided will only be $9\frac{999}{1000}$ inches."

On the formation of the screw of dividing engines.

The screw of a dividing engine, whether for right lines or circles, must be considered as a most essential part, and should be of the most perfect workmanship. Probably from knowing, that there are several good methods of producing a screw now well known to artists, Troughton omitted to send an account of that by which his was made, at the time he transmitted to us the description of his engine. We will, however, annex the method of making one; and as that employed by Ramsden for his straight line engine, may, for aught we know, be as good as any, it has been selected. The following is Mr Ramsden's own directions for making the screw, and the Plate is a copy from his original.

Ramsden's method of making a screw.

"The exactness of the above described engine, depends very much on the correctness of the endless screw, which here is required to have some properties, that were not absolutely necessary in the endless screw for the circular engine. In that, as there were but a few threads of the endless screw engaged in the teeth of the wheel, it only required that those threads should have an equal inclination to the axis of the screw; but in this engine, where the whole length of the screw is engaged in the teeth of the moveable plate, it is necessary also that the distance between the threads should be the same throughout the whole length of the screw. This is effected by the screw engine hereafter described.

Plate CCLXXXI.

Fig. 7. Represents the plan;

Fig. 8. The elevation; and

Fig. 9. A section on the line BO. The same letter refers to the same part in each of the figures. A represents a strong circular plate of brass, having its edge ratched by the method given in the description of the circular engine. On its centre is firmly fixed the pulley B by four screws; a groove is turned on the cylindric part of the pulley, perfectly concentric to the plate A.

Figs. 8, 9. C is a steel axis two feet long, terminating in a point whereon it rests. The upper part of the axis is firmly screwed to the plate A, and turns in the collar D.

Fig. 7. E represents an endless screw, which, being turned on its axis, moves the plate A round its centre. F, a divided circular plate, which may be turned with or without turning the endless screw. On the other end of the screw arbor is a wheel *a*, having its outer edge cut into teeth. X is a winch whereby the endless screw is turned round.

Figs. 7, 8, 9. G represents a triangular bar of steel, which passes over the circular plate A, and is firmly screwed to the frame at H and I.

K, a piece of steel whereon the screw is intended to be cut, having its pivots formed in the manner before described. On one end of this steel is a wheel L, having teeth round its circumference, which take into those on the wheel *a*, on the arbor of the endless screw.

Figs. 7, 8. M and N represent two strong pieces of brass, in which the steel whereon the screw is to be cut turns. They are firmly fixed to the triangular bar G, by tightening the piece I by the screw *n*.

Figs. 7, 8, 9. O is a piece of brass, which slides on the triangular bar G. Its two extremities are made to fit the bar, it slides regularly thereon, and is prevented from rising by the two springing pieces *c*, *c*. (Fig. 8.) Near one end of the piece O, is an angular groove *q*, (Fig. 7.) that holds the tool by which the threads are cut. As it was necessary to cut the screw after the steel was hardened and tempered, therefore the tool was pointed with a diamond. The cock W serves to fasten the tool, which may be set to take proper hold on the steel, by turning the finger screw S, and is fixed there by the screw V.

Ramsden's method of making screw. Plate CCLXXXI. Figs. 7, 8.

To make a screw perfect, it is only required to give the point which cuts the threads an uniform motion parallel to itself, and to the axis of the intended screw, and that this motion be proportioned to the revolution of the intended screw, as the number of threads may require.

To effect this, a piece of thin tempered steel, exactly of the same thickness throughout, is fastened to the slide O at *r*; the other end of the spring is fastened to the pulley B, in the groove. Now, while the circle A, (Fig. 7.) with the pulley, is turning round its centre, by turning the endless screw towards the right hand, the spring *t* draws the slide O with the cutter *q*, along the triangular bar; at the same time the steel K, whereon the screw is to be cut, is turned round its axis by the communication of the wheel *a*, on the endless screw with the wheel L.

It hath already been mentioned, that the screw of the engine before described hath 20 threads in an inch; therefore, if the number of teeth on the wheel *a* be to the number on the wheel L, as the number of teeth on the wheel A, is to the number of twentieths of an inch round the circumference of the pulley B, allowing for part of the thickness the spring *t*, the spaces between each of the threads of the screw to be cut will be twentieths of an inch.

The size of the pulley was determined in this manner: the endless screw being disengaged from the wheel A, the slide O was drawn back till the end of it came nearly to the piece M; the endless screw was again engaged in the wheel A; then having two very small dots on the slide O set off parallel to one side, and exactly five inches distant from each other; the slide was moved by turning the endless screw, till one of the dots was bisected by a small silver wire fixed across a hole in a thin piece of brass attached to the piece N; then the O on the divided wheel F was set to its index, without moving the endless screw, and the pulley was reduced, till 600 revolutions of the endless screw brought the other dot to be exactly bisected by the fixed wire. These bisections were examined by a lens of half an inch focus, set in a small brass tube, which was fixed perpendicularly over the wire."

Remarks on Ramsden's straight line engine.

We believe that the above described right-line engine, has been chiefly employed in dividing such scales as surveyors use for mapping their work, barometer plates, &c. But contrary to what Mr Ramsden has stated, it should be remarked, that, for unequal parts, (sines, tangents, &c.) its performance must be tedious, and of course expensive; for after every tread, the screw would require to be put forward by hand, to the amount of at least one significant figure of the Tables for every division from which they are gathered.

Mr Ramsden states the accuracy of this engine to be equal to the 4000th part of an inch, which it certainly ought to be; this exceeds in precision, by a small degree, what may generally be expected from Bird's standard measures; yet, as we know that Sir George Shuckburgh Evelyn sought in vain when he examined our national standards, for some work of Ramsden's to place in his list; and as in the apparatus for our great trigonometrical survey, otherwise made entirely by himself, a 42 inch scale of Bird's was used, it may be presumed he never executed any thing of the kind.

Soon after the above described engine was finished, and before the description was published, another right-line engine appeared. This, with the assistance of an

Engine Graduation.

Harrison's dividing engine.

ingenious workman, was made by the late Mr Harrison, a son of the celebrated artist, who gained the great reward for finding the longitude at sea by means of time-keepers. There is reason to believe, that this engine possesses great merit, and that, in its construction, it is materially different from Ramsden's; but we are not sufficiently acquainted with it to point out those differences, or to offer any description of it. We know, however, that this engine is not idle; it is in the possession of John Barton, Esq. a relation of Harrison, who, we think, is now deputy comptroller of his Majesty's mint. But the avocations of office cannot suppress his natural inclination to mechanical exercises, for which his ingenuity, as well as his nice hand and eye, so eminently qualify him.

Coventry's micrometers.

There was a man of the name of Coventry, a glazier, who for many years rendered himself useful by dividing with wonderful minuteness and accuracy upon glass and other substances, the micrometer scales for microscopes and other purposes. His engine consisted of a very long beam compass, nicely balanced, having at one end a socket moveable by a micrometer screw, and furnished with a fine diamond point. The death of this man, which only happened a few years ago, would have been more regretted, had not Mr Barton, with the engine of Harrison, produced in similar works, still more exquisite specimens of art. The mother-of-pearl scales (Cavallo's micrometer) come from his hand almost miracles of neatness and accuracy.

Barton's micrometers.

It is, however, comparatively easy, to produce equality among neighbouring divisions in short measures, to what is required in larger works, where the most distant parts would occupy their relative places as correctly as adjacent ones. The latter, indeed, is the great difficulty of the art in all its branches, but more particularly so, in that which is the subject of the next Section.

SECT. III. *Original Graduation.*

Original graduation the most difficult of the mechanical arts.

WE now come to treat of the art in its highest order; the importance of which may be inferred from considering with what attention it has been cultivated, during a succession of ages, by men of science as well as artists. A modern journalist has designated it, "one of the nicest operations of manual labour;" the truth of which may be evinced from the very limited number of those who have performed it with success, and the high consideration in which they are held by all who are qualified to appreciate their labours. But the exactness required in the art may be drawn from still more certain sources. In a circle of three feet radius, which is that of the mural circle at Greenwich, a minute of a degree is little more than the 100th part of an inch, and this quantity, respecting latitude, is the measure of about a mile upon the surface of the earth; but if we speak of longitude, as derived from lunar and solar tables, the minute represents upon a mean no less than about 30 miles; while some of the elements of astronomy respecting their maxima, are by observation brought down from heaven to earth under an infinitely greater disparity.

Astronomers formerly divided their own instruments.

There was a time when astronomers graduated their own instruments. Tycho Brahe and Hevelius are said to have done so; but neither the methods used by them, nor by any of the more ancient astronomers, have come down to us; nor perhaps need this, excepting from mere curiosity, be regretted, if the statement of the errors of their instruments, given by Sir George Shuckburgh Evelyn (*Phil. Trans.* for 1793) be tolerably correct. Sir George says, "With respect to the precision of astronomical instruments in general, I may notice, by the way, that from the time of Hipparchus and Ptolemy, before and at the commencement of the Christian æra, to the age of Walther and Copernicus, in the beginning of the 16th century, few observations can be depended on to less than five, eight, or perhaps ten minutes; those of Tycho Brahe, indeed, that princely promoter of astronomy, to within one minute. The errors of Hevelius' large sextant of six feet radius, towards the middle of the 17th century, might amount to 15 or 20 seconds; Flamstead's sextant to 10 or 12 seconds; and lastly, those of Graham's quadrant, of eight feet radius, with which Dr Bradley made so many observations from 1742, might amount to seven or eight seconds." It should, however, be remarked, that the above statement, being derived from inspection of the observations made with the several instruments, exhibits errors not strictly imputable to graduation; a part may have been produced by other defects in the instruments, and also by imperfect observation.

Original Graduation. — Errors of the old astronomical instruments.

Sir George Shuckburgh's comparison of standard measures.

Sir George (*Phil. Trans.* for 1798) examined the errors of division in several of the old British standard measures, and compared their length with his own, made by Troughton in 1796. The first in his list is the standard yard of Henry VII. about the year 1490, which is said to have been taken from the length of the arm of that monarch; but as history is silent respecting this trait of his greatness, it may be presumed that the surveyors of his Majesty's person took for the purpose half the distance between the extreme finger ends of out-stretched hands and arms. Upon this standard the greatest measured interval exceeds the least, by no less a quantity than .132 of an inch; and the whole yard is .076 of an inch shorter than Sir George's. In the standard yard of Elizabeth, about 1588, the greatest interval exceeds the least by .185, and the entire yard is .015 longer. For the standard ell of Elizabeth, of the same date, the greatest difference of intervals is .072, and the whole length exceeds the modern standard by .016 of an inch.

Many of our standard measures bear no subdivisions, being simply finished to the length. Of these, nothing but their whole extent could be examined; and this was done by Graham in the four following instances. The yard-bed of Guildhall, about 1660, too long by .032. Ell-bed of Guildhall, same date, .018 too long. A standard belonging to the clock-makers' company, about 1671, too short by .028 on 36 inches. And the standard of the tower of London, about 1720, made by Rowley, was .004 too long.

Graham's own standard, made by Sisson, in 1742, with which it is supposed the above comparisons were made, was itself examined by Sir George, and found to be as follows: line E, .0013 longer, and line Exch. .0067 shorter, upon 36 inches than his own.

Many of the above measures exhibit miserable work; a neat hand by doubling, tripling, &c. a string, and making notches with a file, would subdivide better. But it is likely, and indeed the list indicates as much, that greater attention was paid to the whole length, than was done to the intermediate parts; yet are the yard-bed of Guildhall, and the standard of the clock-makers company, exceptions, and differ from each other by no less than .06 of an inch. Indeed, it seems difficult to suppose that the makers of those measures did their very best. It is more probable, that, according to their own judgment, or that of the times in which they lived, they

Original Graduation.

thought their works sufficiently correct for the purpose; or, as the ancient astronomers graduated their own instruments,—might not the magistrates of old make their own standard measures?

Hevelius, and the astronomers who preceded him, made their observations without the assistance of telescopes, and the result of the well-known controversy between Hevelius and Dr Hook speaks highly in favour of the division of his sector; for men of science decided the dispute in favour of the Dantzig astronomer, from the superior accuracy of his observations; whereas, had the instruments of Hook been equal in other respects, the telescopic sights, as is now well known, must have given him the advantage.

Hook's method of graduation.

Dr Hook, in his animadversions upon the *Machina Cœlestis* of Hevelius, published in 1674 the first method of graduation that has been described. It consisted of indenting the edge of an arc by the rotation of a screw about its axis, in the manner that has since been practised with success in the dividing engine; the indentations themselves stood for the divisions of the instrument, the angular value of which were to be found by other means. A screw similar to that which cut the teeth, was connected with the telescope; and the number of teeth, and parts of a tooth, as shewn upon the micrometer head of the screw, gave the observed angle.

As the inventor of this method describes no means for correcting distant divisions, it may fairly be concluded, that he did not foresee the necessity of any. And his own words bear out this supposition. Dr Hook entitles it, *An explication of the new way of dividing:* and says, that *the perfection of his instrument is in the way of making the division;* that *it excels all the common ways of division;* and that *it does not at all depend upon the care and diligence of the instrument-maker, in dividing, graving, or numbering the divisions, for the same screw makes it from end to end.*

With such screws as may be supposed to have been in use at that time, their want of truth could have had no good effect upon the run from end to end of the arc; yet as the same error would recur at every complete revolution, no material mischief might arise. But it is evident that the parts of a revolution would be affected by the whole amount of such error. The method was put in practice by Tompion, Sharp, Rowley, the Duc de Chaulnes, and perhaps many others; but in every recorded instance it completely failed; and such instruments as bore this graduation, before they could be depended on to any useful degree, were furnished with hand dividing.

Mr Smeaton seems to ascribe the failure of Hook's method to the different resistance which the different hardness in parts of the metal presented to the action of the screw; and undoubtedly this afforded one source of error. But we are of opinion, that much greater errors arose from the screw not being so sharp at the end of the arc, as it was at the beginning; and that notching the screw, in order to produce the full tooth, made it cut sharper with the preceding edge of the threads in some parts, and the following edge in others; a fact which is mentioned by Troughton as having embarrassed him in racking his engine.

Both Hook and Hevelius, in their controversy, pretended, in measuring an angle, to come at the exactness of a single second; but as they flourished upon the verge of an age when most things relative to science were taken upon credit, perhaps their works should not be too severely criticised by those who live at a time when every thing is tried by the test of experiment.

Flamstead's polar sector.

The polar sector of Flamstead, made by Tompion, with which he made so many observations from 1676 to 1689, bore the screw division; but its gross errors obliged Mr Flamstead himself to perform an original diagonal graduation upon its limb. It was about the latter date that a mural arc was completed for the royal observatory, which, under the direction of Flamstead, was altogether constructed by his assistant Mr Sharp. This also had the division of Hook, but it does not appear to have succeeded better than that executed by Tompion: however, Sharp's instrument was at first furnished with a diagonal graduation more accurate than any that had preceded it.

Roemer's mural arc.

The celebrated astronomer of Denmark, Olaus Roemer, about the year 1715, finished a mural arc. Probably knowing of the failure of the screw method in England, he performed his graduation in a very different way. Mr Smeaton, in the paper before alluded to, introduces his account of Roemer's method with the following remark: "Though it is a very simple problem by which geometricians teach how to divide a given right line into any number of parts required; yet it is still a much more simple thing to set off upon a given right line, from a point given, any number of equal parts required, where the total length is not exactly limited; for this amounts to nothing more than assuming a convenient opening of the compasses, and beginning at the given point, to set off the opening of the compasses as many times in succession, as there are equal parts required; which process is as applicable to the arch of a circle, as it is to a right line. Of this simple principle Roemer endeavoured to avail himself." To this end he took two finely pointed pieces of steel, and bound them firmly together at a distance which, as nearly as he could calculate, would give him divisions upon his arc of 10′ each. This contrivance was to avoid the spring of long-legged compasses, and was, for the purpose intended, much better than the best spring-dividers of the present day. With this distance between the points of the tool, set off in succession 450 times, Roemer divided his arc of 75°. This way of dividing has appropriately been denominated *stepping*, and Hook's can be considered in no other light. Neither of them could give exactness in the total arc, even within moderate limits; but this defect, great as it is, would have been amply compensated for, had they secured the grand desideratum of equal parts. Smeaton is of opinion, that of those two methods, Hook's is the best, because the screw, in making the teeth, has hold of several at a time; and, as far as neighbouring divisions are concerned, it certainly is so: but with respect to distant ones, as well as general accuracy, we feel inclined to give the preference to Roemer's. The astronomer of Uraniburg was the first who read off the angles observed with instruments, by means of a double microscope; not indeed by a wire put in motion by a micrometer screw, as is now done. Instead of this, 10 equidistant parallel lines of single silk were stretched across the field of view, and being adjusted so as to fill the space between two of his dots, gave him single minutes: the seconds were obtained only by estimation.

Tycho Brahe reads off his divisions by a double microscope.

Soon after the death of Flamstead, the royal observatory was unfurnished. It has been said, that his executors demanded a higher price for the instruments than government thought it right to pay. This was the more excusable in the latter, as it is probable that it was in contemplation to procure new ones, in which case the old ones were intrinsically of no more value than the materials of which they were composed; yet it

Original Graduation.

Graham constructs the eight feet mural quadrant.

is a pity that those venerable and solid records of art should have left the spot where they had been so useful in their day.

Graham undertook, about the year 1725, to construct for our national establishment an eight feet mural quadrant. This magnificent instrument still occupies its place; and though great part of a century has elapsed since its erection, it seems not to have suffered at all from either use or time. Its frame is made of iron: the arc which bears the graduation, as also the telescope and centre work, are of brass. The contrivance and execution of the whole are admirable; but it should be remembered, that its division alone is applicable to our present article.

To Graham, in the graduation of this quadrant, has been ascribed the rejection of the diagonal method; but certainly he was not the first; for Hook and Roemer did the same. He has also the credit of being the first who discontinued the practice of cutting the divisions by the edge of a ruler with the dividing-knife, instead of which he substituted the beam-compass. His strokes cut in this way, of course, were circular arcs; but as they were short in comparison with the length of the beam, the bend was scarcely perceptible; and as the resting point was set in a line that made a tangent to the arc where the strokes were cut, the latter would stand nearly in the direction of the radius. With respect to making divisions with the beam-compass, it may be doubted whether it was not a practice among instrument-makers, particularly upon chamfered edges, before the time that the Greenwich quadrant was finished; and we have seen old works that indicated it. But there was another improvement of much more importance than either of the above, which was indisputably the invention of Graham; that is, the division of the quadrant into 96, which precludes altogether the practice of stepping, and has rendered essential service to astronomy.

Graham's quadrant is described at length in Smith's *Optics*, and we have availed ourselves of the process pursued in its graduation, by copying the following account from that celebrated work.

Account of Graham's method of graduating this quadrant.

"There are 2 arches struck upon the brass limb; one with a radius of 8 feet, or more exactly of 96.85 inches; and the other with a radius of 95.8 inches. This inner arch is divided into degrees, and 12th parts of a degree; and the outward arch into 96 equal parts, which are severally subdivided into 16 equal parts. The beam of the compass which struck these arches, was secured from bending, by several braces fastened to it; and when an arch was struck, 60 degrees of it was determined, by placing one point of the compass at *a*, (Fig. 1. Plate CCLXXXII.) and by making a stroke with the other at *b*. This arch *a b*, was bisected in *c*, by drawing two small arches upon the centres *a* and *b*, with such a radius as to cross the arch *a c b*, in two points as near together as possible, without touching each other; then the small interval between them was bisected at *c*, by estimation of the eye, assisted by a magnifying glass. After this, the interval between the points *a* and *c*, or *c* and *b*, was taken with the beam compass, and was transferred from *b* to *d*, which determined the length of the quadrantal arch *a c b d*. Every one of the three arches being bisected in the same manner, the quadrant became divided into six equal parts, containing 15 degrees a piece; and every one of these was divided into three equal parts, as follows. To avoid making any false or superfluous points in the quadrantal arch, with its radius unaltered, but upon any other centre, there was struck another

Plate CCLXXXII. Fig. 1.

faint arch, upon which the chord of 15 degrees, already found, was transferred from the quadrantal arch; and the third part of 15 degrees, being determined by trials upon the faint arch, was transferred back again upon the quadrantal arch; which then was divided into 18 equal parts, containing 5 degrees a piece; and the 5th part of these was found by trials, as before, in dividing a separate arch, drawn upon a new centre for this purpose only. The subdivisions of the degrees into 12 equal parts, were made by bisections and trisections, as before. Thus was the whole quadrant divided without any false or superfluous points.

The outward quadrantal arch was divided into 96 equal parts, by no other method than that of bisection, till 60 degrees, or two thirds of the quadrant, became divided into 64, and the remaining third into 32 equal parts, which make 96 in the whole. And every one of these was also divided into 16 equal parts by continual bisections. These two sorts of divisions are a check upon each other, being in effect two different quadrants; and the divisions in one being reduced into the divisions of the other, by a table made for that purpose, they are never found to differ above five or six seconds in any place of the limb, and when they do, the preference ought to be given to the bisected divisions, as being determined by a simpler operation.

The divisions hitherto mentioned being only very fine points in a fine arch *a b d*, scarce discernible by the naked eye, it was necessary, as usual, to strike lines perpendicular to the arch, through every one of them. But since it is very difficult, and tedious too, to draw lines exactly through every point by the edge of a ruler, the following method was judged more accurate and expeditious. It was proposed then to divide any other concentric arch, *f h t*, by cross strokes, into similar parts to those in the given arch *a c g e b d*. Take a small beam compass, and having once fixed its points at any convenient interval; upon the centres *e*, *g*, &c. being the given points of the divided arch, strike the small arches *f i*, *h k*, &c. cutting the undivided arch in *f*, *h*, &c.; then will the intercepted arches, as *f*, *h*, &c. be similar to the arches *e*, *g*, &c. that is, they will subtend the same angles at their common centre *o*. For joining *e f*, *g h*, and also *o f*, *o h*, *o e*, *o g*, the triangles *e o f*, *g o h*, will be similar and equal to each other; every side in one being respectively equal to every side in the other. Therefore, by taking away the common angle *e o h*, from the equal angles, *e o f*, *g o h*, the angles *e o g*, *f o h*, that remain, will also be equal.

If the triangles *e f o*, *g h o*, &c. be right angled at *f* and *h*; the dividing strokes *f i*, *h k*, &c. will cut the quadrantal arch *f h t*, at right angles also, at *f* and *h*, &c."

Remarks on Graham's method.

Respecting the means employed by Graham in the division of the arc of 90°, there is nothing in them, except what has already been noticed, that evinces superior contrivance; it is to his accurate execution, and the invention of the continually bisectional arc, that he owes the well-deserved reputation which he holds among those who have distinguished themselves in the art of graduating astronomical instruments.

Before the time that Bird flourished, there is not a word to be found in the history of graduation about the dilatation and contraction of metals in different temperatures; and it may be supposed, that as Graham made his quadrant of iron, and the limb of brass, he was unacquainted with the different expansions of those metals. Our doubts, however, respecting the accuracy of that instrument, from this circumstance, have been partly removed by the writer of this part of our article

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having heard Troughton say, that he had looked at it with an eye to this matter; that he is of opinion, from estimating the elasticity of those metals at 8 or 10 times their difference of expansion, in such temperatures as they are exposed to in the observatory, that the iron will command the brass, and little or no error will ensue. The same artist also observes, that as the iron quadrant has long borne an additional arc of 96°, divided by Bird, and as there is no proof of its having changed its figure, since that arc was put on, as the brass one has certainly done to the amount of 7 or 8 seconds, for aught that is known to the contrary, the iron one may be the better instrument; but as both of them are now superseded by the new mural circle, this question may, perhaps, remain for ever at issue, and its discussion is now rendered of far less interest than it would have been 30 years ago.

Graham laid it down as a principle or maxim, "that it is possible, practically, to bisect an arch or a right line, but not to trisect quinquisect, &c." Bird not only acted upon this maxim, to the full scope of what had been done by the artist who conceived it, but extended it even to the division of the arc of 90°. We will not, however, anticipate the method of Bird, which is in many respects original and ingenious; for every one who dips into these matters, will derive the most satisfactory information from perusing his own account of it, as published by order of the Board of Longitude in 1767, the whole of which is subjoined.

Bird's method of graduation.

"The following method of dividing astronomical instruments, &c. is collected principally from the experience which I have gained in the space of thirty-four years; and, in some parts, from the instructions which I received from the late Mr Jonathan Sisson.

What I call my own, I have distinguished by Italic characters. If any other instrument-makers have used the same method, it is unknown to me; and shall, therefore, pay no regard to any pretensions unsupported by evidence;—I mean, pretensions, without producing astronomical instruments superior, or, at least, equal to those which I have made.

How far the lunar theory hath been improved by the observations of the late Dr Bradley and Mr Mayer, I leave to the decision of those who have tried it by observations, in order to find the longitude at sea, &c. I cannot help, however, being fully of opinion, that a still more perfect knowledge of the motion of the heavenly bodies may be obtained by future observations, skilfully made, with accurate instruments.

I have been favoured with so distinguished a mark* of approbation from the Commissioners of Longitude, that nothing on my part shall be wanting, that may, in the least, contribute to so desirable an end:"—So far the preface.

"It will be sufficient, for my purpose, to make use of no more lines and arcs than are represented in Fig. 2. Plate CCLXXXII.

Plate CCLXXXII. Fig. 2.

The requisites for the performance of this work are as follow:—A scale of equal parts, by which the radius may be measured to 0.001 *of an inch, must be provided. My scale is* 90 *inches long, each inch divided into* 10, *contiguous to which are nonius divisions, viz.* 10.1 *inches divided into* 100 *equal parts, shewing* 0.001 *of an inch; and, by the assistance of a magnifying glass, of one inch focal length, a third of* 0.001 *may be taken off by estimation.*

Provide five beam compasses, to which magnifying glasses, of not more than one inch focal length, should be applied. Let the longest beam be sufficient to draw the arcs, and measure the radius; the 2d, to measure the chord of 42° 40′; *the 3d, to measure the chord of* 30°; *the 4th,* 10° 20′; *the 5th,* 4° 40′; *and if a 6th, to measure* 15°, *be made use of, so much the better.*

I have, for the sake of a round number, mentioned above, that the radius of the mural arc in the Royal Observatory at Greenwich is eight feet; but, as I shall here put down the lengths of the several chords made use of in the dividing, it will be necessary to note the exact radius in inches and decimal parts.

The radius of the arc of 90°, *at the points,* = 95.938 *inches, from which the following numbers were computed, viz.* 49.6615 *inches = chord of* 30°, — 25.0448 *inches = chord of* 15° — 17.279047 *inches, = chord of* 10° 20′— 7.81186 *inches, = chord of* 4° 40′, *and* 69.80318 *inches, = chord of* 42° 40′. *Having drawn the several arcs, between which the divisions were to be cut, the radius and the lengths of the above chords were taken by the beam compasses, which, together with the scale, were laid upon the quadrant, where they remained till the next morning, during which time the door of the room was kept locked. Before sun-rise I remeasured the radius, which required some correction; the beam being of white fir, and the scale of brass, which probably contracted, while the beam remained unaltered. The other beam compasses also required correction.*

Now the quadrant and scale being of the same temperature, the faint arc *b*, *d*, was struck, and, with a very fine prick-punch, the point *a* was made. With the same beam compass, unaltered, I laid off, from *a* to *e*, the chord of 60°, making also a fine point. *With the chord of* 30°, a e *was bisected in* c. *Now, one point of the beam compass, containing* 60°, *was fixed in* c; *and with the other was marked the point* r, *or* 90°. *Next, with the beam compass, containing* 15°, *was bisected* e r *in* n, *or* 75°. *From* n *was laid off the chord of* 10° 20′, *and from* r, 4° 40′; *which two last chords joined exactly in* g, *being the point of* 85° 20′. Now each degree being to be divided into 12 parts, or every 5′, *therefore* $\overline{85 \times 12} + 4 = 1024$, *a number divisible by continual bisections. The last chord computed was* 42° 40′, *with which* a g *was bisected in* o; a o *and* o g *were bisected by trials. But whoever undertakes to divide a large quadrant, will do well to compute also the chord of* 21° 20′; *but for this chord any of the beam compasses already provided, which will take in the length, may be used. The point* g *being found as above, I proceeded, by continual bisections, till I had the number required, viz.* 1024. *To fill up the space between* g *and* r, *containing* 56 *divisions, the chord of* 64 *divisions was laid off from* g *towards* d, *and divided, like the rest, by continual bisections, as was also from* a *towards* b. *The points* 30°, 60°, 75°, *and* 90°, *fell in without any sensible inequality.*

Here it is necessary to mention in what manner the bisecting and pointing were performed. Having the chord of 42° 40′ in the beam compass, and one point placed in *a*, with the other a faint arch of about $\frac{1}{20}$ of an inch in length was made in *o*. Again, one point of the beam compass was placed in *g*, and with the other the aforesaid faint arch was intersected. Here, as in all other places, great care was used to make the points exactly in the arc to be divided, and also in the intersection.

* Bird received the sum of £560, by certificate, from the Commissioners of Longitude, for his method of graduation, together with that of constructing mural quadrants; the latter of which was published soon afterwards.

Original Graduation. Bird's method of graduation. Plate CCLXXXII. Fig. 2.

In the following pages, I shall not only describe the farther process in dividing the mural arc in the Royal Observatory, but endeavour, also, to make the description general.

If the chord should be taken a little too long, or too short, so that the intersection be made on one side or the other of the arc to be divided, it will not occasion an inequality, provided the point be made in the middle between the two short lines, *except at the point of 85° 20′, where great care must be used in taking the chords from the scale. Great care must also be used in pointing intersections in general, being more difficult than a single line. But here I must not be understood to mean a single line made by one point of the compass; for, in all bisections, the place to be* pointed must be laid off from left to right, and from right to left; and if any error arises from an alteration of the beam compass, it will be shewn double.

In dividing, the points of the beam compass should never be brought nearer together than two or three inches, except near the ends of the arch or line to be divided; and there spring-dividers, having round points, which may be put in and taken out occasionally, will best answer the purpose.

The next thing to be considered is, the method of making the points. The prick-punch, for this purpose, must be extremely sharp and round, the conical point to make a pretty acute angle; and as the points herewith to be made, *should not exceed 0.001 of an inch, when linear divisions are to be cut from them, a magnifying glass of ½ inch focal length should be used;* by the assistance of which, the impression, or scratch, made by the points of the beam compass, will be very conspicuous; *and, if the said impression be not too faint, feeling, as well as seeing, will greatly contribute to make the points properly.*

It is scarce necessary to say any thing about the arc of 96°. I shall only mention, that it contains 1536 divisions; is to be divided into three equal parts, in the same manner as the arc of 90°. Each third contains 512 divisions; which number is divisible continually by 2, and gives 16 in each 96th part of the whole arc.

This arc of 96, (so far as I know,) was first applied to the iron quadrant in the Royal Observatory, in the year 1725, by my late worthy friend, Mr George Graham. It was not only a severe check upon that great mechanic, but will be so to all others, who divide the two arcs, upon one and the same instrument; yet, if the above instructions be strictly followed, the agreement between the two will be surprising, and differ very little from the truth.

The next step is to cut the linear divisions from the points. The best instrument for this purpose is the beam compass, *having both its points conical, and* very sharp. Draw a tangent to the arc *b d*, suppose at *e*, it will intersect the arc *x y* in *q*; this will be the distance between the points of the beam compass to cut the divisions (nearly at right angles to the arc *b d*.)

Lodge that point of the beam compass next your right hand, in the point r; *let the other fall freely into the arc,* x y; *press gently with your finger upon the screw-head, which fastens the socket* (this screw-head must be *convex*, and right over the point;) *and, with the point towards the right hand, cut the divisions.—In this manner you must proceed with the rest.*

Having finished the divisions of the limb, the nonius divisions are next to be divided. Chuse any part of the arch, where there is a coincidence of the 90 and 96 arches, which let be at e: Draw the faint arcs *s t* and *i k*, which may be continued to any length towards A, upon which the nonius divisions must be divided in points; a tangent line, as before, intersecting this arc, gives the distance of the points in the beam-compass. Now as the nonius divisions of the arc 90° subdivide the divisions of the limb of the mural arc at Greenwich to half a minute, 11 divisions of the limb being equal to 10 upon the nonius plate (a number which only 5 and 2 will divide,) *recourse must again be had to computation. Measure the radius of the arc, and compute the chord of 16, or rather 32, of the nonius divisions; the quantity of an arc equal thereto, may be easily had by the following proportion: As 10 div. : 55′ (the number of minutes in 11 divisions of the limb) : : 32 div. : 2° 56, the chord of which must be computed, and taken from the scale of equal parts:* But as different subdivisions by the nonius may be required, *let* n = *number of nonius divisions,* m = *number of minutes taken in by the nonius,* b = 16, 32 or 64, *and* x=*arc sought; then as* n : m : : b : x.

Lay off with the beam-compass, having the length of the tangent between the points, the point q *from* e, *and the chord of 32 from* q, *towards the left hand,* and divide by continual bisections, 10 *of those divisions, counting from* q *to the left, will be the points required.* As the number of nonius divisions for the 96 arch should always be 16, 32, &c. I need only mention, that the extremes may be laid off from the divisions of the limb, without computation.

Now the place upon the chamfered edge of the nonius plate, where the nonius is to begin, may be found in the following manner. *Measure the distance of the quadrant centre, from the axis of the telescope; this distance from the axis of the telescope at the eye-end, will be the place for the first division of the nonius, where draw a faint line from the centre. The greater accuracy with which this is laid off, the nearer to the axis of the tube will be the intersection of the wires, in the common focus of the object and eye-glasses.*

I will suppose that no instrument-maker will fix to the telescope the nonius, and centre-plates, without steady-pins, as well as screws. Screw the centre-plate of the telescope very fast: put the nonius plate upon the steady-pins, without screws, and put the telescope upon the quadrant: make fast the nonius plate to the arch with two pair of hand-vices, and take the telescope away. *Now with one point of a beam-compass, in the centre of the quadrant, and the other at the middle of the nonius plate, draw a faint arch from end to end: Where this arch cuts the faint line before-mentioned, make a fine point: From this point lay off on each side another, which may be at any distance in the arch; only care must be taken, that they be equally distant from the middle point: From the two last make a faint intersection as near as possible to either of the chamfered edges of the nonius plate: Through this intersection, the first division of the nonius must be cut.*

Put the telescope again upon the centre of the quadrant, the steady-pins into the nonius plate as before; unscrew the hand-vices, and bring the last-mentioned intersection to e *or 60° upon the limb, where fasten it again with the hand vices, and take away the telescope.* Now, from the point before divided, the nonius divisions must be cut; by lodging the left hand point of the beam-compass in the point upon the arch, and cutting with the right.

Here great care must be taken, to cut the first division of the nonius through the point of *intersection;* which may be done by altering the distance of the points in the beam-compass, if necessary: This will not sensibly affect the perpendicularity of the divisions, provided the intersection be placed very near to *e*, or 60°.

Having cut the nonius divisions, suppose of the 90 arc, take up the plate, polish off the bur, and fasten it to the limb, as before; but here great care must be taken to make the first division of the nonius coincide with the 60th deg. so as to appear one line; and the nonius of the 96 arc may be cut in the same manner, making the first division coincide with 64 = 60° upon the limb.

Now, take up the plate, and draw a tangent at the point in the faint arc in the middle of the nonius plate; and with a distance about a quarter of an inch longer than the nonius, lay off from the tangent point another in the tangent line; also lay off this distance from the centre of the collar at the object end of the telescope, and make a fine point: Then extend the beam-compass nearly the whole length of the nonius, or centre plate (which should reach, at least, half an inch beyond the telescope, on the contrary side), and lay off other points in the tangent line before mentioned, and in a line passing through the centre of the quadrant, at right angles to the telescope.

Now screw the two plates to the telescope, and draw lines by the edge of a steel-ruler through the correspondent points, to which lines the plates must be carefully filed. Then the ends of the plates will be in lines parallel to each other, and to the axis of the tube, which affords an excellent mechanical method of finding the line of collimation of the telescope.

The apparatus used for this purpose by the late Mr Graham, was a box equal in length to the telescope, having deep sides, to prevent its bending by its own weight. The ends were of hard wood. *Instead of which, I use two flat pieces of brass, which I can move according to different lengths required; and by the help of a small spirit-level, these pieces of brass may be fixed in one and the same plane.* This apparatus should stand firm upon the ground, where a distant and distinct object can be seen. Rest the ends of the nonius and centre plates upon the two pieces of brass, and observe what point of the object is cut at the intersection of the horizontal and vertical wires. Invert the telescope, and if the horizontal wire does not cut the same point of the object, it must be altered by the screws for that purpose, half the difference. By repeating this, you may approximate extremely near the truth.

In the middle, between the 90 and 96 arches of the mural quadrant, in the royal observatory, is an arch of points (96), which are used with a silver wire, of about 600 in an inch, carried by a small frame, screwed to the end of the nonius plate. When the wire, in an observation, falls between two points, it must, by the micrometer screw, be made to bisect the nearest point to the left hand, the instrnment shewing the zenith distance; and the minutes and seconds shewn by the micrometer added. If the next point to the right hand be bisected, the minutes and seconds must be subtracted. This arch of points was divided in every respect like the other arch of 96.

Having gone through the whole process of dividing the mural arc, &c. it will be necessary to shew some reasons why this kind of management hath succeeded better than any other, as far as I either know or have heard.

After I had found by experience, that the expansion of the instruments to be divided, occasioned by the increasing heat of the sun, or a contraction by a decrease thereof, was the grand difficulty with which I had to struggle, especially when two or three hours were required to lay off the principal points; I immediately set about contriving how to lay them off in the least time possible, i. e. *before any expansion or contraction could take place; and as the heat of three or four persons in the room may produce the same effect as the sun, I never admit more than one as an assistant. Neither must any fire be suffered in the room, till the principal points are done.*

The above being understood, it was easy to conceive, that, having all the chords before-mentioned computed and measured, the evening before they were to be laid off, I should be enabled to perform in a few minutes, what by trials would require some hours; and as too much caution cannot be used, it is proper to lay off the principal points before sun-rise, or else chuse a cloudy morning.

The method of cutting the divisions as described above, is to prevent any inequality that would arise from the expansion of the beam compass by the heat of the hands, especially if the beam be of metal. Wooden beams will also alter, probably from a small bending; *but in this method, if the beam should alter $\frac{1}{10}$ of an inch or more, it would not cause any sensible inequality.* As the points of the nonius divisions cannot be divided upon the nonius plate without inconvenience, it is best to use the method formerly described, *holding the beam compass a small while in the hand* previous to the cutting. The points being but few in number, the divisions may be cut, before any expansion can sensibly take effect.

Sextants, or octants, for observing the distance of the moon from the fixed stars, should be divided by the foregoing method, great accuracy being required. *If instead of dividing sextants to every 20′ upon the limb, as is commonly done, they should be divided to 15′, a chord of 64° might be laid off, and divided by continual bisections.* This would, in some measure, crowd the limb with divisions; but it would shorten the nonius; for 15, instead of 20, would shew one minute.

In dividing either arches or straight lines, a number (which will divide continually by 2) greater than is required upon the arc or line, is the best to begin with, and may be used in dividing a circle, by laying off the chord of the difference. Suppose it was required to divide a circle into 54 equal parts, it would be 64—54 = 10 = 10° 30′; the chord of which laid off must be added to 360°, and it will be 360° + 10° 30′, to be divided into 64 equal parts, 54 of which will complete the circle. If the arc of 10° 30′ be laid off from a dividing plate, it will answer the same purpose.

Analogous to the foregoing method, my scale of equal parts was divided. I took $\frac{512}{10}$ of an inch in a beam compass, laid the scale which I took it from, the brass scale to be divided, and the beam compass in a room facing the north, where they lay the whole night. Early next *morning, after correcting the lengths, the above* $\frac{512}{10}$ were laid off three times (the brass being long enough to take it in); then, having in other compasses 256, 128, and 64, I bisected the three spaces of 512 with all the expedition I could. Having now only 64 inches in the last beam compass, any partial or unequal expansion was not to be feared; therefore worked by continual bisections till I had done. *The linear divisions were cut from the points with a beam compass, as before described.*

The nonius divisions of this scale contains $\frac{101}{10}$ of an inch, which were divided into 100 in the following manner: *As* 100 : 101 :: 256 : 258.56 *tenths of an inch, the integer in this case being* $\frac{1}{10}$. Suppose the scale to be numbered at every inch from left to right; then exactly against $\frac{1}{10}$, to the left of 0, was made a fine point, *from which was laid off* 258.56 to the right hand. This was taken from a scale 3 feet in length, which was divided after the common method; but the error was so small as to vanish at the other extremity of the nonius, when divided continually by 2.

Original Graduation.

Whoever undertakes to divide a scale of the above kind, not being furnished with one long enough to lay off 258.56, *may take* $\frac{250}{10}$ *from that before him, to which he may add* 8.56 *taken from a diagonal scale, that may be made at a small expence.*

To prove the expedience of the above methods of dividing astronomical instruments, &c. I need only to mention the following particulars, taken from the Nautical Almanac for this present year 1767, page 152.

"Mr Mayer made his observations with his six-foot mural arch, from the year 1756 to the time of his decease: with it he settled the mean obliquity of the ecliptic, to the beginning of the year 1756, at 23° 28′ 16″; which Dr Bradley settled by his observations, made in the years 1750 and 1751, at 23° 28′ 18″. The difference is agreeable to what ought to arise from the gradual diminution of the obliquity of the ecliptic at the rate of about ½ a second in a year," &c. That two different observers, with instruments of different radii, and in different parts of Europe, should so nearly agree, is matter of no small astonishment, and sufficiently proves, that a mean of several observations, made by good observers, with accurate instruments, properly adjusted, will always lead us either to the truth itself, or extremely near to it.

Remarks on Bird's method of graduation.

Excepting the means of rendering the common subdivision of the circle bisectional, and his care in avoiding errors from expansion, Bird's method of cutting the strokes was its most important deviation from the practice of Graham. The latter made his dots in the tangential line, which supported the resting point of the compass, while the other point, at a considerable distance, traced the divisions. Bird, by making his dots extremely near to the outer ends of the strokes, and resting the point in an undivided tangential line, avoided any error that might arise from an alteration of the length of the beam during the operation, which was a serious objection to Graham's way of proceeding. We should, however, have been afraid that the resting point, on being simply dropped into the line, and having apparently nothing to hold it there, might have been in danger of slipping, did not we know that artists themselves, provided the metal be sound, are apprehensive of little or no error on this account.

The Duke de Chaulnes' method of graduation.

Soon after the publication of Bird's method, that of the Duke de Chaulnes' made its appearance, which has in the preceding Section been noticed as applicable to a dividing engine. He was the first who employed double microscopes in the graduation of the circle; a practice which, in the hands of others, the Duke's work, known or unknown to them, has essentially improved the art. There are also two more peculiarities in De Chaulnes' method, that deserve to be noticed. One is its being purely visual. The whole is done by the eye, except cutting the real divisions; and even this, to prevent the errors of the hand, is performed by machinery. The other is, that, to avoid superfluous marks upon the limb, he had provided, ready for his purpose, a competent number of thin pieces of brass, about one-third of an inch long, and one-sixth broad, with a fine line upon the surface of each, drawn perpendicular to its length. To make these pieces adhere to the surface that was to receive the divisions, their under planes were thinly coated with wax, and thereby made capable of being easily adjusted to their places, and of retaining that position until the divisions represented by them were inserted.

The circle to be divided moves round horizontally upon a vertical axis, within a strong frame of wood, to which the microscopes are fixed, and applicable to any part of it.

The first step is to bisect the circle. To this end one of the brass pieces is to be made fast with screws, at the place which is intended to be zero, the line upon its surface being directed towards the centre. A microscope is affixed to the frame, with its radial wire coincident with the line, and its cross one a tangent to the circle. Another microscope is secured on the frame, by estimation or any better way, diametrically opposite to the first, and one of the waxed pieces placed under it, so that the line and wires may have to each other, and to the circle, the same relation as above. Let the circle be turned half round within the frame, so as to bring the zero line coincident with the radial wire of the other microscope. If now the line of the waxed piece be found exactly under the wire of the first microscope, it is evident that the circle is bisected; but as this can hardly happen in the first instance, the apparent error must be corrected one half, by sliding the waxed piece towards the wire, and the other half by moving the microscope to it. The circle must again be turned half round, to verify the correction, or, if necessary, to afford means for a second correction, and the operation repeated until the lines exactly coincide with the wires in both positions of the circle. This being done, the microscope which has under it the zero piece should be regarded as fixed, and let its name be A; the other, which we will call B, is to be taken off, and reserved for future use. In the room of B there is to be fixed the tracer or cutting point, so that if the piece were taken off, which it must not be, the tracer would cut a line exactly in its place, or diametrically opposite to the zero line. By this contrivance, it becomes necessary only to divide half the circle; for if the divisions of one semicircle are brought successively to the wire of A, the tracer will cut their opposites in the other.

The second step is to trisect the semicircle, which is to be done by two more of the adjustable pieces, and the two microscopes. With *zero* under A, place B as nearly at an angle of 60° from it as can be done by estimation or otherwise, and put a waxed piece under it; move back the circle so as to bring the waxed piece to A, and put another under B; again move the circle so as to bring the second piece under A, when, if B should happen to coincide with the line opposite to *zero*, the thing is done; but if not, as most likely will be the case, then B must be moved towards the line one-third of the quantity of apparent error, and the operation repeated, as was done for bisecting the circle. The third step is to bisect the three equal arcs of the semicircle, which is done by similar means; and at the fourth step by which those last are trisected, arcs of 10° are obtained.

The Duke de Chaulnes' microscopes could not be brought near enough to each other to bisect the arcs of 10°; he therefore had recourse to that of 9°, which he found and used in the following manner. He obtained it by taking ten steps with nine additional waxed pieces for each of the two quadrants, which he brought to their places by frequent trial and adjustment. With this opening between the microscopes, from the tens he set off all the nines forwards, and all the ones backwards. He then resumed the former opening of 10°; and as the operation for ascertaining the arc of 9° had left a waxed piece in every interval of 10°, which would in their respective places represent 8°, 7°, 6°, &c. to 2° in each quadrant, with the opening of 10° from eight, he set of all the eights, from seven he set off all the sevens, &c. and in this manner put in every single degree of the semicircle.

Original Graduation.

The Duke de Chaulnes' method of graduation.

As all the waxed pieces had their opposites cut in the other, it was not necessary to have 180 of them; for it is evident from the mode of procedure, that after the ones and nines had been put in, neither these nor the tens could be wanted. The semicircle of trial has yet upon it no divisions, and how (the waxed pieces being removed) it was divided from the other, has already been mentioned.

It is observed, that when a circle is large enough to allow the microscopes to come so near each other as to bisect the arc of 10°, the numbers four and five may with advantage be substituted for nine and ten; and when half degrees are required, it is proposed to bisect the arc of 15°, and with this opening to put in all the half degrees.

To subdivide the degree into five-minute spaces, the Duke de Chaulnes proposes to mount a telescope with a vertical wire in its focus, upon the centre arbor of the circle, so that it may either revolve with the circle, or concentric to it by itself, as the case may require; and let a long beam of wood be provided, accurately divided into 12 equal parts, and placed at such a distance as to subtend an angle of one degree; a thin piece of brass is to be fixed upon the circle under the tracer; and as the telescope and circle are turned round together, and the wire made successively to coincide with the divisions of the beam, the corresponding strokes are to be drawn upon the piece of brass: and lastly this piece is to be placed under the fixed microscope, in order that by means of it and the tracer, every degree may be filled up.

Remarks on the Duke de Chaulnes's method.

The ingenious inventor of the above method, like those who preceded Bird, has made no provision against the errors arising from expansion; indeed, his tracer being fixed opposite to the point of trial, subjects his work to the greatest possible error in that respect; and under this disadvantage, his division of the first semicircle is no more than a copy of the wax-work; and, again, the second semicircle is, under the same disadvantage, a copy from the first.

Hindley's method of graduation.

The method of Hindley having been in part communicated to Smeaton in 1741, and fully in 1748, might in our article have preceded some of the methods already noticed, but as he received it under the seal of secrecy, it was unknown to the public until 1785, in which year Mr Smeaton's paper, before referred to, concerning it, was read to the Royal Society.

Smeaton introduces this method under the full persuasion that vision, even when assisted by glasses, cannot command a greater degree of accuracy than to the 4000th part of an inch; and maintains, that by contact, the 60,000th becomes equally sensible. Were this true, and contact applicable to the graduation of instruments without *drawback*, a fine field of improvement would have been opened to the artist through the paper under consideration.

Mr Smeaton says, " It now comes to be time to open a principle, upon which there is a prospect of effecting such an improvement. I have shewn that a 4000th part of an inch is the ultimatum that we are to expect from sight, though aided by glasses, when observing the divisions of an instrument. But in the 48th volume of the *Philosophical Transactions*, (p. 149 of this volume), I have shewn the mechanism of a new pyrometer, and experiments made therewith; whereby it appears, that, upon the principle of contact, a 24,000th part of an inch is a very definite quantity. I remember very well that I did not then go to the extent of what I might have asserted, being willing to keep within the bounds of credibility; but on occasion of the present subject, I have re-examined this instrument, and find myself very well authorised to say, that a 60,000th part of an inch, with such an instrument, is a more definite and certain quantity than a 4000th part of an inch is to the sight, conditioned as above specified. The certainty of contact is, therefore, fifteen times greater than that of vision, when applied to the divisions of an instrument: and if this principle of certainty in contact did not take place, even much beyond the limit I have now assigned, we never should have seen those exquisite mirrors for reflecting telescopes that have already been produced.

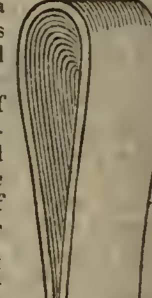
These reflections apply immediately to my present subject, as Hindley's method of division proceeds wholly by contact, and that of the firmest kind; there being scarcely need of magnifying glasses in any part of the operation.

In the year 1748, I came to settle in London; and the first employment I met with was that of making philosophical instruments and apparatus. In this situation, my friend Hindley, from a principle the reverse of jealousy, fully communicated to me, by letter, his method of division; and though I was enjoined secrecy respecting others, (for the reasons already mentioned), yet the communication was expressly made with an intention that I might apply it to my own purposes.

The following are extracts from two letters, which contain the whole of what related to this subject; and since I have many things to observe thereon, so that the paraphrase would be much greater than the text, I think it best not to interrupt the description with any commentary, as perhaps his own mode of expression will more briefly and happily convey the general idea of the work, than any I can use instead of it.

" My Dear Friend, " York, 14th Nov. 1748.

" As to what you was mentioning about my brother's knowing how I divided my engine plate, I will describe it as well as I can myself; but you will want a good many things to go through with it. The manner is this: first choose the largest number you want, and then choose a long plate of thin brass; mine was about one inch in breadth, and eight feet in length, which I bent like a hoop for a hogshead, and soldered the ends together, and turned it of equal thickness, upon a block of smooth-grained wood, upon my great lathe in the air, (that is, upon the end of the mandrel); one side of the hoop must be rather wider than the other, that it may fit the better to the block, which will be a short piece of a cone of a large diameter: when the hoop was turned, I took it off, cut, and opened it straight again.



The next step was to have a piece of steel bended into the form as per margin; which had two small holes bored in it, of equal bigness, one to receive a small pin, and the other a drill of equal size. I ground the holes after they were hardened, to make them round and smooth. The chaps formed by this steel plate were as near together as just to let the long plate through. Being open at one end, the chaps so formed would spring a little, and would press the long plate close, by setting in the vise. Then I put the long plate to a right angle to the length of the steel chaps, and bored one hole through the long plate, into which I put the

Original Graduation.

Hindley's method of graduation.

small pin; then bored through the other hole; and by moving the steel chaps a hole forward, and putting in the pin in the last hole, I proceeded till I had divided the whole length of the plate.

The next thing was to make this into a circle again. After the plate was cut off at the end of the intended number, I then proceeded to join the ends, which I did thus: I bored two narrow short brass plates, as I did the long one, and put one on the inside, and the other on the outside of the hoop, whose ends were brought together; and put two or three turned screw pins, with flat head and nuts to them, into each end, which held them together till I rivetted two little plates, one on each side of the narrow plate, on the outside of the hoop Then I took out the screws, and turned my block down, till the hoop would fit close on; and by that means my right line was made into an equal divided circle of what number I pleased.

The engine plate was fixed on the face of the block, with a steel hole fixed before it, to bore through; and I had a point that would fall into the holes of the divided hoop; so by cutting shorter, and turning the block less, I got all the numbers on my plate.

I need not tell you, that you get as many prime numbers as you please; nor that the distance of the holes in the steel chaps must be proportioned to the length of the hoop.

You may ask my brother what he knows about my method of dividing; but need not tell him what I have said about it; for I think neither he nor John Smith knows so much as I have told you, though I believe they got some knowledge of it in general terms. I desire you to keep the method of dividing to yourself, and conclude with my best wishes. And am, dear sir, yours, &c. HENRY HINDLEY.

Though the above letter was in itself very clear and explicit as to the general traces of the method, yet some doubts occurring to me, a farther explanation became necessary. A copy of my letter not being preserved, the purport of it may be inferred from the answer, which was as follows:

Dear Friend, *York*, 13*th March*, 1748-9.

I think, in your last, you seem to be apprehensive of some difficulties in drilling the hoop for dividing: First, that the centre of the hole in the hoop might not be precisely in the centre of the hole of the steel chaps it was drilled in; but if I described fully to you the method I used, I can see no danger of error there; for my chaps were very thick, and the two corresponding holes were a little conical, and ground with a steel pin; first one pair, and then the other, alternately, till the pin would go the same depth into each. Then for drilling the hoop, I took any common drill that would pass through and bore the hole. After that I took a five-sided broach, which opened the hole in the brass betwixt the steel chaps, but would not touch the steel; so, consequently, the centre of the holes in the brass must be concentric with the holes in the chaps; and for alterations by air, heat, cold, &c. I was not above two or three hours in drilling a row of holes, as far as I remember.

2*dly*, For drilling, in a right line, I had a thin brass plate, fastened between the steel chaps, for the edge of the hoop to bear against, whilst I thrust it forward from hole to hole. What you propose of an iron frame with a lead outside, will be better than my wooden block; but considering the little time that past betwixt transferring the divisions of the hoop to the divisions of my dividing plate, I did not suffer much that way. It was when I drilled the holes in my dividing plate that I used a frame for drilling, which had one part of it that had a steel hole; that in lying upon the plane of the dividing plate, was fixed fast in its place for the point of the drill to pass through; then, at the length of the drill, there was another piece of steel, with a hole in it, to receive the other end of the drill to keep it at right angles to the plane of the plate. This piece was a spring, which bended at the end, where it was fastened to the frame of the lathe, at about 18 inches from the end of the drill; so it pushed the drill through with any given force the drill would bear; and though that end of the drill moved in the arch of a circle, it was a very small part of it, being no more than equal to the thickness of the dividing plate. My good wishes. Conclude me yours, HEN. HINDLEY.

Remarks on Hindley's method of dividing.

Nothing ever surpassed in originality the method described in the above letters, which is in no respect like any other. There is not a tool employed in it, except the lathe, but what may either be found in the shop of the most common worker in metals, or made by him. It is, however, like Hook's and Roemer's, a system of uncontroulled stepping; and, like theirs, if only applied to an arc, would have ended in the same uncertainty; but being extended to the whole circle, it secures the intended number of divisions, and closes without a remainder, which is what theirs never could have done.

Mr Smeaton's method of dividing.

To avoid errors occasioned by expansion, which Hindley seems not to have been aware of, Smeaton recommends that the work should be done when the air is of a moderate temperature; and that, to prevent the materials from being heated, it should be carried on at short intervals; but his chief improvement was directed to correct the effect of long continued stepping. Mr Smeaton would divide his circle into 1440 parts, or quarters of a degree. To effect the correction last mentioned, two pieces of brass must be provided, in every respect like that which is to be the hoop, except that they need not be longer than is required to contain 30°; these pieces, which are called *straps*, he would drill in the manner that Hindley prescribes, and it should be mentioned, that the first hole in each must be made in a short piece of hardened steel, which in the first instance had been soldered to the ends of the straps. For the purpose of obtaining the total length, the straps are drilled from end to end; but no more than the first, middle, and last holes are used. The zero hole being made in the long, or hoop-piece, the middle holes of the straps are to be pinned to it on opposite sides, and the steel pieces directed forwards; the three pieces extended in a right line are to be pressed together, and the 60th hole in the hoop-piece bored coincident with those of the straps. The straps are now taken off, and the 59 intermediate holes drilled by means of the chaps only. Again, the extreme holes of the straps are to be pinned to the zero holes of the hoop-piece, and arranged as before, when the 120th hole of the latter is to be bored agreeable to the steel holes in the former; and recourse again had to the chaps for the next 59 holes. As the process described above fills up as much of the hoop-piece as is equal to 30°, eleven similar double operations will complete the whole length; and, as Smeaton observes, produce 12 master checks, and 12 subordinate ones. The next thing to be done is to fasten the ends of the long piece together, so as to form

Original Graduation.

it into a hoop, by pressing it upon the edge of a *chock*, as directed by Hindley.

Farther than this, Smeaton's paper cannot be considered as describing an original method of graduation, the remainder being directed to the forming it into an engine, of which, in its proper place, we declined giving a description, and here it would be inapplicable. We may however observe, that Smeaton has improved upon Hindley in every part, with his usual ingenuity and ability; and provided the foundation were good, so would be the superstructure. Smeaton was no advocate for large astronomical instruments, and therefore would have an engine constructed of sufficient magnitude to graduate any that ought to be made.

Mr Smeaton's paper was not well received by the instrument makers; but he predicted, that when half a century had worn off the prejudice against it, the method would be adopted and improved to the advantage of astronomy. But as Mr Troughton, in a paper to be noticed hereafter, ventures to make a quite contrary prediction concerning it, and gives his reasons for it; we decline entering into the question.

Ramsden's method of dividing.

Considering the celebrity of Mr Ramsden, his long career and extensive practice in making instruments that required the nicest graduation, we have in this department of our article comparatively little to say of him. Excepting the descriptions of his engines, we believe he never wrote upon the subject; nor has any one else, so far as we know, described how he proceeded. Troughton has indeed pointed out the manner in which he adjusted erroneous dots to their places; a practice which it is said was suggested to Ramsden by the adjustable waxed pieces of the Duc de Chaulnes. A pupil of Ramsden informs us, that in an early part of his practice he had used the scale of equal parts, agreeably to the manner of Bird, but that he soon abandoned it; and that he had often varied his apparatus and method. At what time the method of coaxing, as it is called, was first applied in the works of Ramsden, is perhaps known to no one except Mr Berge: this artist, who at his death succeeded him, had long been his able and indefatigable assistant, and in the graduation of instruments had honoured the name of his employer,

"By patient touches of unwearied art."

That the coaxing could not have been in practice so early as the time when the dividing engine was made, may be inferred from the circumstance, that the description of the engine was given in upon oath, and nothing said about it.

For many years previous to the publication of the following method by Troughton, the art of graduation had been carried on in secrecy and silence; every artist had, or pretended to have a method of his own, of which astronomers could only judge, perhaps indeed the best way, by the comparative exactness of the work that came from their hands. Mr Troughton's paper was read to the Royal Society in February 1809, and appeared in the first part of the volume of the *Phil. Trans.* for that year.* It contains not only an account of a method invented by himself, and which he had successfully practised for many years, but also remarks upon other methods, which had been, or were then in use. To abridge this work, after giving Bird's at length, is what we will not attempt; for we think our readers may not be displeased to see Troughton's ideas upon the subject in general, expressed in his own way; we therefore give the whole, notwithstanding a few repetitions, that will thus be introduced into our article.

"It would ill become me, in addressing myself to the members of this Society upon a subject which they are so well enabled to appreciate, to arrogate to myself more than may be assigned as my due, for whatever of success may have been the result of my long continued endeavours, exerted in prosecuting towards perfection *the dividing of instruments immediately subservient to the purposes of astronomy.* A man very naturally will set a value upon a thing on which so much of his life has been expended; and I shall readily, therefore, be pardoned for saying, that, considering some attainments which I have made on this subject as too valuable to be lost, and being encouraged, also, by the degree of attention which the Royal Society has ever paid to practical subjects, I feel myself ambitious of presenting them to the public through what I deem the most respectable channel in the world.

It was as early as the year 1775, being then apprentice to my brother, the late Mr John Troughton, that the art of dividing had become interesting to me; the study of astronomy was also new and fascinating; and I then formed the resolution, to aim at the nicer parts of my profession.

At the time alluded to, my brother, in the art of dividing, was justly considered the rival of Ramsden; but he was then almost unknown beyond the narrow circle of the mathematical and optical instrument makers, for whom he was chiefly occupied in the division, by hand, of small astronomical quadrants, and Hadley's sextants of large radius. Notwithstanding my own employment at that time was of a much inferior nature, yet I closely inspected his work, and tried, at leisure hours, on waste materials, to imitate it. With as steady a hand, and as good an eye, as young men generally have, I was much disappointed at finding, that, after having made two points, neat and small, to my liking, I could not bisect the distance between them, without enlarging, displacing, or deforming them with the points of the compasses. This circumstance gave me an early dislike to the tools then in use; and occasioned me the more uneasiness, as I foresaw, that it was an evil which no practice, care, or habit, could entirely cure;—beam-compasses, spring-dividers, and a scale of equal parts, in short, appeared to me little better than so many sources of mischief.

I had already acquired a good share of dexterity as a general workman. Of the different branches of our art, that of *turning* alone seemed to me to border on perfection. This juvenile conceit, fallacious as I afterwards found it, furnished the first train of thoughts which led to the method about to be described; for it occurred to me, that if I could, by any means, apply the principle of turning to the art of dividing instruments, the tools liable to objection might be dispensed with. The means of doing this were first suggested by seeing the action of the perambulator, or measuring wheel; the surface of the Earth presenting itself as the edge of the instrument to be divided, and the wheel of the perambulator as a narrow roller acting on that edge; and hence arose an idea, that some easy contrivance might be devised, for marking off the revolutions and parts of the roller upon the instrument. Since the year above-mentioned, several persons have proposed to

* The Royal Society voted to Mr Troughton the gold medal on Sir Godfrey Copley's Donation, for his valuable Paper.—ED.

Original Graduation.

me, as new, dividing by the roller, and I have been told, that it also occurred long ago to Hook, Sisson, and others; but, as Hatton on watch-making says, "I do not consider the man an inventor, who merely thinks of a thing. To be an inventor, in my opinion, he must act successfully upon the thought so as to make it useful." I had no occasion, however, to have made an apology for acting upon a thought, which, unknown to me, had been previously conceived by others; for it will be seen in the sequel, how little the roller has to do in the result, and with what extreme caution it is found necessary to employ it.

hen most urate, de-uive.

When a roller is properly proportioned to the radius of the circle to be divided, and, with its edge, made a small matter conical, so that one side may be too great, and the other side too little, it may be adjusted so exactly, that it may be carried several times around the circle, without the error of a single second; and it acts with so much steadiness, that it may not unaptly be considered as a wheel and pinion of indefinitely high numbers. Yet, such is the imperfection of the edges of the circle and roller, that, when worked with the greatest care, the intermediate parts, on a radius of two feet, will sometimes be unequal to the value of half a minute or more. After having found the terminating point of a quadrant or circle so permanent, although I was not prepared to expect perfect equality throughout, yet I was much mortified to find the errors so great, at least ten times as much as I expected; which fact indicated, beyond a doubt, that if the roller is to be trusted at all, it must only be trusted through a very short arc. Had there been any thing slippery in the action, which would have been indicated by measuring the same part, at different times, differently, there would have been an end of it at once; but this not being the case in any sensible degree, the roller becomes a useful auxiliary to fill up short intervals, the limits of which have been corrected by more certain means.*

ust be ufined short arcs.

rd's me-od of divi-n.

Bird, who enjoyed the undisputed reputation of being the most accurate divider of the age in which he lived, was the first who contrived the means how to render the usual divisions of the quadrant bisectional; which property, except his being unusually careful in avoiding the effects of unequal expansion from change of temperature, chiefly distinguished his method from others who divided by hand. This desirable object he accomplished by the use which he made of a finely divided scale of equal parts. The thing aimed at was, to obtain a point upon the arc at the highest *bisectional number of divisions* from 0, which in his eight feet quadrants was 1024 = 85° 20′. The extent of the beam compasses, with which he traced the arc upon the limb of the instrument to be divided, being set off upon that arc, gave the points 0° and 60°; which being bisected, gave 30° more to complete the total arc. A second order of bisections gave points at 15° distance from each other: but that which denoted 75° was most useful. Now, from the known length of the radius, as measured upon the scale, the length of the chord of 10° 20′ was computed, taken off from the scale, and protracted from 75° forwards; and the chord of 4° 40′, being ascertained in the same manner, was set off from 90° backwards, meeting the chord of 10° 20′ in the continually bisectional arc of 85° 20′. This point being found, the work was carried on by bisections, and the chords, as they became small enough, were set off beyond this point, to supply the remainder of the quadrantal arc. My brother, whom I mentioned before, from mere want of a scale of equal parts upon which he could rely, contrived the means of dividing bisectionally without one. His method I will briefly state as follows, in the manner in which it would apply to dividing a mural quadrant. The arcs of 60° and 30° give the total arc as before; and let the last arc of 30° be bisected, also the last arc of 15°, and again the last arc of 7° 30′: the two marks next 90° will now be 82° 30′ and 86° 15′, consequently the point sought lies between them. Bisections will serve us no longer; but if we divide this space equally into three parts, the most forward of the two intermediate marks will give us 85°, and if we divide the portion of the arc between this mark and 86° 15′ also into three, the most backward of the two marks will denote 85° 25′. Lastly, if we divide any one of these last spaces into five, and set off one of these fifth parts backwards from 85° 25′, we shall have the desired point at 1024 divisions upon the arc from 0°. All the rest of the divisions which have been made in this operation, which I have called marks, because they should be made as faint as possible, must be erased; for my brother would not suffer a mark to remain upon the arc, to interfere with his future bisections.

Mr John Troughton's method of dividing bisectionally without a scale.

Smeaton's preference of division by the computed chord.

Mr Smeaton, in a paper to be more particularly noticed presently, justly remarks the want of a unity of principle in Mr Bird's method; for he proceeds partly on the ground of the protracted radius, and partly upon that of the computed chord; which, as Smeaton ob-

* There are two things in the foregoing account, of the action of the roller, which have a tendency to excite surprise. The first is, that the roller should, in different parts of its journey round the circle, measure the latter so differently. One would not wonder, however, if in taking the measure across a ploughed field, it should be found different to a parallel measure taken upon a gravel walk; and, in my opinion, the cases are not very dissimilar. Porosity of the metal, in one part of the circle more than in the other, must evidently have the same effect. Brass unhammered is always porous; and the part which has felt the effect of two blows, cannot be so dense as other parts which have felt the effect of three; and, should the edge of the circle be indented by *jarring turning*, it would produce a visible similitude to ploughed ground. Every workman must be sufficiently upon his guard against such a palpable source of error; yet, perhaps, with our greatest care, we may not be able to avoid it altogether. The second is, that, notwithstanding the inequality above-mentioned, the roller having reached the point upon the circle from which it set out, should perform a second, third, &c. course of revolutions, without any sensible deviation from its former track. This is not, perhaps, so easily accounted for. It must be mentioned, that the exterior border of the circle should be *turned rounding*, presenting to the roller a convex edge, the radius of curvature of which is not greater than one-tenth of an inch. Now, were the materials perfectly inelastic and impenetrable, the roller could only touch the circle in a *point*, and, in passing round the circle, it could only occupy a *line* of contact. This, in practice, is not the case; the circle always marks the roller with a broad list, and thereby shows, that there is a yielding between them to a considerable amount. The breadth of this list is not less than one-fiftieth of an inch; and it follows, that at least 12° of the circle's edge must be in contact at the same time; that the two surfaces yield to each other in depth, by a quantity equal to the *ver. sin.* of half that arc, or $\frac{1}{1800}$th of an inch; and that the circle has always hold of the roller by nearly 1° of the edge of the latter. Whoever has examined the surfaces of metals, which have rolled against each other, must have observed that peculiar kind of indentation that always accompanies their action; and there can be no doubt, that the particles of a roller, and those of the surface on which it acts, which mutually indent each other, will, upon a second course begun from the same point, indent each other deeper. This is not, however, exactly the case in question; for whatever of fitting might have taken place between the surfaces of our roller and circle, in the first revolution of the former, we should imagine would be obliterated by the fifteen turns which it must repeat over fresh ground. Experience shows, however, as every one will find who tries the experiment with good work, that on coming round to the point of commencement, the roller has the disposition to regain its former track; for, were this not the case, although the commensurate diameters were adjusted so exactly as to be without sensible error in one course, yet a less error than that which is so would become visible, when repeated through many courses.

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serves, may or may not agree. Bird, without doubt, used the radius and its parts, in order to secure an exact quadrant; but Smeaton, treating exactness in the total arc as of little value to astronomy, would, in order to secure the more essential property of equality of division, reject the radius altogether, and proceed entirely upon the simple principle of the computed chord. The means pursued by my brother, to reach the point which terminates the great bisectional arc, is the only part in which it differs from Bird's method; and I think it is without prejudice that I give it the preference. It is obvious, that it is as well calculated to procure equality of division as the means suggested by Smeaton, at the same time that it is equal to Bird's in securing the precise measure of the total arc. It proceeds entirely upon the principle of the protracted chord of 60° and its subdivision; and the uncertainty which is introduced into the work, by the sparing use which is made of subdivision by 3 and 5, is, in my opinion, likely to be much exceeded by the errors of a divided scale, * and those of the hand and eye in taking off the computed chords, and applying them to the arc of the instrument to be divided.

Advantages of Mr John Troughton's method.

Ramsden's method by the engine.

Ramsden's well known method of dividing by the engine unites so much accuracy and facility, that a better can hardly be wished for; and I may venture to say, that it will never be superseded in the divisions of instruments of *moderate radii.* It was well suited to the time in which it appeared; a time, when the improvements made in nautical astronomy, and the growing commerce of our country, called for a number of reflecting instruments, which never could have been supplied, had it been necessary to have divided them by hand; however, as it only applies to small instruments, it hardly comes within the subject of this paper.

Hindley's method.

The method of Hindley, as described by Smeaton, † I will venture to predict, will never be put in practice for dividing astronomical instruments, however applicable it might formerly have been for obtaining numbers for cutting clockwork, for which purpose it was originally intended. It consists of a train of violent operations with blunt tools, any one of which is sufficient to stretch the materials beyond, or press them within their natural state of rest; and, although the whole is done by contact, the nature of this contact is such, as I think ought rather to have been contrasted with, than represented as being similar to, the nature of the contact used in Smeaton's Pyrometer, which latter is performed by the most delicate touch; and is represented, I believe justly, to be sensible to the $\frac{1}{60000}$ part of an inch. Smeaton has, however, acquitted himself well, in describing and improving the method of his friend; and the world is particularly obliged to him for the historical part of his paper, as it contains valuable information, which perhaps no one else could have written.

London practice of dividing large instruments.

The only method of dividing large instruments now practised in London, that I know of beside my own, has not yet, I believe, been made public. It consists in dividing by hand with beam compasses and spring dividers, in the usual way; with the addition of examining the work by microscopes, and correcting it, as it proceeds, by pressing forwards or backwards by hand, with a fine conical point, those dots which appear erroneous; and thus adjusting them to their proper places. The method admits of considerable accuracy, provided the operator has a steady hand and good eye; but his work will ever be irregular and inelegant. He must have a circular line passing through the middle of his dots, to enable him to make and keep them at an equal distance from the centre. The bisectional arcs also, which cut them across, deform them much; and what is worse, the dots which require correction (about two-thirds perhaps of the whole) will become larger than the rest, and unequally so in proportion to the number of attempts, which have been found necessary to adjust them. In the course of which operation, some of them grow insufferably too large, and it becomes necessary to reduce them to an equality with their neighbours. This is done with the burnisher, and causes a hollow in the surface, which has a very disagreeable appearance. Moreover, dots which have been burnished up are always ill defined, and of a bad figure. Sir George Shuckburg Evelyn, in his paper on the Equatorial, ‡ denominates these 'doubtful or bad points;' and (considering the few places which he examines) they bear no inconsiderable proportion to the whole. In my opinion, it would be a great improvement of this method, to divide the whole by hand at once, and afterward to correct the whole; for a dot forced to its place as above, will seldom allow the compass-point to rest in the centre of its apparent area; therefore other dots made from these will scarcely ever be found in their true places. This improvement also prevents the corrected dots from being injured or moved by the future application of the compasses, no such application being necessary.

Its defects.

Its tediousness.

I will now dismiss this method of dividing, with observing, that it is tedious in the extreme; and did I not know the contrary beyond a doubt, I should have supposed it to have surpassed the utmost limit of human patience. § When I made my first essay at subdividing with the roller, I used this method, according to the improvement suggested above, of correcting a few primitive points; but even this was too slow for one who had too much to do. Perhaps, however, had my instruments been divided for me by an assistant, I might not have grudged to have paid him for the labour of going through the whole work by the method of adjustment; nor have felt the necessity of contriving a better way.

Mr E. Troughton's method.

I might now extend the account of my method of dividing to a great length, by relating the alterations which the apparatus has undergone during a long course of years, ‖ and the various manner of its application, before I brought it to its present state of improvement; but I think I may save myself this trouble, for truly I do not see its use. I will, therefore, proceed immediately to a disclosure of the method, as practised on a late occasion, in the dividing of a four feet meridian circle, now the property of Stephen Groombridge, Esq. of Blackheath.

* That Bird's scale was not without considerable errors, will be shewn towards the end of this paper.

† Phil. Trans. for 1788.

‡ Phil. Trans. for 1793.

§ At the time alluded to, the double microscopic micrometer was unknown to me, and I did not learn its use, for these purposes, till the year 1790, from General Roy's description of the large theodolite. Previous to that time, I had used a frame, which carried a single wire very near the surface to be divided. This wire was moveable by a fine micrometer screw, and was viewed by a single lens inserted in the lower end of a tube, which, for the purpose of taking off the parallax, was four inches long. The greatest objection to this mode of constructing the apparatus is, that the wire, being necessarily exposed, is apt to gather up the dust; yet it is preferable to the one now in use, in cases where any doubt is entertained of the accuracy of the plane which is to receive the divisions.

‖ The full conception of the method had occupied my mind in the year 1778; but, as my brother could not be readily persuaded to relinquish a branch of the business to me in which he himself excelled, it was not until September 1785 that I produced my first specimen, by dividing an astronomical quadrant of two feet radius.

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riginal Graduation. Dcribed.

The surface of the circle which is to receive the divisions, as well as its inner and outer edges, but especially the latter, should be turned in the most exact and careful manner; the reason for which will be better understood, when we come to describe the mode of applying the roller: and, as no projection can be admitted beyond the limb, if the telescope, as is generally the case, be longer than the diameter, those parts which extend farther, must be so applied, that they may be removed during the operation of dividing. Fig. 1. and 2. Plate CCLXXXIII. represent the principal parts of the apparatus; Fig. 1. showing the plan, and Fig. 2. the elevation; in both of which the same letters of reference are affixed to corresponding parts, and both are drawn to a scale of half dimensions. AA is a part of the circle, the surface of which is seen in the plan, and the edge is seen in the elevation. BBB is the main plate of the apparatus, resting with its four feet *a*, *a*, *a*, *a* upon the surface of the arc; these feet, being screws, may be adjusted to as to take equal shares of the weight, and then are fastened by nuts below the plate, as shown in Fig. 2. CC and DD are two similar plates, each attached to the main plate, one above and the other below, by four pillars; and in them are centred the ends of the axis of the roller E. F and G are two friction wheels, the latter firmly fastened to B, but the former is fixed in an adjustable frame, by means of which adjustment these wheels and the roller E may be made to press, the former on the interior, and the latter on the exterior edge of the circle, with an equal and convenient force.* At the extremities of the axis of the roller, and attached to the middle of the plates C and D, are two bridges *c*, *c*, having a screw in each; by means of which an adjustment is procured for raising or lowering the roller respecting the edge of the circle, whereby the former, having its diameter at the upper edge about .001 of an inch greater than at the lower edge, (being, as before described, a little conical,) it may easily be brought to the position where it will measure the proper portion of the circle.

Apparatus. Plate CCLXXXIII Figs. 1, 2.

The roller.

Much experience and thought upon the subject have taught me, that the roller should be equal to one sixteenth part of the circle to be divided, or that it should revolve once in 22° 30′; and that the roller itself should be divided into sixteen parts; no matter whether with absolute truth, for accuracy is not at all essential here. Each of such divisions of the roller will correspond with an angle upon the circle of 1° 24′ 22″.5, or $\frac{1}{256}$th part of the circle. This number of principal divisions was chosen, on account of its being capable of continual bisection; but they do not fall in with the ultimate divisions of the circle, which are intended to be equal to 5′ each.

Microscopes.

The next thing to be considered is, how to make the roller measure the circle. As two microscopes are here necessary, and those which I use are very simple, I will in this place give a description of them. Fig. 6. is a section of the full size, and sufficiently explains their construction, and the position of the glasses; but the micrometer part and manner of mounting it, are better shown at H, in Fig. 1. and 2. The micrometer part consists of an oblong square frame, which is soldered into a slit, cut at right angles in the main tube; another similar piece nicely fitted into the former, and having a small motion at right angles to the axis of the microscope, has at one end a cylindrical guide pin, and at the other a micrometer screw; a spring of steel wire is also applied, as seen in the section, to prevent play, by keeping the head of the micrometer in close contact with the fixed frame. This head is divided into one hundred parts, which are numbered each way to 50; the use of which will be shown hereafter. A fine wire is stretched across the moveable frame, for the purpose of bisecting fine dots. Two of these microscopes are necessary; also a third, which need not have the divided head, and must have in the moveable frame two wires crossing each other at an angle of about 30°: this miscroscope is shown at I, Fig. 1. In the two first micrometers, a division of the head is of the value of about 0″.2, and the power and distinctness such, that when great care is taken, a much greater error than to the amount of one of these divisions cannot well be committed in setting the wire across the image of a well made dot. The double eye-glass has a motion by hand, for producing distinct vision of the wire; and distinct vision of the dots is procured by a similar adjustment of the whole microscope.

Micrometer.

Original Graduation.

Adjustment of the size of the roller.

The first step towards sizing the roller, is to compute its diameter according to the measure of the circle, and to reduce it agreeably thereto, taking care to leave it a small matter too large. The second step is, after having brought the roller into its place in the plate BB, to make a mark upon the surface of the circle near the edge, and a similar one upon the roller, exactly opposite each other; then carrying the apparatus forward with a steady hand, until the roller has made sixteen revolutions. If now, the mark upon the roller, by having over-reached the one upon the circle, shows it to be much too large, take it out of the frame and reduce it by turning accordingly: when, by repeating this, it is found to be very near, it may be turned about .001 of an inch smaller on the lower edge, and so far its preparation is completed. The third and last step is, the use and adaptation of the two microscopes; one of these must take its position at H in Fig. 1. viewing a small well-defined dot made for the purpose on the circle; the other, not represented in the Figure, must also be fixed to the main plate of Fig. 1. as near to the former as possible, but viewing one of the divisions on the roller. With a due attention to each microscope, it will now be seen to the greatest exactness, when, by raising or depressing the roller, its commensurate diameter is found.

Use and adaptation of the two microscopes.

Apparatus for making the dots in the circle.

Fig. 3. is a representation of the apparatus for transferring the divisions of the roller to the circle. It consists of two slender bars, which, being seen edgewise in the figure, have only the appearance of narrow lines; but, when looked at from above, they resemble the form of the letter A. They are fastened to the main frame, as at W and Z, by short pillars, having also the off leg of the angle secured in the same manner; Y is a fine conical steel point for making the dots, and X is a feeler, whereby the point Y may be pressed down with a uniform force, which force may be adjusted, by bending the end of the bar just above the point, so as to make the dots of the proper size. The point Y yields most readily to a perpendicular action; but is amply secured against any eccentric or lateral deviation.

Primary dots.

The apparatus, so far described, is complete for laying our foundation, *i. e.* making 256 primary dots; no matter whether with perfect truth or not, as was said respecting the divisions of the roller; precision in either

* Sufficient spring for keeping the roller in close and uniform contact with the edge of the circle is found in the apparatus, without any particular contrivance for this purpose. The bending of the pillars of the secondary frames, and of the axis of the roller, chiefly supplies this property.

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is not to be expected, or wished; but it is of some importance, that they should be all of the same size, concentric, small, and round. They should occupy a position very near the extreme border of the circle, as well to give them the greatest radius possible, as that there should be room for the stationary microscope and the other mechanism, which will be described hereafter.

It must be noticed, that there is a clamp and adjusting screw attached to the main plate of Fig. 1; but, as it differs in no respect from the usual contrivances for quick and slow motion, it has been judged unnecessary to incumber the drawing with it.

Method of making the dots.

Now the roller having been adjusted, with one microscope H upon its proper dot on the circle, and the other microscope at the first division on the roller; place the apparatus of Fig. 3. so that the dotting point Y may stand directly over the place which is designed for the beginning of the divisions. In this position of things, let the feeler X be pressed down, until its lower end comes into contact with the circle; this will carry down the point, and make the first impression, or primary dot, upon the circle; unclamp the apparatus, and carry it forwards by hand, until another division of the roller comes near the wire of the microscope; then clamp it, and with the screw motion make the coincidence complete; where again press upon the feeler for the second dot: proceed in this manner until the whole round is completed.

Method of ascertaining the errors of the dots.

From these 256 erroneous divisions, by a certain course of examination, and by computation, to ascertain their absolute and individual errors, and to form these errors into convenient tables, is the next part of the process, and makes a very important branch of my method of dividing.

The apparatus must now be taken off, and the circle mounted in the same manner as it will be in the observatory. The two microscopes, which have divided heads, must also be firmly fixed to the support of the instrument, on opposite sides, and their wires brought to bisect the first dot, and the one which should be 180° distant. Now, the microscopes remaining fixed, turn the circle half round, or until the first microscope coincides with the opposite dot; and, if the other microscope be exactly at the other dot, it is obvious that these dots are 180° apart, or in the true diameter of the circle; and if they disagree, it is obvious that half the quantity by which they disagree, as measured by the divisions of the micrometer head, is the error of the opposite division; for the quantity measured is that by which the greater portion of the circle exceeds the less. It is convenient to note these errors + or —, as the dots are found too forward or too backward, according to the numbering of the degrees; and for the purpose of distinguishing the + and — errors, the heads, as mentioned before, are numbered backwards and forwards to fifty. One of the microscopes remaining as before, remove the other to a position at right angles; and, considering for the present both the former dots to be true, examine the other by them; *i. e.* as before, try by the micrometer how many divisions of the head the greater half of the semicircle exceeds the less, and note half the quantity + or —, as before, and do the same for the other semicircle. One of the micrometers must now be set at an angle of 45° with the other, and the half differences of the two parts of each of the four quadrants registered with their respective signs. When the circle is a vertical one, as in the present instance, it is much the best to proceed so far in the examination with it in that position, for fear of any general bending or spring of the figure; but, for the examination of smaller arcs than 45°, it will be perfectly safe, and more convenient, to have it horizontal; because the dividing apparatus will then carry the micrometers, several perforations being made in the plate B for the limb to be seen through at proper intervals. The micrometers must now be placed at a distance of 22° 30′, and the half differences of the parts of all the arcs of 45° measured and noted as before; thus descending by bisections to 11° 15′, 5° 37′ 30″, and 2° 48′ 45″. Half this last quantity is too small to allow the micrometers to be brought near enough; but it will have the desired effect, if they are placed at that quantity and its half, *i. e.* 4° 13′ 7″.5; in which case the examination, instead of being made at the next, will take place at the next division but one to that which is the subject of trial. During the whole of the time that the examination is made, all the dots, except the one under examination, are for the present supposed to be in their true places; and the only thing in this most important part of the business, from first to last, is to ascertain with the utmost care, in divisions of the micrometer head, how much one of the parts of the interval under examination exceeds the other, and carefully to tabulate half of their difference.

The instrument to be engraved before dividing.

I will suppose that every one, who attempts to divide a large astronomical instrument, will have it engraved first. Dividing is a most delicate operation, and every coarser one should precede it. Besides, its being numbered is particularly useful to distinguish one dot from another: thus, in the two annexed tables of errors, (see p. 380, 381.) the side columns give significant names to every dot, in terms of its value to the nearest tenth of a degree, and the mistaking of one for another is rendered nearly impossible.

Table of apparent errors.

The foregoing examination furnishes materials for the construction of the table of half differences, or apparent errors.* The first line of this table consists of two varieties; *i. e.* the micrometers were at 180° distance for obtaining the numbers which fill the columns of the first and third quadrant; and at 90° for those of the second and fourth quadrant. The third variety makes one line, and was obtained with a distance of 45°: the fourth consists of two lines, with a distance of 22° 30′: the fifth of four lines, with a distance of 11° 15′: the sixth of eight lines, with a distance of 5° 37′ 30″: the seventh of sixteen lines, with a distance of 2° 48′ 45″: and the eighth and last variety, being the remainder of the table, consist of thirty-two lines, and was obtained with a distance of 4° 13′ 7″ 5.

Table of errors.

The table of apparent errors, or half differences, just explained, furnishes data for computing the table of real errors. The rule is this: let a be the real error of the preceding dot, and b that of the following one, and c the apparent error, taken from the table of half differences, of the dot under investigation; then is $\frac{a+b}{2}+c=$ its real error. But, as this simple expression may not be so generally understood by workmen as I wish, it may be necessary to say the same thing less concisely. If the real errors of the preceding and following dots are both +, or both —, take half their sum, and prefix thereto the common sign; but if one of them is + and the other —, take half their difference,

* If the table of real errors be computed as the work of examination proceeds, there will be no occasion for this table at all; but I think it best not to let one part interfere with another, and therefore I examine the whole before I begin to compute.

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prefixing the sign of the greater quantity: again, if the apparent error of the dot under investigation has the same sign of the quantity found above, give to their sum the common sign for the real error; but if their signs are contrary, give to their difference the sign of the greater for the real error. I add a few examples.

Example 1.

For the first point of the second quadrant.	
Real error of the first point of the first quadrant	— 0.0
Real error of the first point of the third quadrant	— 6.9
Half sum or half difference	— 3.4
Apparent error of the dot under trial .	+ 12.2
Real error	+ 8.8

Example 2.

For the point 45° of the second quadrant.	
Real error of the first point of the quadrant	+ 8.8
Real error of the last point of the quadrant	— 6.9
Half difference	+ 0.9
Apparent error of the dot under trial . .	— 8.9
Real error	— 8.0

Example 3.

Point 88°.6, or last point, of the third quadrant.	
Real error of the point 84°.4 of the third quadrant	— 21.0
Real error of the point 2°.8 of the fourth quadrant	— 2.9
Half sum	— 11.9
Apparent error of the dot under trial . .	— 4.0
Real error	— 15.9

Example 4.

Point 88°.6, or last, of the fourth quadrant.	
Real error of the point 84°.4 of the fourth quadrant	— 21.6
Real error of the point 2°.8 of the first quarant	— 10.2
Half sum	— 15.0
Apparent error of the dot under trial . .	+ 9.5
Real error	— 6.4

It is convenient, in the formation of the table of real errors, that they should be inserted in the order of the numbering of the degrees on their respective quadrants; although their computation necessarily took place in the order in which the examination was carried on, or according to the arrangement in the table of apparent errors. The first dot of the first quadrant having been assumed to be in its true place, the first of the third quadrant will err by just half the difference found by the examination; therefore these errors are alike in both tables. The real error of the first dot of the second quadrant comes out in the first example; that of the fourth was found in like manner, and completes the first line. It is convenient to put the error of the division 90° of each quadrant at the bottom of each column, although it is the same as the point 0° on the following quadrant. The line 45° is next filled up; the second example shows this; but there is no occasion to dwell longer upon this explanation; for every one, who is at all fit for such pursuits, will think what has already been said fully sufficient for his purpose. However, I will just mention, that there can be no danger, in the formation of this table, of taking from a wrong line the real errors which are to be the criterion for finding that of the one under trial, because they are in the next line to it, the others, which intervene in the full table, not being yet inserted. The last course of all is, however, an exception; for, as the examining microscopes could not be brought near enough to bisect the angle 2° 48′ 45″, recourse was had to that quantity and its half; on which account the examination is prosecuted by using errors at two lines distance, as is shown in the two last examples.

All the computations should be preserved.

When the table of real errors is constructed, the other table, although it is of no farther use, should not be thrown away; for if any material mistake has been committed, it will be discovered as the operation of dividing is carried on, and in this case the table of apparent errors must be had recourse to; indeed not a figure should be destroyed until the work is done. *

Respecting the angular value of the numbers in these tables, it may be worth mentioning that it is not of the least importance, 100 of them being comprised in one revolution of the micrometer screw; and, in the instance before me, 5.6 of them made no more than a second. It is not pretended that one of these parts was seen beyond a doubt, being scarcely $\frac{1}{10000}$ of an inch, much less the tenths, as exhibited in the tables; but as they were visible upon the micrometer heads, it was judged best to take them into the account.

True divisions to be made from the erroneous dots.

Having now completed the two first sections of my method of dividing; namely, the first, which consists of making 256 small round dots; and the second, in finding the errors of these dots, and forming them into a table; I come now to the third and last part, which consists in using the erroneous dots in comparison with the tabulated errors, so as ultimately to make from them the true divisions.

Subdividing sector described.

It will here be necessary to complete the description of the remaining part of the apparatus. And, first, a little instrument which I denominate a subdividing sector presents itself to notice. From all that has hitherto been said, it must have been supposed, that the roller itself will point out, upon the limb of the instrument to be divided, spaces corresponding to others previously divided upon itself, as was done in setting off the 256 points: but, to obviate the difficulty of dividing the roller with sufficient exactness, recourse was had to this sector; which also serves the equally important purpose of reducing the bisectional points to the usual division of the circle. This sector is represented of half its dimensions by Fig. 5, Plate CCLXXXIII. It is formed of thin brass, and centered upon the axis at A, in contact with the upper surface of the roller: it is capable of being moved round by hand; but, by its friction upon the axis, and its pressure upon the roller, it is sufficiently prevented from being disturbed by accident. An internal frame BB, to which the arc CC is attached, moves freely in the outer one, and by a spring D is pushed outwards, while the screw E, the point of which touches the frame B, confines the arc to its proper radius. The arc of this sector is of about four times greater radius than the roller, and upon it are divided the spaces which must be transferred to the instrument as represented on a magnified scale by Fig. 4. Now, the angle of one of the spaces of the circle will be measured by sixteen times its angular value upon the sectorial arc, or 22° 30′; but this does not represent any number of equal parts upon the instrument, the subdivisions of which are to be 5′ each; for $\frac{1° 24' 22''.5}{5}$ is exactly $16\frac{7}{8}$, therefore so many divisions are exactly equal to a mean

Plate CCLXXXIII. Fig. 5.

* This is a very useful hint, applicable on many occasions.

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Plate CCLXXXIII. Fig. 4.

space between the dots, the errors of which have been tabulated. Let, therefore, the arc of the sector be divided into 16 spaces of 1° 20′ each, and let a similar space at each end be subdivided into eight parts of 10′ each, as in Fig. 4; we shall then have a scale which furnishes the means for making the true divisions, and an immediate examination at every bisectional point.

Dividing by the engine.

I have aways divided the sector from the engine, because that is the readiest method, and inferior to none in point of accuracy, where the radius is very short; but, as it is more liable than any other to centrical error, the adjustment of the arc by the screw E becomes necessary: by that adjustment, also, any undue run in the action of the roller may be reduced to an insensible quantity.

Division by lines preferable to dots.

When the utmost degree of accuracy is required, I give the preference to dividing by lines, because they are made with a less forcible effort than dots are; and also because, if any small defect in the contexture of the metal causes the cutter to deviate, it will, after passing the defective part, proceed again in its proper course, and a partial crookedness in the line will be the only consequence; whereas a dot, under similar circumstances, would be altogether displaced. But, on the other hand, where accuracy has been out of the question, and only neatness required, I have used dots; and I have done so, because I know that when a dot and the wire which is to bisect it are in due proportion to each other, (the wire covering about two-thirds of the dot,) the nicest comparison possible may be obtained. It may be farther observed, that division by lines is complete in itself; whereas that by dots requires lines to distinguish their value.

Apparatus for cutting the divisions.

On the upper side of Fig. 1. is represented the apparatus for cutting the divisions. It consists of three pieces JKL, jointed together so as to give to the cutter an easy motion, for drawing lines directly radiating from the centre, but inflexible with respect to lateral pressure; *dd* are its handles. The cutting point is hidden below the microscope H; it is of a conical form, and were it used as a dotting point, it would make a puncture of an elliptical shape, the longer diameter of which would point towards the centre. This beautiful contrivance, now well known, we owe to the ingenuity of the late Mr Hindley of York; it was borrowed by Mr Ramsden, * and applied with the best effect to his dividing engine.

Invented by Mr Hindley.

It might have been mentioned sooner, that in the instance which I have selected as an example of my dividing, the operation took place when the season of the year, and the smoke of London, had reduced the day to scarcely six hours of effective light; and rather than confine my labours within such narrow limits, I determined to shut out the day-light altogether. Fig. 7. shows the construction of the lanterns which I used. A very small wick gave sufficient light, when kept from diverging by a convex lens; while the inclining nossel was directed down exactly upon the part looked at, and the light, having also passed through a thin slice of ivory, was divested of all glare. I enter into this description, because, I think, I never saw my work better, nor entirely to so much advantage as in this instance; owing, perhaps, to the surrounding darkness allowing the pupil of the eye to keep itself more expanded, than when indirect rays are suffered to enter it. The heat from a pair of these lanterns was very inconsiderable, and chiefly conducted along with the smoke up the reclining chimney.

Lanterns employed. Fig. 7.

Previous to cutting the divisions, the parts now described must be adjusted. The cutting apparatus must be placed with the dividing point exactly at the place where the first line is intended to be drawn, and clamped, so that the adjusting screw may be able to run it through a whole interval. The microscope H must be firmly fixed by its two pillars *b*, *b* to the main frame, with its micrometer head at *zero*; and with its only wire in the line of the radius, bisecting the first of the 256 dots. And it should be observed, that the cutting frame and this must not vary respecting each other, during the time that the divisions are cut; for any motion that took place in either would go undiminished to the account of error. The microscope I is also fastened to the main frame; but it is only required to keep its position unvaried, while the divisions of the sector pass once under its notice; for it must have its wires adjusted afresh to these divisions at every distinct course. The microscope I has two wires, crossing each other at an angle of about 40°; and these are to be placed so as to make equal angles with the divisions of the sector, which are not dots but lines. The sectorial arc must also be adjusted to its proper radius by the screw E, Fig. 5; *i. e.* while the main frame has been carried along the circle through a mean interval shewn by H, the sector must have moved though exactly $16\frac{7}{8}$ths of its divisions, as indicated by I. †

Things being in this position; after having given the parts time to settle, and having also sufficiently proved the permanence of the micrometer H and the cutting frame with respect to each other, the first division may be made; then, by means of the screw for slow motion, carry the apparatus forward, until the next line upon the sector comes to the cross wires of I; you then cut another divison, and thus proceed until the 16th division is cut, $= 1° 20'$: Now, the apparatus wants to be carried further, to the amount of $\frac{7}{8}$ths of a division, before an interval is complete; but at this last point no division is to be made; we are here only to compare the division on the sector with the corresponding dot upon the instrument. This interval, however, upon the circle, will not be exactly measured by the corresponding line of the sector, which has been adjusted to the mean interval, for the situation of the dot 1°.4 is too far back, as appears by the table of real errors, by — 4.8 divisions of the micrometer head. The range of the screw for slow motion must now be restored, the cross wires of H set back to — 4.8 divisions, and the sector moved back by hand, but not to the division 0 where it began before; for, as it left off in the first interval at $\frac{7}{8}$ths of a division, it has to go forwards $\frac{1}{8}$th more before it will arrive at the spot where the 17th division of the instrument 1° 25′ is to made, so that in this second course it must begin at $\frac{1}{8}$th short of 0. Go through this interval as before, making a division upon the circle at every one of the 16 great

* This I learned from that most accurate artist Mr John Stancliffe, who was himself apprentice to Hindley.

† For the sake of simplicity, the account of the process is carried on as if the roller measured the mean interval without error. But it was said (Page 371), that the roller, in a continued motion quite round the circle, would, in some part of its course, err by 30″, or more; therefore, when this is the case, an extreme run of the roller cannot agree with a mean interval of the circle nearer than $\frac{30''}{12} = 0.23''$; and most probably this kind of error will, on some intervals, amount to double that quantity. It, therefore, becomes matter of prudent precaution, to examine every interval previous to making the divisions; and, where necessary, to adjust the sector, so that its arc may exactly measure the corresponding interval as corrected by the tabulated errors.

divisions of the sector; and H should now reach the third dot, allowing for a tabular error of — 10.2 when the division $\frac{4}{5}$ths of the sector reaches the cross wires of I. It would be tedious to lead the reader through all the variety of the sector, which consists of eight courses; and it may be sufficient to observe, that at the commencement of every course, it must be put back to the same fraction of a division which terminated its former one; and that the wire of the micrometer H must always be set to the tabular error belonging to every dot, when we end one interval and begin another. The eight courses of the sector will have carried us through $\frac{1}{32}$d part of the circle, 11° 15′, and during this time the roller will have proceeded through half a revolution; for its close contact with the limb of the circle does not allow it to return with the sector when the latter is set back at every course. Having in this manner proceeded, from one interval to another, through the whole circle, the micrometer at last will be found with its wire at *zero*, on the dot from which it set out; and the sector, with its 16th division, coinciding with the wires of its microscope.

Advantages of this method.

Having now given a faithful detail of every part of the process of dividing this circle, I wish to remind the reader, that, by verification and correction at every interval, any erroneous action of the roller is prevented from extending its influence to any distant interval. It will be farther observed, that the subdividing sector magnifies the work; that by means of its adjustable arc, it makes the run of the roller measure its corresponding intervals upon the circle; and, without foreign aid, furnishes the means of reducing the bisectional intervals to the usual division of the circle. Farthermore, the motion of the wire of the micrometer H, according to the division of its head and corresponding table of errors, furnishes the means of prosecuting the work with nearly the same certainty of success, as could have happened, had the 256 points been (which in practice is quite impossible) in their true places.

Why termed dividing by the eye.

Now, the whole of my method of dividing being performed by taking short measures with instruments which cannot themselves err in any sensible degree, and, inasmuch as those measures are taken, not by the hand, but by vision, and the whole performed by only looking at the work, the eye must be charged with all the errors that are committed until we come to cut the divisions; and, as in this last operation the hand has no more to do than to guide an apparatus so perfect in itself, that it cannot be easily made to deviate from its proper course, I would wish to distinguish it from the other methods, by denominating it, *dividing by the eye*. *

Few persons capable of dividing originally.

The number of persons at all capable of dividing originally have hitherto been very few: the practice of it being so limited, that in less than twice seven years, a man could hardly hope to become a workman in this most difficult art. How far I shall be considered as having surmounted these difficulties, I know not; but if, by the method here revealed, I have not rendered original dividing almost equally easy with what copying was before, I have spent much labour, time, and thought in vain. I have no doubt, indeed, that any careful workman who can divide in common, and has the ability to construct an astronomical instrument, will, by following the steps here marked out, be able to divide it, the first time he tries, better than the most experienced workman, by any former method.

Subdivision with the screw instead of the roller.

If, instead of subdividing with the roller, the same thing be performed with the screw, it will not give to dividing by the eye any very distinctive character: I have practised this on arcs of circles with success, the edge being slightly racked, the screw carrying forward an index with the requisite apparatus, and having a divided micrometer head; the latter answers to the subdividing sector, and, being used with a corresponding table of errors, forms the means of correcting the primitive points; but the roller furnishes a more delicate action, and is by far more satisfactory and expeditious.

Six feet circle for the Royal Observatory, dividing on its edge.

It is known to many, that the six feet circle, which I am now at work upon for our Royal Observatory, is to be divided upon a broad edge, or upon a surface at right angles to the usual plane of division: the only alterations which will on this account be required, are, that the roller must act upon that plane which is usually divided upon; which roller, being elevated or depressed, may be adjusted to the commensurate radius without being made conical, as was necessary in the other case. The apparatus, similar to the other, must here be fixed immoveably to the frame which supports the circle: its position must be at the vertex, where also I must have my station; and the instrument itself must be turned around its axis, in its proper vertical position, as the work proceeds. The above may suffice, for the present, to gratify those who feel themselves interested upon a subject which will be better understood, if I should hereafter have the honour of laying before the Royal Society a particular description of the instrument here alluded to; a task which I mean to undertake, when, after being fixed in the place designed for it, which I hope will be effected at no very distant period, it shall be found completely to answer the purposes intended. See Circle, Vol. VI. p. 485.

A circle may readily be divided centesimally, and in the common way.

Should it be required to divide a circle according to the centesimal division of the quadrant, as now recommended and used in France, we shall have no difficulty. The 100° of the quadrant may be conveniently subdivided into 10 each, making 4000 divisions in the whole round. The 256 bisectional intervals, the two tables of errors, and the manner of proceeding and acting upon them, will be exactly the same as before,

* I must here remark, that Smeaton has represented the greatest degree of accuracy that can be derived from vision, in judging of the coincidence of two lines, at $\frac{1}{4000}$th part of an inch. From this it may fairly be inferred, that he had not cultivated the power of the sight, as he had done that of the touch; the latter of which, with that ability which appeared in all his works, he rendered sensible to the $\frac{1}{60000}$th part of an inch. Were materials infinitely hard, no bounds could be set to the precision of contact; but taking things as they are, the different degrees of hardness in matter, may be considered as a kind of magnifying power to the touch, which may not unaptly be compared with the assistance which the eye receives from glasses. It is now quite common to divide the seaman's sextant to 10″, and a good eye will estimate the half of it; which, on an eight-inch radius, is scarcely $\frac{1}{10000}$th of an inch. This quantity, small as it is, is rendered visible by a glass of one inch focal length; and such is the certainty with which these quantities are seen, that a seaman will sometimes complain that two pair of these lines will coincide at the same time; and this may happen, and yet no division of his instrument err, by more than $\frac{1}{4000}$th part of an inch. All this is applicable to judging of the coincidence of lines with each other, and furnishes not the most favourable display of the accuracy of vision. But with the microscopes here described, where the wire bisects the image of a dot, or a cross wire is made to intersect the image of a line, by an eye practised in such matters, a coincidence may undoubtedly be ascertained to $\frac{1}{30000}$th part of an inch. I am of opinion, that as small a quantity may be rendered visible to the eye, as can by contact be made sensible to the touch; but whether Mr Smeaton's $\frac{1}{60000}$ and my $\frac{1}{30000}$ be not the same thing, I will not determine; the difference between them, however, is what he would no more have pretended to feel, than I dare pretend to see.

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until we come to cut the divisions; and for this purpose we must have another line divided upon the sector. For $\frac{1}{4000}$th part of the circle being equal to 5′.4 of the usual angular measure $\frac{1^\circ\, 24'\, 22''.5}{5'.4} = 15\frac{5}{8}$ divisions; and just so many will be equivalent to one of the intervals of the circle. The value of one of the great divisions of the sector will be 1° 26′ 24″, and that of the $\frac{1}{8}$th parts, which are to be annexed to the right and left as before, will be 10′.48″, therefore divisible by the engine. Should any astronomer choose to have both graduations upon his instrument, the additional cost will be a mere trifle, provided both were done at the same time.

Dividing by the eye applicable to straight lines as well as circles.

It must already have been anticipated, that dividing by the eye is equally applicable to straight lines as it is to circles. An apparatus for this purpose should consist of a bar of brass, three quarters of an inch thick, and not less than three inches broad; six feet may do very well for the length; it may be laid upon a deal plank strengthened by another plank screwed edgewise on its lower surface. The bar should be planed on both its edges and on its surface, with the greatest exactness; and it will be better if it has a narrow slip of silver, inlaid through its whole length, for receiving the dots. An apparatus nearly similar to the other should slide along its surface, carrying a roller, the circumference of which is 12.8 inches, and turned a little conical for the sake of adjustment. The roller may be divided into 32 parts, each of which, when transferred to the bar, will give intervals of 0.4 of an inch each: the angle of the subdividing sector should of course be 11° 15′, and subdivided into four parts, which will divide the inch into tenths: the surface may also receive other lines, with subdivisions suited to the different purposes for which it may be wanted. The revolutions of the roller and its $\frac{1}{32}$ parts must be dotted upon the bar; taking care, by sizing the roller, to come as near the true standard measure as possible: when this is done, compare the extent of the greater bisectional number that is contained in the length, *i. e.* 128 intervals or 51.2 inches, with the standard measure; noting the difference as indicated by the micrometer heads: the examination and construction of the table of errors may then be conducted just as was done for the circle.

Apparatus for the purpose.

Method of using it.

Being now ready for the performance of its work, the scale to be divided must be laid alongside of the bar, and the true divisions must be cut upon it by an appeal, as before, to the erroneous dots on the bar, corrected by a corresponding table of errors. The apparatus, remaining entire in the possession of the workman, with its primitive dots, the table of errors, &c. is ready for dividing another standard, which will be precisely similar to others that have been, or may be, divided from it. It may be considered, indeed, as a kind of engine; and, as it is not vitiated by the coarse operation of racking with a screw, but performed by only looking at the work, the method will command about three times the accuracy that can be derived from the usual straight-line dividing engine. Should it be asked, if an engine thus appointed would succeed for dividing circles? I answer, Yes; but I would not recommend it; because, beyond a certain extent of radius, it is not necessary; for the errors, which would be introduced into the work by the violence of racking a large wheel, are sufficiently reduced by the comparative shortness of the radius of such instruments as we divide by that method: and, what is still more to the purpose, the dividing engine is four times more expeditious, and bears rough usage better. I cannot quit the subject of dividing straight lines without observing, that I never had my apparatus complete. The standard which I made for Sir George Shuckburgh Evelyn in 1796, was done by a mere make-shift contrivance, upon the principle of dividing by the eye; how I succeeded, may be seen in Sir George's papers on Weights and Measures, in the *Phil. Trans.* for 1798. I made a second, some years after, for Professor Pictet of Geneva, which became the subject of comparison with the new measure of France, before the National Institute; and their report, drawn up by Mr Pictet, has been ably re-stated and corrected by Dr Young, as published in the Journals of the Royal Institution. I made a third for the magistrates of Aberdeen. I notice the two latter, principally to give myself an opportunity of saying, that, if those three scales were to be compared together, notwithstanding they were divided at distant periods of time, and at different seasons of the year, they would be found to agree with each other as nearly as the different parts of the same scale agree.

It might be used for dividing circles, but not to be recommended.

Constr[uc]tion o[f] standa[rd] measu[re].

Inad[ver]tency [of] G. Sh[uck]burgh [E]lyn.

I hope I may here be allowed to allude to an inadvertency which has been committed in the paper mentioned above; and which Sir George intended to have corrected, had he lived to conclude his useful endeavours to harmonise the discordant weights and measures of this country. The instruments which he has brought into comparison are, his own five feet standard measure and equatorial; General Roy's forty-two inch scale; the standard of Mr Aubert; and that of the Royal Society. The inadvertency is this: in his equatorial, and the standard of the Royal Society, he has charged the error of the most erroneous extent, when compared with the mean extent, alike to both divisions; *i. e.* he has supposed one of the divisions, which bound the erroneous extent, to be too much to the right, and the other too much to the left, and that by equal quantities. This is certainly a good-natured way of stating the errors of work; and perhaps not unjustly so, where the worst part has been selected; but in the other three instances, namely, in General Roy's, Mr Aubert's, and his own standard, he has charged the whole error of the most erroneous extent to one of the bounding lines.

Gen[eral ac]cura[cy of] Bird['s di]vidin[g]. The [Green]wich [qua]drant.

I was well confirmed in my high opinion of the general accuracy of Bird's dividing, when, last winter,* I measured the chords of many arcs of the Greenwich quadrant. That instrument has indeed suffered, both from a change in its figure, and from the wearing of its centre; but the graduation, considering the time when it was done, I found to be very good. Sir George, in his paper upon the equatorial, (*Phil. Trans.* for 1793,) after some compliments paid to the divider of his instrument, says, "the late Mr John Bird seems to have admitted a probable discrepancy in the divisions of his eight feet quadrant, amounting to 3″;" and he refers to Bird on the construction of the Greenwich quadrant. This quantity being three times as great as any errors that I met with, I was lately induced to inquire how the matter stood. Bird, in the paper referred to, says, "in dividing this instrument, I never met with an inequality that exceeded one second. I will suppose, that in the 90 arch this error lay toward the left hand, and in the 96 arch that it lay towards the right, it will cause a difference between the two arches of two seconds; and, if an error of one second be allowed to the observer in reading off his observation, the whole amount is no more than three seconds, which is

* This paper was written in June 1808.

Original Graduation.

Compared with Sir G. Shuckburgh's equatorial.

agreeable to what I have heard, &c." Sir George's examination of his own equatorial furnishes me with the means of a direct comparison: in his account of the declination circle, we find an error $+2''.35$, and another $-1''.5$; to these add an error of half a second in each, for reading off, which Sir George also admits, we shall then have a discrepancy of $4''.85$; but, as the errors of reading off are not errors of division, let them be discharged from both, and the errors will then stand for the quadrant $2''$, and for the circle $3''.85$. As the radius of the former, however, is four times greater than that of the latter, it will appear, by this mode of trial, that the equatorial is rather more than twice as accurately divided as the quadrant. In doing justice to Bird in this instance, I have only done as I would be done by: for, should any future writer set me back a century on the chronological scale of progressive improvement, I hope some one will be found to restore me to my proper niche. I now subjoin a restatement of the greatest error of each of the instruments that are brought into comparison by Sir George, after having reduced them all by one rule, viz. allowing each of the two points which bound the most erroneous extent, to divide the apparent error equally between them. They are expressed in parts of an inch, and follow each other in the order of their accuracy.

Errors of different standards.

Sir George Shuckburgh's 5 feet standard	.000165
General Roy's scale of 42 inches	.000240
Sir George's equatorial, 2 feet radius	.000273
The Greenwich quadrant, 8 feet radius	.000465
Mr Aubert's standard, 5 feet long	.000700
*The Royal Society's standard, 92 inches long	.000795

For the justness of the above statement, I consider my name as pledged; requesting the permission to say, that if, on the result of each respective examination, as here presented, there could have been more than one opinion, it would not have appeared here. I am farther prompted to add, that the above comparative view presents one circumstance to our notice, which cannot do less than gratify every individual, who is at all conversant in these matters; I mean, the high rank which General Roy's scale takes in the list; that scale having been made the agent in measuring the base line of our national trigonometrical survey.

Care must be taken, to have the circle of a uniform temperature while turning the outer edge,

To return, finally, to the dividing of circles; I must state, as matter of precaution, that great care should be taken during the turning of the outer edge, to have the circle of the same temperature; for one part may be expanded by heat, or contracted by cold, so much more than another, as to cause the numbers in the tables of errors to be inconveniently large. A night is not more than sufficient for allowing the whole to take the same temperature, after having been handled by the workmen; and the finishing touch should be given within a short space of time. But, if the effects of temperature are to be regarded in turning a circle, it is of tenfold more importance to attend to this circumstance, while the examination of the larger arcs of the instrument is carried on; for it is absolutely necessary, that, during this time, the whole circle should be of the same heat exactly. Few workmen are sufficiently aware of this. They generally suppose the expansion of metals to be a trifle, which need not be regarded in practice; and wonder how the parts of a circle can be differently heated, without taking pains to make it so. One degree of Fahrenheit's thermometer indicates so small a portion of heat, that, in such places as workmen are usually obliged to do their business in, it is not very easy to have three thermometers attached to different parts of a large instrument, showing an equality of temperature within that quantity: Yet so necessary is correctness in this respect, that if a circle has the vertex one degree warmer than its opposite, and if this difference of temperature be regularly distributed from top to bottom, the upper semicircle will actually exceed the lower by $2''$: And, if such should happen to be the case while the examination of the first dot of the third quadrant is made, the regularity of the whole operation would thereby be destroyed.

and while examining the larger arcs.

Effects of temperature much more important than generally supposed.

The apparatus not expensive.

It may not be improper to remark, that dividing by the eye does not require a more expensive apparatus than the operation of dividing by hand; and, indeed, less so when the scale of inches is deemed necessary. The method by adjustment is still more expensive, requiring whatever tools Bird's method requires, and, in addition to these, a frame and microscopes, somewhat similar to those for dividing by the eye.

Much time saved by it.

It is somewhat more difficult to give a comparative estimate of the time, which the different methods of dividing require. I know, that 13 days of eight hours each, are well employed in dividing such a circle by my method; about 52 days would be consumed in doing the same thing by Bird's method; and I think I cannot err much, when I state the method by adjustment, supposing every dot to be tried, and that two thirds of them want adjusting, to require about 150 of such days.

The economy of time, (setting aside the decided means of accuracy,) which the above estimate of its application offers to view, will, I think, be considered of no little moment. By the rising artist, who may aspire to excellence, it will at least, and I should hope with gratitude, be felt in the abbreviation of his labours. To me, indeed, the means of effecting this became indispensible; and it has not been without a sufficient sense of its necessity, that I have been urged to the progressive improvement and completion of these means, as now described. It is but little that a man can perform with his own hands alone; nor is it on all occasions, even in frames of firmer texture than my own, that he can decisively command their adequate, unerring use. And I must confess, that I never could reconcile it to what I hold as due to myself, as well as to a solicitous regard for the most accurate cultivation of the science of astronomy, to commit to others an operation requiring such various and delicate attentions, as the division of my instruments.

That my attentions on this head have not failed to procure for me the notice and patronage of men, whose approbation makes, with me, no inconsiderable part of my reward, I have to reflect on with gratitude and pleasure: and as I look with confidence to the continuance of that patronage, so long as the powers of execution shall give me the inclination to solicit it, I cannot entertain a motive, which might go to extinguish the more liberal wish of pointing out to future ingenuity a shorter road to eminence; sufficiently gratified by the idea of having, in the present communication, contributed to facilitate the operations, and to aid the progress of art, (as far as the limited powers of vision will admit,) toward the point of perfection."

* This is the same which Mr Bird used in dividing his eight feet mural quadrants, and was presented to the Royal Society by Bird's executors.

Table of apparent Errors.

Original Graduation.									
Name of the Dot.	First Quadrant.	Second Quadrant.	Third Quadrant.	Fourth Quadrant.	First Quadrant.	Second Quadrant.	Third Quadrant.	Fourth Quadrant.	Name of the Dot.
0°0	0.	+12.2	—6.9	+17.9	+4.6	+17.1	—4.4	+17.3	1°.4
45.0	—21.3	—8.9	16.7	—29.6	—5.2	—9.7	8.9	—6.4	4.2
22.5	1.6	2.2	1.0	2.7	0.0	3.8	1.0	4.7	7.0
67.5	+1.0	+15.6	0.0	+13.7	+1.0	+3.5	5.1	5.5	9.8
11.2	—16.6	—20.2	22.6	—30.3	—5.5	—1.6	0.0	+1.2	12.7
33.7	4.0	4.2	13.2	23.1	7.6	7.6	4.2	—2.3	15.5
56.2	16.9	22.2	17.0	22.7	9.4	3.9	0.0	5.3	18.3
78.7	30.8	16.6	31.3	30.3	+1.1	+12.1	+4.2	+4.3	21.1
5.6	2.7	8.6	4.1	10.1	12.3	0.9	6.2	14.4	23.9
16.9	11.5	11.3	11.2	16.1	—5.7	6.2	1.1	—11.2	26.7
28.1	9.0	7.4	5.8	14.3	+1.5	3.5	—6.3	4.2	29.5
39.4	9.3	8 2	5.8	13.1	0.0	7.0	7.7	+1.4	32.3
50.6	4.2	6.6	8.2	4.4	1.5	+9.0	+3.0	4.3	35.2
61.9	4.3	8.4	12.5	4.4	—8.6	—5.9	—2.0	—6.7	38.0
73.1	7.6	10.0	13.6	9.7	3.3	+2.7	4.9	1.5	40.8
84.4	18.0	+6.0	16.3	7.1	+4.0	3.1	3.5	+1.0	43.6
2.8	3.4	—7.5	8.9	2.1	13.5	10.5	+16.0	14.9	46.4
8.4	0.0	5.0	4.6	5.7	2.1	0.0	1.7	—3.5	49.2
14.1	6.6	8.2	5.6	4.8	—5.0	—10.7	—2.9	1.5	52.0
19.7	1.6	2.4	+1.0	2.5	4.2	7.9	2.2	7.2	54.8
25.3	3.7	8.2	—2.9	2.5	4.0	3.0	2.5	1.0	57.7
30.9	+2.4	7.1	7.0	0.0	7.3	+6.2	6.1	1.5	60.5
36.6	—5.9	+1.0	2.5	1.5	3.2	—10.1	5.6	12.7	63.6
42.2	+3.1	1.9	5.8	+2.5	1.4	7.2	3.9	+2.2	66.1
47.8	7.1	5.2	+2.4	4.8	+11.2	+14.9	+21.2	7.2	68.9
53.4	—5.6	—6.0	—5.0	—6.1	—7.1	—1.0	—8.9	—11.7	71.1
59.1	10.7	+1.0	3.0	+1.4	5.3	1.2	6.6	2.7	74.5
64.7	7.	—18.0	10.7	—9.0	7.2	9.9	+1.0	5.9	77.3
70.3	2.7	7.4	1.5	9.0	6.5	1.8	5.3	2.6	80.2
75.9	1.2	5.2	2.2	4.7	+4.4	+1.4	—2.2	4.3	83.0
81.6	1.6	+1.7	0.0	2.0	—20.8	—0.0	11.4	+1.0	85.8
87.2	13.7	6.0	3.5	+5.6	+2.1	+11.0	4.0	9.5	88.6

Table of real Errors.

Original Graduation. | Original Graduation.

Name of the Dot.	First Quadrant.	Second Quadrant.	Third Quadrant.	Fourth Quadrant.	First Quadrant.	Second Quadrant.	Third Quadrant.	Fourth Quadrant.	Name of the Dot.
0°.0	0.0	+ 8.8	— 6.9	+ 14.4	— 16.9	— 8.0	— 13.4	— 22.4	45°.0
1.4	— 4.8	— 0.6	16.0	5.9	8.7	5.5	9.7	16.1	46.4
2.8	10.2	9.3	24.0	— 2.9	14.3	9.6	17.4	22.3	47.8
4.2	13.8	15.1	28.3	12.8	22.3	17.9	19.9	33.8	49.2
5.6	13.7	12.5	23.3	16.1	26.0	21.6	26.7	31.9	50.6
7.0	15.9	16.8	28.7	19.4	25.5	26.0	23.6	28.9	52.0
8.4	17.6	19.6	32.0	27.0	32.0	27.8	30.3	38.3	53.4
9.8	21.4	16.1	35.5	30.7	34.0	27.3	29.1	35.2	54.8
11.2	21.6	16.7	31.5	26.5	26.8	22.1	24.0	32.6	56.2
12.7	27.9	21.6	32.2	28.6	29.6	24.5	29.7	29.8	57.7
14.1	31.1	26.8	37.5	34.4	33.7	17.7	27.2	24.6	59.1
15.5	28.5	22.7	30.2	26.8	30.2	15.6	29.3	26.5	60.5
16.9	27.3	20.5	32.4	32.7	19.2	15.3	24.1	19.4	61.9
18.3	29.9	18.2	24.2	25.7	21.5	14.6	18.8	23.7	63.3
19.7	20.2	13.5	20.6	22.2	19.0	21.5	22.4	17.4	64.7
21.1	22.4	5.9	22.1	24.0	18.8	19.9	22.8	17.1	66.1
22.5	10.0	1.8	10.9	6.7	3.0	+ 8.2	+ 0.7	+ 2.5	67.5
23.9	8.8	12.2	16.0	14.9	9.8	— 2.8	— 2.5	— 13.0	68.9
25.3	19.8	15.5	20.2	24.0	15.7	10.2	13.7	19.2	70.3
26.7	21.7	16.1	20.0	33.0	21.9	7.0	21.8	25.8	71.7
28.1	22.1	12.8	23.8	36.4	23.0	13.9	25.1	23.0	73.1
29.5	17.1	15.8	28.9	35.0	27.1	14.3	25.3	26.8	74.5
30.9	22.1	18.0	31.4	37.0	26.6	20.1	26.6	30.7	75.9
32.3	24.7	19.3	33.3	37.7	33.3	21.1	22.7	31.1	77.3
33.7	17.4	9.1	25.1	37.6	27.9	16.0	23.8	29.1	78.7
35.2	22.7	8.0	25.1	35.7	35.5	14.5	18.5	28.7	80.2
36.6	27.3	11.9	27.4	41.8	2 .3	9.0	22.4	27.3	81.6
38.0	26.5	15.6	26.9	40.6	21.0	6.6	17.5	21.4	83.0
39.4	26.4	16.7	24.8	43.1	27.5	5.4	21.0	21.6	84.4
40.8	25.4	7.2	25.1	33.6	31.0	7.9	15.4	12.6	85.8
42.	18.5	10.4	24.7	30.2	23.0	0.1	6.8	5.2	87.1
43.6	16.3	10.0	24.6	31.7	16.3	3.7	15.9	6.4	88.6
45.0	16.9	8.0	13.0	22.4	+ 8.8	6.9	+ 14.4	0.0	90.0

Original Graduation.

Remarks on Mr Troughton's method of dividing.

It can hardly have escaped notice, on perusing the above account, how strictly Troughton has adhered to the *maxim* of Graham. Beginning with bisecting the circle, he has, by his mode of examination, without a change, followed the principle through eight successive courses. The action of the roller is stepping, notwithstanding that it consists of the exactest species of contact, and closes without a remainder; and so fully is he aware of this, that 256 checks are employed. As far as the examination and computation is carried, Troughton's method, for aught we know, may be as tedious as any other; but, by the contrivance of combining his subdividing-sector with the roller, he throws the quinquisections and trisections altogether into a species of engine dividing, and thereby reduces the remaining part of the work to a labour little surpassing that of cutting the divisions.

Mr Thomas Jones succeeds in dividing a circle by Mr Troughton's method.

After the above paper was published, several gentlemen were of opinion, that the celebrity of Troughton's graduation was owing more to the hand and eye of the artist, than to the method by which it was effected. Troughton, it will be remembered, in one part at least of the paper, expresses himself of a contrary opinion; and, to shew that he was not mistaken, we insert the following letter, which was addressed to him by a rising artist, who is not too conceited to profit by the skill and experience of a veteran in the art:

Letter from Mr Jones to Mr Troughton.

Dear Sir, "Charing-Cross, 15th July, 1813.

Having now performed the graduation of a circle by your method, I take the liberty of addressing to you the following lines upon the subject. The method which was used at Mr Ramsden's was, before your's appeared, considered as the best. I learned it in the course of instruction, and practised it with patience and perseverance, for it requires much of both. I may, therefore, be allowed to consider myself a competent judge of the two methods; and, without presuming more than becomes me, give an opinion concerning them. From various motives, I feel great pleasure in saying, that *dividing by the eye* is greatly preferable to the other method; the saving in time is very great, and accuracy in the result certain. With these properties, which it possesses in the first degree, were I debarred from using it in future, I should return to the old method with the greatest reluctance. I do not hesitate to say, that I feel myself equal to the dividing of a circle with a degree of accuracy equal to any one except yourself, (nor do I think I should be very far behind you); and I shall solicit that practice, which alone can make me quite your equal in the art. With many thanks for your liberal communications upon this as well as other subjects, I am, Dear Sir, your most sincere and obliged

To Mr Edward Troughton. THOS. JONES.

Mr Cavendish's proposed method of graduating instruments.

A paper by the late Henry Cavendish, Esq. called "An improvement in the manner of dividing Astronomical Instruments," was published in the second part of the *Phil. Trans.* for 1809. Mr Cavendish introduces his improvement in the following words:

"The great inconvenience and difficulty in the common method of dividing, arises from the danger of bruising of the divisions, by putting the point of the compass into them, and from the difficulty of placing that point mid-way between two scratches very near together, without its slipping towards one of them; and it is this imperfection in the common process, which appears to have deterred Mr Troughton from using it, and thereby gave rise to the ingenious method of dividing described in the preceding part of this volume. This induced me to consider, whether the above-mentioned inconvenience could not be removed, by using a beam compass with only one point, and a microscope instead of the other; and I find that in the following manner of proceeding, we have no need of ever setting the point of the compass into a division, and consequently that the great objection to the old method of dividing is entirely done away."

Mr Cavendish's proposed method of graduating instruments.

To this end, Mr Cavendish proposes to have a frame for supporting his beam compass, that shall rest upon the circle to be divided, and which, by bearing against the edge of the latter, may be turned round without altering its distance from the centre. The figure of this frame is triangular, and nearly as large as the circle itself. One of the angles is placed outwards, and the opposite side forms a chord of about 150° to the circle. One end of the beam compass is attached to the outer angle of the frame by a vertical joint, round which it may be turned from one side to the other at pleasure; and the joint must be moveable in the direction of the radius, in order that the beam may be adjusted, so as to form the chords of different arcs. At the opposite end of the beam is a fixed point, wherewith faint arcs are to be cut across the line of division, and with which the divisions themselves are finally to be made. There should be a groove or slit cut out all along the beam, in which a double microscope with cross wires is to slide, and which may be fixed at any required distance from the point. Two props, one to the right and the other to the left, are to support the end of the beam opposite to the joint in the two positions.

With this apparatus, Mr Cavendish shews how to perform the different operations required in graduating an instrument, namely, to bisect, trisect, and quinquisect; but does not follow the subdivision through their repeated courses.

In the bisection of an arc, the distance between the point and the axis of the microscope, is to be taken as nearly as may be to the chord of half the arc, and the joint adjusted, so that the cross wires and point may both at the same time coincide with the line of division. With the beam to the right, by moving the frame upon the circle, the wires of the microscope must be brought to coincide with the point that marks the left boundary of the arc, and then a faint mark across the line of division must be cut with the point. The beam is next turned to the left, and the point which bounds the arc on the right, is by turning the frame to be set to the microscope, and another mark across the line made as before. It is evident, that if the opening between the microscope and point was exactly equal to the chord of half the arc, the two marks would coincide upon the line of division; but if that opening was too great or too little, the marks would cut each other without or within the circle. But in neither of these cases would Mr Cavendish put in a dot. Instead of which, when in subsequent division these marks are to be used, as well as when the final strokes are cut, he would place the wire of the microscope by estimation in the middle between them, where they cut the line of division.

In quinquisecting an arc, the opening being taken as near as possible, equal to the chord of a fifth part of it, bring the microscope to one extremity of the arc, and with the point make a mark across the line; bring the microscope to the mark just made, and with the point make another mark, &c. until four are put in; change the position of the beam, and from the other extremity of the arc set off four marks as before. If the chord in the above operation was not correctly taken, it is evident that there will now be four double marks, and the spaces between them equal to each other, and five times greater than the error of the opening. The real point of quinquisection, reckoning from one end of the arc or

Original Graduation.

the other as the opening, was + or —, will be $\frac{1}{5}$, $\frac{2}{5}$, $\frac{3}{5}$, and $\frac{4}{5}$ of the space between them; and these Mr Cavendish would also use by estimation in the subsequent progress of the work. Mistakes in making a wrong estimation of the spaces are to be prevented, by making proper marks upon the circle opposite to them. Mr Cavendish has given three different ways of proceeding; but that which we have described, is the one which he himself thinks the best.

To give a general idea of Mr Cavendish's method was all that we intended. To follow him through his whole paper would be useless; for, notwithstanding that much ingenuity is displayed in pointing out such errors as he foresaw it would be liable to, and in contriving means to obviate them, we consider it as altogether inconsistent with practice, and inelegant in design.

Mr Lax's proposed method of examining the divisions of astronomical instruments.

Immediately after Mr Cavendish's paper, we find one by Professor Lax of Cambridge in the form of a letter to Dr Maskelyne. It is entitled, *On a Method of examining the Divisions of Astronomical Instruments.*

The learned professor sees no reason why astronomers should trust to the ability and integrity of artists, when, by means of a proper apparatus, they have it in their own power to examine and note the error of every division of an instrument. Mr Lax is in possession of an altitude and azimuth circle, of one foot radius, made by Mr Cary, and it is to this instrument that his examining apparatus is adapted; but the computation of error is expressed in general terms.

His apparatus consists of an arc fixed to the frame of the instrument, exterior to, and concentric with, the circle, and which stands still while the circle is turned round. The arc contains about 90°, and a microscope, which slides upon it from end to end, may be clamped to any part of it. The microscope regards the divisions of the circle, and is used in combination with one of the reading micrometers: the former has an inclination of about 30° to the latter, in order that both of them may be made to coincide with one and the same division of the circle; by means of which contrivance, any opening between them from 0 to 90° may be taken. Professor Lax finds the error of the division 180° by help of the two reading micrometers, exactly as Troughton did, but in every other step the examination is carried on in a way quite different from that pursued by the artist.

The second step is performed when zero of the circle is brought to one of the micrometers, and the microscope fixed to the exterior arc at the division 90°, by bringing in succession to the microscope the divisions 180°, 270°, and 360°, and comparing the first arc of 90° with the other three arcs of 90°, the difference of which having been measured with the micrometer, and distinguished by + or — affords data for computing their respective errors. In like manner, the first arc of 60° is to be measured against all the other five arcs of 60° precisely as the first arc of 90° was measured against all the other arcs of 90°. And again, the first arc of 45° is to be measured against all the other seven arcs of 45°. So far the Professor proceeds before sunrise, in order to avoid the effect of expansion; the rest, on account of the small arcs that are used, may be done at any time. The arc of 30° may now be measured against every succeeding arc of 30° in the first, third, fourth, and sixth arcs of 60°; and let the length be determined from a separate comparison with the arc of 60° in which it is comprehended, and not from a general comparison with all the four. The arc of 15° must then be measured against every succeeding arc of 15° in all the arcs of 30° except the second, fifth, eighth, and eleventh, and the value of each deduced from a comparison with the arc of 30° in which it is contained.

We will follow Professor Lax no farther in his ingenious and laborious examination; suffice it to say, that, by pursuing the same principle of comparing short arcs with their multiples, he obtains the errors of every individual division of his circle, down to the ten-minute spaces into which it is graduated.

Mr Lax says, that with his microscopes and his circle of one foot radius, he cannot commit an error greater than three quarters of a second in reading off, and with this datum and that of the number of times that some divisions have been dependent upon previous examinations, he reckons upon a possibility of error in extreme cases amounting to 9″.63. This is a very large quantity: the truth however is, that the examiner not only under-rates the ability and integrity of artists, but also the powers of his own method. To make out the above quantity, Mr Lax is obliged to suppose, that at every step he commits the greatest possible error, and that, in every course, the error lies in that direction which produces the greatest accumulation. After the examinations have been completed, and the calculations made, the Professor says:

"The time and labour required for this examination are no doubt very considerable; but it ought to be recollected, that it will render any great degree of precision, in dividing the instrument, totally unnecessary. Whoever, indeed, employs this method of examination, will be virtually the divider of his own instrument; and all he will ask of the artist, is to make him a point about the end of every five or ten minutes, whose distance from zero he will determine for himself, and enter in his book, to be referred to when wanted. We may likewise observe, that, by this examination, we shall not only be secured against the errors of division, but against those that arise from bad centring, and from the imperfect figure of the circle, and which, in general, are of too great a magnitude to be neglected."

Remarks on Mr Lax's method.

Now, the greatest part of all this is certainly very true; yet we doubt if astronomers in general will not save themselves the expence of the apparatus, and the trouble of performing the work; and we think that they will continue, as heretofore, to demand of the artist the utmost exertion of his talents.

Professor Lax has shewn the analogy between his method of examination and that of observing by repetition, as much practised abroad, which is but another way of reducing the errors of dividing. As, however, things do not easily get out of their usual course, we are of opinion, that the paper under consideration will have no tendency to relax the efforts of the artists of this island to approach the point of truth, any more than the improvement of the art of graduation will, upon the continent, supersede the use of the repeating circle.

We are not satisfied with the inclining microscope. In order that this should occasion no error, the plane which bears the graduation should be almost a miracle of truth. Were the microscope so fixed as to be capable of being inclined as much the contrary way, the effect of parallax would be contrary too; and if a succession of the same angle were repeated in both positions of the microscope, an identity of results would prove our doubts to be groundless, or a disagreement between them shew the thing we are afraid of.

Captain Kater's proposed method of dividing astronomical circles.

In the second part of the *Phil. Trans.* for the year 1814, we meet with a paper by Captain Kater: it is called, "An Improved Method of dividing Astronomical Circles, and other Instruments."

Original Graduation.

To give a general idea of this method, which is itself ideal, is all that we think necessary; and with it, and a general remark or two, we shall close our article.

Captain Kater's proposed method of dividing astronomical circles.

This method is extremely like that of the Duc de Chaulnes: the chief difference between them is, that, instead of the waxed pieces, Captain Kater proposes to perform the work by means of two pieces which are to be clamped upon the circle to be graduated, and adjusted to their places each by two appropriate screws. He would use three double microscopes, one plain with cross wires, the other two with micrometers: they are to be applied to an exterior arc exactly like that which Professor Lax used in the examination of his circle. Captain Kater leaves the manner of fixing the arc to the frame of the instrument, to the ingenuity of the artist, who may practise the method; a task by no means easy, considering the stability that would be required. The cutting-frame of Hindley is to be used, which, being properly placed at one extremity of the exterior arc for tracing the divisions, the plain microscope should be fixed over the tracer, and adjusted to a line drawn with it exterior to the circles which are to bound the length of the divisions: this is called the line of verification. The fixed microscope not only regards this line and a dot upon the cutting apparatus, but also assists the eye in tracing the divisions. This is altogether a good contrivance; for by it the stability of the several parts may be examined at pleasure, and, if necessary, rectified. The two micrometer microscopes are also applied to the exterior arc, and have a range upon it from contact to a distance of one-fifth part of the circle. After being clamped, they have each a screw-adjustment in the line of the radius, and the adjustment for the correct angular opening is found in the micrometer wire.

Remarks on Captain Kater's method.

Captain Kater would first divide the circle into five equal parts, then trisect each of these, and then would perform another trisection. This is not the course that an artist would take: his instruments are to be read off at opposite divisions, and he would not toil through the most difficult part of the work without a trial. De Chaulnes, in the first instance, bisected the circle, and whatever course he afterwards followed, every division would have its opposite; but Captain Kater's scheme admits of no opposites until his arcs of 8° are bisected. The Duke, in every subdivision, left waxed pieces at every step of an interval, which he could examine again and again, before he cut the divisions. But Captain Kater, by using but two adjustable pieces, deprives his method of that advantage; for, in order to obtain a proper opening between the microscopes, the two pieces are set alternately in advance of each other, and a blank space is left behind.

In all operations of this kind, there is a certain space that one may either see or not see, and which Mr Lax, in his circle of one foot radius, which is the same that Captain Kater proposes to divide, states to be three quarters of a second. Now if, at the time that the opening of 72° for quinquisecting the circle was adjusted, a succession of five + errors to that amount were committed, the circle would appear to be equally quinquisected, by an opening of ″.75 — its proper measure. And with this error of opening in the similar operation for cutting the divisions, let it be supposed, that at each step of shifting the adjustable pieces, a — error to the same amount were committed, then it is evident, that the division 288° would err by a quantity $8 \times {}''.75 = 6''$. This is Professor Lax's way of reckoning the amount of error, which is indeed too severe; but, in the case which we have exemplified, there is nothing improbable in the supposition, that the error might amount to more than half that quantity, and yet neither the apparatus nor artist be at all to blame. Captain Kater observes, that errors, if any, would be seen: True; but divisions have been cut, and what is to be done with them? They are of course to be rubbed out, and a trial again made, in hopes of better luck.

Original Graduation. Remarks on Captain Kater's method.

Besides this, the method before us is still farther very objectionable. A division, when cut, whatever its error may be, communicates that error to others made from it, through every course of subdivision; and thus the sins of the fathers are visited upon the children down to the seventh generation.

There is another thing that is not adverted to by Captain Kater: no division can be viewed by the microscopes, to any useful degree of accuracy, until the *bur* is polished off; and the frequent recourse that must be made to this operation, which could not be done without carrying the circle round, to get it out of the way of the apparatus, would prove a source, not indeed of inaccuracy, but of very much embarrassment and delay. It may be observed, that the method of coaxing is fully as much liable to this objection, and that Troughton's is the only one that is perfectly free from it.

Captain Kater's apparatus is the most complex, and, if made, would be the most expensive, that has been either used or proposed for graduating; and we should remark, that the method would turn out to be extremely tedious. The Captain expresses himself upon both these matters as being of quite a different opinion: we are not surprised at this, considering, as we do, how much faster the nimble ideas of a speculator get on, than the fumbling fingers of an artist.

Observations on theoretical methods of graduating.

The gentlemen graduators have one and all rejected the *maxim* of Graham: they know that it is not geometrically true, and to what extent it is practically so are perhaps incapable of judging. The bisection of an arc, as Graham meant it to be understood, consisted in setting off the chord of half that arc from left to right, and then from right to left. It was a condition, that the points of the beam-compass should be so sharp, short, and strong, that they would not be deflected towards the arc struck in the first position, when that in the second was made, even were the distance between the points somewhat erroneous; for, in this case, the line of division would only be intersected by a broader stroke, which would still occupy the mean distance. Graham would have said, that this kind of bisection continually halved the error; while that of the gentlemen, which he would have denominated stepping with the chord of half the arc, was continually extending it. As division by three, five, &c. cannot be performed without stepping, Graham pronounced them to be practically impossible.

It is our opinion, that the art of graduation is now in a state not to be improved by any one who is not a practitioner. Those who excel in the highest branch, are men capable of thinking for themselves, and of course, for improvement, will naturally look inwards. On the other hand, the effusions of gentlemen can do no harm, for their schemes will ever be inconsistent with practice. Should they, which is possible, suggest an useful hint to the practical man, it ought to be accepted with gratitude; and, at any rate, their well-meant endeavours should be kindly received. With this view before us, we think, that when the real graduators of instruments shall be incorporated into a society, Professor Lax should be chosen an efficient member; that Captain Kater ought to be admitted an honorary one; and that we ourselves, after all this, may look up to the latter distinction.

GRAFTING. See HORTICULTURE.

GRAIN. See AGRICULTURE and CORN LAWS.

GRAHAM, JAMES, *Marquis of Montrose*, an eminent soldier in the reigns of Charles I. and Charles II. and distinguished by his enterprises against the Covenanters in Scotland.

Having been treated with some disrespect by the King, Charles I. he was at first attached to the cause of the Presbyterians, and supported them in their endeavours to secure the civil and religious liberties of the nation. It has been questioned, indeed, whether he was sincere in this attachment; and it must be owned, that, in the early part of his life, his conduct had every mark of duplicity and perfidy. Even his panegyrists have allowed, that his intercourse with the Presbyterians was that of convenience, not of inclination; that he enrolled himself in their armies, and held conferences with their divines, in order to be admitted into their secret counsels; and that having obtained the intelligence which he required, he made use of this intelligence against the very party whose confidence he had enjoyed. The facts are certainly strong. At one time he was entrusted with a high military command among the Covenanters, and actually passed the Tweed at the head of their troops; and the historian of England assures us, that, at this very time, he had entered into a close correspondence with the partizans of the king. At length, after a course of perfidiousness, unworthy of his illustrious birth, and, it must be acknowledged, altogether at variance with his general character, which appears to have been that of manliness and heroism, he disclosed all he knew of the purposes of the Presbyterians, and openly declared his attachment to the royal cause. Such, however, was his vacillation, to give it no other name, that Charles himself was for some time unwilling to trust him; but having succeeded in detaching the Hamiltons, who were his political antagonists, from the confidence of the monarch, he rose in the royal estimation, and was at length appointed lieutenant-general of the king's forces in Scotland.

Yet he who deserted the cause of liberty and of true religion, and betrayed his countrymen, proved faithful to his king. He had taken upon him, however, as Burnet expresses it, the post of a hero too much. With very inadequate means, and relying chiefly on his personal prowess, he undertook to subdue the Presbyterians by force of arms. And, at this time, the Presbyterians were not, in strict language, a party in Scotland; they constituted the strength and the talent, the energy, physical and intellectual, of nearly the whole nation; they were united in the cause of religion and of liberty, bound by a public and solemn engagement to adhere to it with their fortunes and their lives, supported by the English parliament, confident in the purity of their intentions, and not without encouragement from previous success. Yet while all this must be allowed, the progress of Montrose, temporary and partial as it was, may serve to shew how much may be atchieved by the enterprise of one man's mind, and the effort of a single arm.

His first concern was to draw around him those of the Scottish nobility, who were either more attached to the king, or less intimately connected with the Presbyterians. Among the persons of distinction who joined him on this occasion, historians have not failed to mention the Lord Napier of Merchieston, son of the celebrated inventor of the logarithms; the Earl of Antrim, a nobleman of Scotch extraction, and who brought into the field a body of the Macdonalds who had served in Ireland, and the two sons of the Marquis of Huntly. To these we might have added the Marquis himself, the chieftain of the powerful clan of the Gordons; but the Marquis had studied astrology, and had learned from the stars, that neither the king, nor the Hamiltons, nor Montrose, should prosper. According to Burnet, he was naturally a gallant man, but the stars had so subdued him, that he made a poor figure during the whole course of these wars. Discouraging as the prospect appeared, Montrose, or as he was usually called, "the Graham," was in haste to take the field. Joining himself to the Macdonalds, and about eight hundred of the men of Athol, who had flocked to his standard, he prepared, with incredible activity and expedition, to attack the Lord Elcho, who lay with a considerable body of troops in the neighbourhood of Perth. No general, either of ancient or of modern times, was ever more rapid in his marches, or more fierce in his onset, than the Marquis of Montrose. Though inferior in numbers, destitute of cavalry and of artillery, and so ill furnished with ammunition that he was obliged to answer the discharges of the enemy by a volley of stones, he assailed the Covenanters with such unexpected fury, that he threw them into disorder, pushed his advantage, and gained the victory; he himself combating with his broad-sword among the foremost of his troops, and animating them by his example. The slaughter of the Presbyterians was great, amounting, by some accounts, to two thousand men; and the town of Perth opened its gates to Montrose, in consequence of the battle. On this occasion, he had an opportunity of proving his clemency, a quality which entered largely into the formation of his character, and to which he made a consoling allusion when about to prepare for the scaffold; for he took possession of the town without injuring its inhabitants, and restrained even the Highlanders from their well known propensity to plunder.

But if the town of Perth experienced his clemency, he let loose all the rage of predatory warfare upon the country of the Duke of Argyle and the estates of the Hamiltons; the former, a leading man among the Presbyterians, and the personal enemy of Montrose, and the latter his rivals in the favour of the king. At the head of the Macdonalds and the Irish, he attacked Argyleshire with the ferocity of a Tartar, carrying off the cattle, in which the wealth of the inhabitants consisted, burning the houses, and wherever he met with opposition, putting men, women, and children to the sword. His panegyrist Wishart informs us, and informs us without apology or remorse, that he sent out his troops "to kill and to destroy." In these expeditions, the life of "the Graham" was frequently in danger. He was constrained to make very long and fatiguing marches, often in the night and in the depth of winter, through a mountainous and pathless district; and he was opposed by the Campbells, the hereditary enemies of his name, warm from the effects of recent aggression, and equally active and revengeful with the other clans of the north. These, however, were antagonists that might be encountered, or sufferings that might be endured; but the age was barbarous, and he seems not to have perceived that he had tarnished the lustre of his achievements by the rapacity of a free-booter. And what was still more to be regretted by the royalists, he had suffered his numbers to be diminished without rendering any essential or lasting service to the cause of the king.

We must refer our readers to the author of the *Memoirs of the Marquis of Montrose*, for a particular account of his expeditions and battles. Early in the spring of 1645, he carried the town of Dundee by assault, and gave it up to be plundered by his soldiers. In the same year he defeated Urrey at Auldcorne, and Baillie at Alford. But it was at Kilsyth that he performed one of his greatest atchievements, and raised his character as a soldier. The battle of Kilsyth was fought on the 15th of August 1645. The forces on both sides were nearly equal, but the character of the troops was not exactly the same; those of the Covenanters being, for the most part, newly raised, while the followers of "the Graham" had been disciplined under his immediate inspection, and accustomed to the field. The Presbyterians were commanded by General Baillie, the same officer who, in the month of July preceding, had been constrained to yield at Alford; and he was assisted, on this occasion, by the Earls of Crawford and Airly, Sir William Murray of Blabo, Colonels Dyce and Wallace, and other adherents of the popular party. It is said that Baillie was displeased with the quality or the condition of his troops, and engaged with reluctance. The action commenced by an attempt of the Covenanters to dislodge a small party, which Montrose had stationed near some cottages in the vicinity of Kilsyth; but the assailants were very warmly received, and at length driven back with considerable loss. At this moment, a body of Highlanders, amounting to 1000 men, without waiting for orders, rushed furiously upon the Presbyterians; these were supported by the Earl of Airly, at the head of 2000 of the infantry, and three troops of horse. The rest of the army imitated the example of Airly and the Ogilvies; the ranks of the Covenanters were broken; no effort of their generals could restore them to order, and a complete rout ensued. Six thousand of the Presbyterians fell in this memorable action; and, in one disastrous day, the cause of religion and of independence was left without the aid of any regular army in Scotland.

After the victory at Kilsyth, Montrose appears to have been elated beyond what we should have expected in so great a commander, and certainly beyond the amount of the essential and profitable service which he had performed. Though he was not in possession of any of the strong holds, or important passes, he wrote to the king as if the whole country had submitted. In those days, both parties made an indiscreet use of the language of scripture; and with improprieties of this nature Montrose is justly chargeable, as well as the chieftains of the covenant; though, if we were to consult the most popular history of the period, we should be led to believe that the practice was peculiar to the Presbyterians. He assured his Majesty that he had over-run the country, "from Dan even to Beersheba;" and prayed the king to come down, in the words of Joab, the Hebrew leader, originally addressed to king David, "now therefore gather the rest of the people together, and encamp against the city, and take it, lest I take the city, and it be called after my name."

The fortunes of Montrose now began to decline. Having advanced, upon some insufficient encouragement, towards the English border, he attempted in vain to rouse the Earls of Hume, Traquair, and Roxburgh, and to animate them in the royal cause. He was deserted likewise by his own troops; for the Highlanders, unaccustomed to a protracted course of military service, had retired to the hills, in order to secure the plunder which they had obtained. He was, moreover, extremely deficient in cavalry. In these circumstances, "the Graham" was met by Lesly, the general of the Covenanters, who had been detached from the army in England; and at Philiphaugh, in Ettrick Forest, the royalists were defeated in so tremendous and so fatal an overthrow, that they were never afterwards able to make head against their antagonists. Montrose, though worsted in the issue, did every thing which experience could suggest, or bravery could fulfil, but the assault of Lesly's cavalry was not to be withstood. Some say that "the Graham" had become careless, in consequence of his success, and that he had allowed himself to be taken by surprise; and, perhaps, he had dreamt of vanquishing the Covenanters by what his followers were wont to call *the terror of his name.* But whatever truth there may be in these surmises, it is certain that he was compelled to fly with his broken forces into the mountains, and to prepare with more leisure than suited his character for new battles and enterprises. His life was now little else than a series of misfortunes. During the progress of the English parliament, he quitted the kingdom; and some time previous to the arrival of Charles II. in Scotland, he made one other unsuccessful attempt to restore the monarchy by force of arms.

Some prophet of the Royalists had assured him, (for the Royalists had their prophets as well as the Covenanters,) that to him, and to him alone, it was reserved to restore the king's autherity in all his dominions; and he eagerly listened to an intimation which agreed so well with his enterprising genius. But, notwithstanding this augury, he was defeated by Strachan, one of Lesly's captains, and taken prisoner after the battle, in the disguise of a peasant, "having thrown away his cloak and the star upon it."

The Covenanters made a rigorous use of the victory, and treated their illustrious captive with a degree of insolence which can find no other apology than the barbarism of the period in which they lived, and the treacherous manner in which he had deserted them. He was brought to Edinburgh under every circumstance of elaborate indignity; and after a trial before the Scottish parliament, during which he conducted himself with the utmost presence of mind, and with a magnanimity which his enemies were constrained to admire, he was sentenced to lose his life by the hands of the public executioner; and with a lofty composure, and using some pious ejaculations, he submitted to his fate. Thus was closed, at the age of thirty-five, the career of James Graham, Marquis of Montrose, a man unquestionably of a most noble and heroic character, bold, active, and for a time successful. All history unites in recording his atchievements, and in celebrating his valour: but he was brave in the hour and in the tempest of the battle, rather than skilful in forming the plan of a campaign. He took up arms against the Presbyterians, without a prudent estimate of his means. And it may be doubted whether, with all his courage and all his activity, his exploits were of any service to the cause of the king. It has been said that he was no stranger to elegant literature; but while every one allows that the verses which he composed on the evening before his death may be regarded as proofs of the serenity of his mind, there are few who will be ready to acknowledge them as a very favourable specimen of his attainments in the poetical art. One foul spot remains upon his character; he be-

Graham of Claverhouse.

trayed the cause of liberty, and the friends of his early life; if, indeed, it be not a fouler and more indelible stain, that he continued through a series of heroic endeavours, the champion of a cause which had for its object to establish an unlimited power in the nation, and to force, by a military apostleship, an abhorred religion, upon the acceptance of the Scottish people. See Wishart's *Memoirs of Montrose;* Hume's *History of England,* vol. x. xi.; Principal Baillie's *Letters and Journals,* vol. ii.; Burnet's *Own Time,* vol. i.; and Fox's *History of the early part of the Reign of James II.* (*h*)

GRAHAM, JOHN, of CLAVERHOUSE, *Viscount Dundee,* a celebrated military character who flourished in the latter part of the 17th century, was descended from the noble family of Montrose in Scotland. Being of an ardent mind, and animated from his earliest years by the study of the poets and orators of antiquity, as well as by the traditionary songs of the Highland bards, he entered early on a military life, and served in the Low Countries, against the French, in the war of 1672. At the sanguinary battle of Senex, he was instrumental in saving the Prince of Orange's life, and he afterwards made application for the command of one of the Scotch regiments in the Dutch service. The request was premature, and was consequently declined by the Prince of Orange, on which Dundee withdrew from the Dutch service in disdain. Returning to Scotland, he obtained a regiment from Charles II. and distinguished himself by his services against the Covenanters. From James II. he obtained a title, and high command in the army. Having been accused of cruelty in his operations against the Covenanters, he pleaded in excuse, that "terror was true mercy, if it put an end to or prevented war." It was after the flight of James II. and the consequent proceedings in Scotland, on the subject of his abdication, that Dundee became chiefly conspicuous. From his cruelties against the Presbyterians or Covenanters, in Scotland, "a poor people, made desperate by the violence of their persecutors;" he is still spoken of in the western counties under the designation of the Bloody Claverhouse. In the year 1679, he marched with a party of dragoons, in order to disperse a meeting of the Covenanters, at Loudon-hill, in Ayrshire. It was a day of peculiar solemnity, when the sacrament of the Lord's supper was to be administered; a great multitude, amounting, as Defoe assures us, to many thousands, had assembled from different parts of the country; and the people sat upon the ground, on the side of a steep hill, while one of their ministers preached to them from a little *tent* placed at the bottom. As was usual and necessary in those troublous times, a considerable proportion of the audience were provided with arms. When Claverhouse approached, these last withdrew to a short distance from the body of the congregation, and waited in good order for the assault of the king's troops. A close and furious engagement took place at Drumclog; the dragoons, advancing hastily, and without the requisite precautions, were surprised when they found an enemy well prepared to receive them; and the Covenanters, after maintaining their position for a while, pressed forward against the royal forces, and compelled them to retreat. Claverhouse himself had his horse shot under him, and escaped with difficulty. But the victory, which was far from being decisive, was dearly bought on the part of the Presbyterians. For soon after, being collected in greater numbers, and joined by Hamilton of Preston, and other gentlemen of the west, they ventured to oppose the king's troops under the Duke of Monmouth, in the well-known action at Bothwellbridge. Previous to this action, however, dissensions had crept in among them; they were deficient likewise in the subordination and discipline, without which it is impossible to resist the attack of a trained and constituted soldiery; and in addition to all their other wants, they were ill provided with arms, and especially with artillery. The consequence was, that the royalists made themselves masters of the bridge at the very first onset, and drove the Presbyterians before them with a great and indiscriminate slaughter. It is true the Duke attempted to restrain the fury of his troops; but the inferior commanders, Linlithgow, Mar, Hume, and Claverhouse, disregarded the orders of their General, and shewed no symptom, either of pity or of remorse, in the pursuit of the discomfited Presbyterians.

But the cruelties of Claverhouse did not terminate with the battle of Bothwellbridge. What Burnet says of Dalziel may be affirmed of this commander, with equal, or perhaps with greater, truth; that he acted the Muscovite too grossly, threatening to spit men and to roast them alive. A whole year after the battle was spent in attempting to discover those who had been present at Bothwell, and in putting them to death, or otherwise punishing them. Many were slaughtered in cold blood; many were shot because they would not acknowledge the *rising,* (as the Covenanters called it), to be rebellion against the king; not a few were put to death upon their knees, declaring that "they were no way concerned in the Bothwell affair," and recommending their souls to the mercy of heaven. Trials, and juries, and regular proof, were rejected as impediments to the king's service. The prisoners were simply asked whether they owned the rising at Bothwell to be rebellion; and if they hesitated, or answered ambiguously, they were instantly shot. Even the private soldiers were authorised to ask such questions, and to inflict the punishment. Children were tortured in order to force them to discover where their parents were concealed; wives were constrained to lead the soldiers to the retreats where their husbands or near relatives had taken refuge; and young and tender women were stript naked, and thrust out into the cold. There being a great majority in the Scotch Convention on the side of William, Dundee took the determination of withdrawing, and of exerting himself to serve the cause of James in the field. He left Edinburgh with a troop of 50 horsemen, after in vain urging the Duke of Gordon to accompany him to the Highlands, and raise his numerous vassals in the cause of the Stuarts.

In the beginning of May 1689, Dundee openly took up arms in the neighbourhood of Inverness, and exerted himself with so much activity, that his force increased to 6000 men. As a descendant of the Marquis of Montrose, he was the object of much attachment on the part of the Highlanders, some of whom even forsook their family leaders to fight under his orders. King William dispatched General Mackay against him, at the head of a regular force, and two months were passed in great impatience by Dundee, in consequence of orders from King James not to fight until the arrival of a large force from Ireland. During this interval, Dundee was obliged, from deficiency of provisions, to shift his quarters continually, and he performed very extraordinary marches. His men were exposed to frequent privations, but disdained to complain, when they saw their commander living on the same coarse fare with themselves.* When he acted offensively, his approach was so rapid, as generally to outrun the notice of his movements; and in retreating, he was commonly out of reach before the enemy was apprized of his intention. His followers were chiefly Highlanders from the interior, and were extremely impatient of delay in fighting. It proved on all accounts matter of regret, as the reinforcement from Ireland, on arriving at last in the end of June, was found to consist of only five hundred raw and spiritless recruits. General Mackay had now determined to march through Athol, and attack the Castle of Blair, which had been taken by Dundee, and by him put into the hands of one of James's adherents. Dundee, aware that the loss of this place would interrupt the communication between the two divisions of the Highlands, determined to bring on the long delayed conflict, and marched southwards with a force considerably diminished, many of the Highlanders having returned home to get in their fuel for the winter. In marching northwards, General Mackay had to go through the pass of Killicrankie, a pass consisting of a road, where for two miles not more than six or eight men could, at that time, go abreast. On the one hand are steep and rugged mountains; on the other, a precipice hanging over a deep river. Dundee declined to occupy this pass, or to obstruct the advance of the enemy, but determined to fight after Mackay had reached the northern side, in the hope that he might defeat him, and cut off his retreat by obstructing the pass. Mackay's army marched from Dunkeld in the morning of the 16th of July; and after resting at the mouth of the pass, marched through it about noon. Arriving at the open ground on the farther side, they saw Dundee's soldiers resting at a distance on the side of a hill. Mackay drew up his men in order, and wished to bring on the engagement without delay; but Dundee knowing that night would be of advantage to the Highlanders, whether successful or defeated, delayed the attack till half an hour before sunset. At that time he made his men rush down from their station, and begin the attack in a series of small columns on the wings of the enemy, on the calculation that this mode of onset was most likely to bring on an action hand to hand, in which he was certain of the superiority of the Highlanders. Such had been the disposition of the Marquis of Montrose at the battle of Alderne. Dundee's plan was completely successful; his columns piercing, though not without considerable loss, through the opposing line in many places, and taking the soldiers in the flank and rear, in a manner wholly unexpected by regular troops. Of all Mackay's men, in number 5000, the centre only, consisting of a regiment and a half, retreated in good order. The rest fled in confusion; and Dundee having mounted on horseback, pushed forward to point out to his men the manner of cutting off the retreat of the enemy at the mouth of the pass. Perceiving in a little time that he had got a head of his followers, he stopped and waved his arm in the air to make them hasten their pace, pointing with his hand to the pass as the object of their exertion. Being thus rendered conspicuous, he became an object of aim to some of the enemy's soldiers, and a musket ball found entrance beneath his arm pit, in an opening of his armour, occasioned by the elevation of his arm. He rode off the field, after desiring his misfortune to be concealed; but no precautionary orders could make up for his absence, as the Highlanders, on falling in with the enemy's baggage, gave over the pursuit, and betook themselves to plundering. The remains of Mackay's army consequently effected their escape, though with a loss of 2500 men. The loss of the Highlanders was nearly 900. Many of the fugitives were killed or taken by the Athol men, whom Dundee had the day before ordered to be in readiness at the south end of the pass. Mackay not daring to venture through it, took his course through the hills to the westward, whence looking back, and seeing no regular pursuit, he said to those around him, that he was sure the enemy had lost their general. A similar observation was made by King William, who hearing that the express sent to Edinburgh with the account of the defeat had been detained a day on the road, exclaimed, "then Dundee must have fallen, for otherwise he would have been at Edinburgh before the express." Some days after, when William was urged to send a strong detachment of troops to Scotland, he replied, "It is unnecessary; the war has ended with Dundee's life." After riding off the field, Dundee had still strength sufficient to write an account of the action to King James. In this dispatch, he anticipated a general insurrection in the country in favour of the absent sovereign; an attempt in which Dundee might have obtained a degree of success similar to the Marquis of Montrose, had he been spared to follow up his victory. His wounds, however, were mortal, and he expired the next morning.

Though the Highland army was kept together, and even descended during the next two years into the low country, nothing of importance was accomplished, and as William had predicted, there was little difficulty in concluding a peace.

The estate of Lord Dundee was made over, after his death, to the house of Douglas; and his widow marrying again, and retiring to Holland, became, along with her children, the victim of a dreadful misfortune; the house in which she resided at Utrecht falling suddenly in, and overwhelming the whole family in a few moments. The title of Dundee has not been revived since the death of this distinguished commander.

See Wodrow's *History of the Church of Scotland*, vol. ii. p. 1; Defoe's *Memoirs*, p. 197; Swift's *Life of Captain Creichton*, p. 298.

GRAHAME, James, best known as the author of *the Sabbath*, was the son of Mr Thomas Grahame, a highly respected writer, or attorney, in Glasgow. He was born on the 22d day of April 1765. The peculiar mildness, and the religious cast of his character, and of his pursuits in the latter part of his life, may be traced back to his training in infancy and youth, by a father and mother who were distinguished for their warm and enlightened attachment to Christianity, and for their chastened cheerfulness of temper and manners. Grahame's minute and delicate discernment of the beauties of nature, and his delight in observing all those nicer shades, which are unnoticed save by the contemplative eye and the feeling heart, probably had their source in his holiday enjoyments on the picturesque banks of the Cart. He and his elder brother were accustomed to pass, at his father's summer residence, in this sweet retirement, those hours which are distinguished from all the other hours of life, by admitting not only of cessation from study, but of carelessness of the past and future, mingled with the gay and ever-varying illusions of juvenile fancy. His education was begun at the

* He was accustomed to march on foot with his men, at one time by the side of one clan, and afterwards by that of another, displaying his knowledge of their genealogies, and reciting the deeds of their ancestors.

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grammar school of his native city, where he was distinguished more for playfulness, than for brilliancy of talents; and where he evinced a disposition to frolicsome sprightliness, which gave little promise of the thoughtful and retired character of his manhood. From the school, he passed to the university of Glasgow, which he attended for five consecutive sessions, during the two last of which he studied the theory of law and government under the celebrated Professor Millar, from whom he imbibed that enthusiastic love of freedom, and that warm attachment to the constitution of his country, especially the popular part, which formed a distinguishing feature in his character through life. This attachment to the cause of freedom, induced him at first to take a warm interest in the success of the French revolution, and led him at a later period of his life, with honourable consistency, to express his detestation of that spirit of aggrandisement, which marked the conduct of too many of its abettors; and especially of the military despot, who availed himself of the misfortunes of the country that cherished him as her adopted son, to destroy her liberties, and desolate the fairest portion of Europe.

When the anxious period arrived, at which it was necessary for him to fix on a profession, Grahame would have preferred the simple and unostentatious duties and the humble emoluments of the Scottish church; but he suffered his own choice to be overruled by the persuasions of his friends, who fancied that they could foresee or secure more certain success for him in the law. After receiving some professional instruction from his father at Glasgow, he was indentured, in his twentieth year, as an apprentice to his cousin Mr Lawrence Hill, writer to the signet in Edinburgh, in 1784. It was about the time of his passing writer to the signet in 1791, that he had the misfortune to lose his father; a misfortune which sunk the more deeply into his feeling heart, from the circumstance of his absence on that occasion. The consolations of religion were at this time peculiarly salutary to his wounded spirit, and his desire for the clerical office returned; but he again yielded to the arguments of his friends, who urged the obstacles that his age now presented against his entering the Scottish church, in consequence of the length of previous study required, a circumstance which also appeared to them a barrier to his preferment in the church of England. He acted for some years as a writer to the signet, and passed advocate in 1795. Though his professional knowledge was extensive, and his law papers were ably written, there were various circumstances, which combined to prevent him from attaining a conspicuous station at the bar. Want of relish for the minute and tedious details of the practice of the law, and a bad state of health, were the principal obstacles; and probably these were the chief causes of his seeking relief in poetical composition.

He was most happily married in 1802, to Miss Graham, the eldest daughter of Mr Graham, writer in Annan, and town-clerk of that burgh; and in the endearments of domestic life, which no man could enjoy with a truer relish, he found a never-failing solace amid the cares of business, and the growing infirmities of his delicate constitution. In 1808, his declining health made him resolve to retire from the bar, and at last to adopt the profession, to which his mind had adhered with constancy from his earliest years. After some abortive attempts to obtain ordination in the English church, he was admitted to holy orders by the Bishop of Norwich in May 1809, and soon entered on the curacy of Shipton, in Gloucestershire. He found his new duties easy and pleasant; but family reasons compelled him in a short time to abandon them, and return to Scotland. After various changes, which are too unimportant to be recorded in a work of this nature, he was finally settled in 1811, as curate of the parish of Sedgefield, in the neighbourhood of the city of Durham. His figure was tall, and his features striking, and his sermons, if not animated, were interesting and earnestly impressive. His benevolent and ardent concern for the poor and afflicted of his flock, secured for him an interest in their hearts, which, however, he was not to be permitted long to retain. Severe headach, to which he had been occasionally subject from his early years, and which materially injured his memory and other mental faculties, increased considerably about this time; and the disease had now made an alarming progress, which was soon to rob his flock of their pastor, his family of their best friend, and the world of a poet, who combined the sublime chords of David's harp, with the simplest melody of the sylvan pipe. In August 1811, he returned on a visit to Scotland; and on the 14th of September, he expired in the house of his elder brother at Whitehill, near Glasgow, in his 47th year. His ashes rest in the sepulchre of his fathers. His afflicted widow, who was absent at the time of his death, and occupied with the duties of her family, was little prepared for this severe trial. She soon after fell into bad health, and died in the year 1815, leaving a son and two daughters to bewail the early loss of both their parents.

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Kindness and sympathy for every thing that could feel, were among the strongest characteristics of Grahame's mind; aud those local attachments, perhaps we may call them local prejudices, which find a place in every mind of sensibility, were deeply rooted in his. We do not think it will be necessary to apologize for mentioning, in a memoir of this amiable man, a little trait which strongly marks this feeling. When he was journeying on horseback towards his native Scotland, he asked of a peasant the name of a stream, which he associated with many tender recollections of times gone by, merely that he might have the delight to hear that name repeated in the native accent, from which he had been lately estranged. One of the tenderest passages in his Georgics, refers to this circumstance:

> " How pleasant came thy rushing silver Tweed
> Upon my ear, when, after roaming long
> In southern plains, I've reached thy lovely bank!
> How bright, renowned Sark! thy little stream,
> Like ray of columned light chasing a shower,
> Would cross my homeward path; how sweet the sound,
> When I to hear the Doric tongue's reply,
> Would ask thy well-known name!" Page 180.

Grahame was early addicted to versification; but his first acknowledged production from the press, was the oft attempted theme of "Mary Queen of Scots," in the form of a tragedy. This is a long and desultory drama, little careful of Aristotle's unities, and is sprinkled with rather too much of the Scottish phraseology; yet it shews so deep and genuine a sympathy, and so high an admiration for the sufferings and virtues of the ill-fated queen, and contains some such tender images, as to give it a claim on the public attention, independently of its dramatic merit. It has amused us to observe also, how his chivalrous enthusiasm and warm nationality seem to have gained such an ascendency over his mind, as to have made him forget the political maxims which he had learned at Glasgow in the school of Millar, as well as those anti-catholic feelings which he had imbibed in his early years. This was a favourite production with the author, but not with the public; and he republished it with very considerable alterations in a 12mo edition of his poems, in two volumes, which appeared in 1807. His next considerable publication in the order of time, and indeed the poem by which his fame is most likely to be established, is "The Sabbath." The day of solemn universal rest, presented peculiar attractions to a soul feelingly alive to the beauties of nature, to the impulses of benevolence, and to the sublime emotions of piety. In Scotland especially, where the duties of that day are still perhaps more decently and religiously observed than in any other part of the Christian world; where the pause from painful toil and frivolous pleasure is more striking; and where even those who do not feel its purest joys, partake by sympathy and association in its reflected influence, the theme could scarcely fail to be a popular one. In short, we are inclined to think, that the subject admits of the highest poetical embellishments which language can furnish, with the additional interest which truth must always claim over fiction. The antiquity of the Sabbath; the authority by which it was appointed; the cause of its institution, first as a memorial of the creation of the world, or rather of that part of the system of the universe with which we are connected, as proceeding from the hand of the Almighty, and as leading us to acts of adoration and praise; the manner in which it was solemnly enacted, amid the stupendous displays of divine power on Mount Sinai; the jubilee, or year of deliverance, as connected with this wonderful institution; then the change from the seventh to the first day of the week, on account of the completion of man's redemption, by the resurrection of Christ; and lastly, its direct and indirect moral influence, its actual and progressive benefits conferred on society, and the prospect of the Sabbath of rest and joy in the realms of endless blessedness;—all these present a combination of grand and affecting topics and images, which are worthy of the highest powers of the noblest poet, and which indeed render it less difficult to find materials, than to select from the abundance that presses on his attention. If Grahame has not attempted to give that kind of unity to his subject of which it would have admitted; if he contents himself with a less ambitious flight, he has, at least, felt the inspiration of his sacred theme, and, by a series of tender and affecting pictures, simply and naturally combined, and derived chiefly from the customs and history of his native land, and from scriptural allusions and associations, has produced a work which renders his name conspicuous, not only among the poets, but among the benefactors of his country.

The "Sabbath Walks" and "Biblical Pictures" which are added in the later editions of this poem, are quite in unison with the spirit of the work; and some of the latter are so strikingly delineated, that a skilful painter might easily give them life and figure, by translating with his pencil the vivid and glowing descriptions of the poet's pen.

The next of Grahame's poems to be slightly noticed, is his "British Georgics," a name which is too boldly chosen, as it leads the mind to the most finished production of the Mantuan Bard; and as it is in itself perhaps the least perfect of the author's writings. When on a visit to a friend on Tweedside in 1797, he inserted a poetic sketch of the month of April, under the signature of *Matilda*, in the Kelso Mail. It was much admired, and was followed by the other months. These sketches are preserved in his works, and there can be little doubt that they gave him the idea of the Georgics, which are only in fact the filling up of the outline, and which afford theoretical and practical instruction to the British husbandman, connected with the different months of the year. An attentive reader will accordingly find in this larger poem, which is also divided into twelve parts, a frequent recurrence of the same thoughts and expressions which occur in the minor pieces. The Georgics, among many prosaic passages, contain also a number of the finest touches of fancy and of feeling, and some affecting allusions to the state of the author's declining health. We are not fond of didactic poetry, especially in blank verse; metre gives at least more entertainment to the ear, when the tameness of the subject precludes the flights of imagination. And we apprehend, that the beauties which are scattered through this poem will hardly preserve it from oblivion.

The "Birds of Scotland," his next large poem, is a production of very superior merit, in which the author describes, with admirable skill and truth, the manners and characters of the winged tenants of our woods and wilds. With his exquisite descriptions are interspersed delineations of the scenes which they frequent, and fine allusions to national character, and historical traditions. He has indeed succeeded in accomplishing the design which he proposed, of "pleasing the imagination, and warming the heart." And he has done more; for he has conveyed much instruction in a most agreeable manner, and furnished us with new sources of delight, in the enjoyment of the cheap and innocent pleasures of nature.

Mr Grahame, whose soul always abhorred the traffic in slaves, and who rejoiced with all good men in its abolition, had the honour of contributing one of the three poems, intended as a grand literary monument, to this noblest triumph of justice and humanity of which our age can boast. The other two were furnished by Eliza Benger and Montgomery, and the whole was published by Bowyer of Pall-Mall in 1809 with most splendid decorations. Mr Grahame also wrote the "Siege of Copenhagen," and published it with the sanction of his name, soon after the details of that expedition were received. It is a spirited little poem, and contains some passages remarkable for beauty and tenderness. It is written in metrical couplets.

Cowper is the poet whom Grahame most resembles, and whom we believe he adopted as his model. Yet there are striking differences between them, independently of the preponderance of talent in favour of the former. Grahame has more flat passages,—Cowper more rugged lines. Grahame is minute in describing all that, in the range of nature, strikes his fancy;—Cowper, with an eye as poetical, was more limited in his sphere of observation, and less ambitious in the choice of his subjects. Cowper's religious views were inwrought and profound;—Grahame's consoling and abiding, but by no means so deep. Grahame feels and admires the simple and varied charms of creation, and expatiates upon them with ever new delight; his forte is accurate description of nature in its simplest forms;—Cowper hunts through the intricacies of the human heart; his chief excellence consists in the faithful delineation of the feelings and moral sympathies of the

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soul. Grahame has more ornament;—Cowper much greater extent and variety of thought. In language they are both careless, and in their measures often incorrect. But there is a grace even in their negligence. To both the praise "above all Roman fame" belongs, of rendering the powers of their cultivated minds subservient to the promotion of the best interests of morality and religion.

Those who only knew Grahame by his works, will form their own estimate of his genius and worth. But his memory will long be embalmed in the minds of those who had the good fortune to enjoy his personal acquaintance, or his friendship. Never, perhaps, did a kinder and gentler heart animate a human frame; never did a man exist more unwilling to give pain to any sentient being, or more desirous of promoting the peace and happiness of all within the sphere of his influence. His country will long cherish the remembrance of the author for the sake of his works; while his friends will, with fond and melancholy pleasure, cherish the effusions of his genius for the sake of the amiable author. (*l*)

GRAMMAR.

Grammar.

GRAMMAR is that knowledge of words which qualifies the possessor for speaking and writing with propriety. PARTICULAR GRAMMAR comprehends the rules of particular languages, as founded on the practice of those who have that sort of conspicuousness in society which is considered as entitling them to fix the standard in each. Every language has thus a grammatical system of its own. All languages, however, possess some circumstances in common. Prevalent analogies are developed in their origin and history, and certain leading principles are found to obtain in the application of them to the purposes of speech. The general doctrines discovered by the comparison of different languages form the important science of PHILOSOPHICAL, or UNIVERSAL GRAMMAR.

UNIVERSAL GRAMMAR.

Universal Grammar.

THIS science unfolds the principles by which man is directed in the contrivance of the varieties of words. Its utility is extended by the opportunities which it gives of tracing the connection which the phenomena of language considered as a production of the human mind have with the other principles of our nature.

[...]ent of [...] subject.

As the term Grammar has been currently applied to a much inferior department of knowledge, some have thought proper to give Universal Grammar the apparently more elegant designation of the THEORY OF LANGUAGE. This latter designation, however, comprehends all the general branches of inquiry connected with language, which are treated under various articles of this work, such as ALPHABET, ETYMOLOGY, PHILOLOGY, and LANGUAGE. Its most interesting branch consists of those inquiries which, under the name of UNIVERSAL GRAMMAR, we here propose to lay before our readers.

Language being the leading instrument by which men communicate their thoughts to one another, it is to it that we undoubtedly owe the most important improvements of which our intellectual character is susceptible. It might therefore have been expected that an inquiry into its nature would necessarily imply an elucidation of all the laws of thought. But its province does not extend altogether so far; and, by keeping it within its due bounds, we shall do greater justice both to this science and to those with which it is connected. We shall find that the points of view in which man appears in thinking and in speaking are not so perfectly identical as has been imagined. It is not true that Universal Grammar implies the whole theory of human thought; yet it implies a great and important part of it: and the habit which the study of it gives us of investigating the subject, and the analogies which it furnishes for the prosecution of the rest, may, under judicious management, contribute materials towards a perfect knowledge of the general philosophy of mind.

Facts by which its doctrines are suggested.

We have intimated that this science originates in the comparison of different languages. It is not indeed very flattering to the pride of human intellect, and it will appear to many inaccurate, as well as undignified, to ascribe the discovery of the principles of Universal Grammar to a circumstance which might be regarded as accidental, viz. the multiplicity of languages existing among mankind. Its principles must operate in the formation of each individual language; and the science might therefore appear to admit of being investigated with sufficient certainty by a direct inquiry into the operations of the human mind, or by the obvious analysis of any single language. This might be thought sufficient to distinguish all that is requisite to the purposes of speech from every thing whimsical or peculiar, that is, from those turns of words and of phraseology which ought to be reckoned idiomatic. It might, at least, seem reasonable to expect that the principles would be discovered by paying attention to the variations and analogies existing among those words of any language which are not immediately and evidently borrowed from a foreign source. It might even be thought possible to collect them by recording the early operations of a child in learning the use of his native language. That the principles of this science *could* have been so discovered, it would be rash to deny. But the well known obstructions opposed to science by the delicacy and proneness to error which mark the human faculties, and the various external biases which the mind receives, operate in all ages to prevent scientific inquiry from being made, and in corrupting the accuracy of the results obtained. Hence we are sometimes indebted to fortunate accidents for an introduction to the right path of inquiry, and for the discovery of truths which had otherwise a chance of remaining

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for ever unknown. One of these fortunate accidents, as relating to the subject of our present article, is the existence of various languages in the world, and the access which individuals have to compare them together. The success which philosophers have met with in these inquiries has arisen from the study of languages the most diversified from each other in their structure. Those of ancient Greece and Rome have, for example, been compared with those of modern Europe, and both these with the languages of the East, and the great differences apparent in their origin and structure have afforded a valuable opportunity of tracing, with a scientific hand, the general operations of man in this conspicuous department of his active efforts. An extensive erudition in literature confers emancipation from that enthralling influence which any single language exercises over those whose knowledge is confined to it. The errors which the habits of one would produce receive correction from the attention exacted by the varying genius of another. These inquiries might even lead us a step higher. They might enable us to discover whether or not there are any circumstances in which the habits common to all languages mark a prevailing erroneous bias in our nature, and might lead us to improve and purify in this department the perspicacity of our intellect.

The difficulty of the subject renders it at least prudent to avail ourselves of all the aids which can be afforded by diversities in the structure of languages. These, indeed, are of themselves elegant subjects of study. No person who cultivates them can be indifferent about Universal Grammar, or insensible to the intimate connection which exists between the two pursuits. A very limited fact in philology not unfrequently suggests an important doctrine in the philosophy of grammar, which is afterwards confirmed by multiplied evidences, and, though formerly overlooked, exhibits, when known, a character of internal truth, and throws a broad light over the whole extent of the subject.

Present state of the science.

In no circumstance does the difficulty of this subject appear more conspicuous than in the diversity of sentiment which prevails on it. This diversity is indeed capable of being represented as chiefly, if not entirely, verbal. But, where verbal differences are pertinaciously adhered to, some misconceptions with regard to the subject itself are undoubtedly more or less prevalent. It cannot be said to be clearly understood among all who cultivate it, unless they either agree in the choice of the words by which their theories are expressed, or concur in acknowledging their differences of phraseology to be immaterial.

This is not at present the case. The cultivators of the science are divided into parties, which seem so distant from one another that the philosophical analysis of language may be considered as still in its infancy. The account which we shall now give of it will not arrogate to itself the rank of a system matured for indiscriminate adoption. It will only be offered for deliberate consideration, as an attempt to advance the progress of this interesting branch of study, by exhibiting explanations which will show to partial systems several of their leading defects, and reconcile a variety of disputes without compromising the spirit of investigation.

CHAP. I.

On the Object or Universal Office of Language.

In order to investigate the characteristic differences by which words are distinguished, it is essential that we entertain correct ideas of the OBJECT or PURPOSE of language. Grammarians have hitherto satisfied themselves, with describing it as consisting in the COMMUNICATION OF OUR THOUGHTS. Yet it does not appear certain that they have always entertained the same views of what is meant by this communication. Vague notions of the office of language have in consequence been entertained, and a confusion arising from this cause has impeded the inquiries which were made into the origin and distinctions of the various parts of speech. Mr Harris describes it as consisting in "an exhibition of the energies or motions of the soul." These he divides into perception and volition; and he considers every sentence as either "a sentence of assertion," or "a sentence of volition." Some consider the object of language as simply consisting in the exhibition of a connection betwixt one idea and another, and therefore make the act of AFFIRMATION its universal office. These opinions, though slightly varying, agree in stating the communication of our thoughts to be the object of language.

Universal Grammar. The general opinion.

That we may divest the subject of ambiguity, we shall enquire in what respects thought is ever communicated by language; what are the circumstances that lead to such communication; and whether or not the importance of this object entitles it to be regarded as the sole and definite purpose for which it is formed and employed.

How do languages communicate thought.

Men may evince, by various signs, that particular thoughts occupy their minds. This is not only done by pantomimical language, but by oral sounds constituting the materials of verbal discourse. We sometimes shew by involuntary exclamations that we are affected by certain impressions called passions, which, though they originate from outward causes, do not necessarily point to such causes in our mode of expressing them. At other times, words are employed as the signs of external objects which are known to the person addressed. The effect of the employment of these is to recal to his recollection ideas formerly possessed by him. We show, at the same time, that they occupy our own minds. The meaning of the words being formerly known, they exhibit nothing new except their connection with some present occasion. Old ideas thus recalled, however, do not constitute exactly the same state of thought which accompanied the former employment of the words. The mental exercises excited by the same word at different times are not strictly the same. They cannot be identical, because they are separate instances of mental exercise. But they are not even perfectly similar. Amidst the varying movements of the human mind, in which one thought impels another, and in which external and internal causes modify the state of the percipient being, the appropriate affection produced by any particular word can never be separately obtained. It is always modified either by humour, by degrees of activity in the mind, or by the kinds of exercise in which it has been previously engaged.

The most important modifications of the mental effects of words arise from their connection with one another. By changes in this connection, new conjunctions of ideas are presented to the mind of the person addressed. The signs of thoughts formerly known to him are so exhibited as to excite impressions possessing the most striking novelty, and imparting the most important character both to the immediate thoughts of the individual, and to those which are liable to occur on numerous future occasions. This is the case when, by means of words well understood, and therefore conveying in their separate state no idea that is new, we communicate information to one another, and exercise an influence on human opinions. On this office of language depends the whole benefit which mankind derive from the records of literature and science.

Engrossed by this most dignified application of language, authors have been induced to consider it as consisting entirely in assertion; that is, in expressing the connection of one idea with another, and conveying by these means new information. But, it may be called in question how far this account is strictly applicable to all language, or may be trusted for our guidance in tracing the steps of its earliest history.

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It has been hastily assumed, that language arises from an original and universal inclination to impart our thoughts gratuitously to one another. From this cause it has sometimes been erroneously concluded that it is nothing else than a faithful transcript of the successions of human thought. This, however, is not its character. A man does not speak simply because he thinks. It is not a necessary result of the possession of a thinking faculty, nor does the inclination to speak regularly accompany its operations. It is the effect of a range of thoughts which must be considered as limited when compared to the whole phenomena of mind. Speech, like every other voluntary act of man, is founded on the presence of particular motives. It originates in his social nature taking advantage of his social state; and it depends on the knowledge which each has of various links of connection existing betwixt himself and other thinking beings.

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It is not natural to man to communicate all his thoughts. Supposing, therefore, that a complete analysis of the origin of thought were in our possession, this would not necessarily bring along with it a perfect theory of the origin and character of language; nor would the most perfect history of the formation of language lead us in the opposite direction to a perfect analysis of the nature of thought.

...anguage ...lied to ...erent ...poses?

But, allowing that we do not by means of language communicate *all* our thoughts, that we make a selection among them suited to our several occasions, it might still be contended that we do *nothing else* by means of language than communicate our thoughts; that this is its universal office; and that this position might be assumed as fundamental in entering on the subject of universal Grammar.

Some considerations will, we conceive, warrant us in hesitating before we concede even this point. We shall not stop to enquire if there is any acceptation in which this theory is true; but it is certainly susceptible of a meaning which is erroneous, and which has tended in some cases to distort philological enquiry. On the supposition now mentioned, language would still be considered as properly an exhibition of human thought. *

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The first observation which we have to make on this account of the subject is, that, if it were correct, language ought always to have a definite reference to our sentiments, and ought in fact to express them with fidelity. But we find that, when we desire a person to perform any act, our motives for it are kept out of view, and are not intended to be contemplated by the individual spoken to. The motives which are expected to operate on him are ideas of a different sort which we endeavour to excite. Even in the use of the plainest affirmations, we do not necessarily exhibit our own thoughts. We may excite thoughts completely the reverse of them. This is always the case when we procure reception to a false proposition. The thought conveyed by our words has indeed been revolved in the mind as a contrivance for operating on another. In that other, however, we mean to produce a particular belief. This is certainly a thought; yet it is not the belief, consequently not the thought, which, in so far as truth is concerned, we ourselves entertain.

It might indeed be replied, that this employment of language is unnatural; that it is as much a deviation from its original purpose, in the right use of our faculties, as any act of drivelling folly committed by means of language, which ought not to be regarded as entering into its original character. But it is to be remembered that this use of language, though disingenuous, is still characteristic of intellect and address.

The pretext for language different from its object.

It might also be said that in this use of language we closely *imitate* the sentences in which our own ideas are *bona fide* communicated, and that our success in falsehood depends on the closeness of this imitation. This fact only shows that dissimulation does not affect language in its structure. But its *object* must imply the real motives of the speaker. This account of it, therefore, must be deficient. If we can form a general theory on the subject which will embrace these as well as all other occasions on which it is used, a material advantage will undoubtedly be obtained.

The existence of false sentences is not our only reason for declining to regard the communication of thought, at least that communication which consists in assertion, as the universal office of language. We shall find that *Imperative sentences* cannot, without great awkwardness, be reduced to affirmations or communications of our knowledge. But, reserving that argument for the next Chapter, we shall now endeavour to unfold, in a more detailed manner, some of the intricacies in which this part of the subject is involved.

A more particular statement of the question.

Different circumstances concur to impress the philosophical inquirer with an idea that the communication of our thoughts is the object of language. One, at which we have already hinted, is, that this communication is the object of a *great part* of language, perhaps by far the greatest. This is most especially the case in polished and literary communities. It is the object of the greater part of the language of men of philosophical habits, the only persons who concern themselves with analytical inquiries on the subject; and it recommends itself as exhibiting the most important species of influence which language has exerted on society.

There are also some particulars in which all human speech agrees with the office of communicating thought, and which have led to an acquiescence in that account of its general object. One is, that the use of it always proceeds from some thoughts existing in the mind. Another is, that language consists of the signs of thought. A third, that the thoughts corresponding to these signs are contemplated by the individual using them. And the last is, that language terminates in exciting thoughts in the person addressed. But, though these points of coincidence are real, a closer attention will, we think, convince our readers that they do not of themselves constitute a communication of our thoughts.

The mere circumstance that the employment of language is in every instance the effect of previous thought is by no means peculiar to this department of human

* For a more varied illustration of this and some other views nearly coinciding with those which are here expressed, we refer to a paper on "the theory of language" contained in the 6th volume of the Transactions of the Royal Society of Edinburgh.

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exertion. All our voluntary actions are as much the effect of our mental operations as the uttering or the writing of sentences. In the use of language, as in other exertions, we indeed execute our own designs; but the enquiry is still equally open as before, what is our specific design in using language?

The second circumstance essential to language, which has perhaps tended to confirm the notion that its specific object is to communicate our thoughts, is, that the signs of human thought form the materials of which language consists. Such signs are always the media employed when we communicate our thoughts to one another. Yet it may be inquired, whether they admit of being also applied to other uses, and whether the object of language is, on that account, still more general?

The third circumstance of which we took notice, that the thoughts of which our words are the signs are entertained by the individual using them, is little more than a condensation of the two former, and requires no separate observation.

The true object of language, the PRODUCTION OF THOUGHT.

The truth will evolve itself in the clearest light when we discuss the last particular in which language has one common character with the communication of thought, that it produces appropriate thoughts in the mind of the person addressed. This is always the intention of the speaker, and if it is used by him in a skilful manner, the production of such thoughts is the consequence. This object is much more general than the communication of our own thoughts; but it is not too general to be stated as the real object of language. The conveyance of our sentiments, volitions, and opinions, is only an important part of it. The definite object of language consists in THE PRODUCTION OF THOUGHT BY MEANS OF ORAL SIGNS.

By adopting this more comprehensive view of the subject, we avoid all difficulty about the nature of such sentences as are the reverse of the belief of the speaker. We avoid the necessity of any inquiry into the propriety of considering them as in some sense exhibitions of the thoughts which he entertains for the moment, or as partial representations of his habitual thoughts. We consider them, in common with all sentences, in a point of view in which they maintain the same unquestionable ground, that is, as instruments fabricated to execute our designs; and our universal design in language is, to produce in one another such mental impressions as we please. Its ulterior purposes, being considerably diversified, admit of subdivision.

CHAP. II.

The General Nature of Sentences.

ACCORDING to the author of the Diversions of Purley, two parts of speech are necessary to language, the noun and the verb, and every sentence must contain both.

Opinions of Mr Tooke and his followers.

The reason assigned for this is, that one part of speech is required as the sign of the idea, and another as the instrument of communication. The views which this author entertained of the characteristic nature of the verb, and the act of communication as distinct from the exhibition of the signs of ideas, are not fully developed in his writings. We have not, therefore, sufficient data for appreciating their merits. The opinion maintained by some of his most acute followers is, that affirmation is the proper character of all sentences. This is considered as closely connected with the doctrine which makes the object of language to consist in the communication of our thoughts; and by this communication seems to be understood, the act of conveying to our neighbours the same connections betwixt ideas, (formerly known to both,) which they possess in our own minds. This conveyance, and the act of affirmation, are reckoned equivalent. Affirmation, from *ad firmare*, means the establishing of a connection betwixt one idea and another. The doctrine which resolves language into assertion does not depend on the truth of the theory, that its object is the communication of our thoughts. Our readers will perhaps agree with us in denying that sentences intended to deceive are communications of the thoughts of the speaker. It must, however, be allowed by all, that these sentences are assertions, and the inquiry still remains open, whether or not assertion is the proper character of sentences? To this inquiry the present Chapter is devoted.

Analysis of assertions.

A sentence of assertion includes two ideas expressed by two signs, and another sign to indicate the affirmation, or the establishment of their mutual connection. In the sentence, "man is rational," "man" expresses one idea, the first two syllables of the word "rational" another, and the last syllable of "rational" along with the word "is" constitutes a sign expressing the connection betwixt the two. These different signs are not always expressed in separate words. Sometimes two of them are contained in one, as in the last word of the sentence, "John walks." Sometimes all the three are contained in a single one, as in the Latin word *loquitur*, for "he speaks;" or *rubet*, for "he is red."

On a full consideration, however, of the variety of arrangement which words assume in the use of language, and the various kinds of words employed, assertion does not appear essential to it. We may produce thought without making any assertion. We may, for instance, merely call the attention of another person to an object formerly known to him. A very extensive department in the uses to which it is applied is that of exciting the person addressed to the performance of voluntary acts.

Language may be used without assertion.

Imperatives.

This is done by *Imperatives*, which certainly differ from assertions. Attempts have indeed been made to reduce them under this head, and to regard them in the same light with those affirmations in which an abbreviation is produced by condensing a plurality of signs into one. This attempt succeeds in so far as it appears to establish a fact, that, according to the habits of speaking and understanding one another which we now possess, the same meaning may be conveyed by an affirmation and by an imperative sentence. The sentence, *I nunc et versus tecum meditare canoros*, is of the same import with the affirmative sentence, JUBEO TE *nunc ire et tecum meditari versus canoros*. But the question recurs, which of these modes of expression is likely to have been the original one in the contrivance of words?

Language founded in our social relations.

We formerly observed that the contrivances of language are founded on the known relations existing, on different occasions, betwixt the speaker and the person addressed, and are so adapted as to enable the former to avail himself of these relations for accomplishing some definite purpose. An answer to the inquiry, what forms of sentences are likely to be the earliest and the simplest, is not obtained by determining what connections of thoughts are simplest in relation to the mind of the solitary individual, but by finding what those purposes are which he is likely soonest to have in view in employing the influence which language gives him over others.

Inference from this.

The first objects that strike the attention of man in becoming acquainted with his fellows are their motions. In other respects, one man is not more interesting to another than any piece of dead unchangeable matter. He first observes voluntary motions of the most palpable kind, and then gradually becomes acquainted with more delicate phenomena, such as the motions and changes of the human countenance, from which he infers the existence of thoughts in other persons, and judges of their nature. In acquiring this knowledge, he is guided by experience, and by a comparison betwixt the motions of others and those of which he is conscious as the natural accompaniments of his own thoughts.

rly date of impera- es.

The helplessness of man as an individual, and the support which he is capable of deriving from the services of his fellows, create perpetual occasions on which he wishes for their assistance; and one of the earliest as well as the most frequent objects of his wishes is to influence them to perform those motions for which he finds occasion. These necessities are prior to the mere luxury of a mutual communication of knowledge and opinion. This fact seems to point out imperative sentences as the earliest forms of language.

'ey are r contract- asser- tis;

On this account, it is not historically correct to consider the imperatives *I, veni, fac*, and *dic*, as brief modes invented in the progress of language for expressing thoughts originally conveyed by means of such affirmative sentences as *jubeo* or *precor te ire, venire, facere*, and *dicere*. The act of commanding, or requesting, does not require to be mentioned. It is actually exhibited. *Jubeo te ire* is something more than *I*. It is a pleonasm in the form of an affirmative sentence; and has the same relation to this imperative which the sentence "I affirm that man is mortal," has to the shorter one, "Man is mortal." When we speak, there is no meaning in affirming that we speak; and in like manner, when we give a command, or make a request, there is no meaning in telling that we do so, unless we intend to enforce a compliance with our wishes by an additional idea contained in the verb prefixed, as by addressing ourselves particularly to the fears of another in the verb *jubeo*, or to his kindness in the verb *precor*. A command ought, in strict propriety, to be given, before it can become the subject of an affirmation.

n asser- s of ies.

As the imperative is an immediate consequence of our wishes, advantage might be taken of that circumstance to represent it as an "assertion that such wishes exist." But the circumstance of being the consequence of our wishes is common to it with all our actions, as well as all our words. It is rather, however, to be considered as an execution of our wishes, than an assertion of their existence. It is a call of attention; a mode of influencing the volitions of other persons, and thus producing, on their part, certain trains of action.

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In corroboration of this view of the subject, we find that words signifying voluntary motion exist in the shortest form in the imperative of the verb. This is the case in all the languages, ancient and modern, which we have had access to examine. Exemplifications of this in the Latin language are afforded in the words already named, *I, veni, fac, dic*, and *duc*; or the common examples of the conjugations in elementary grammars, *ama, doce, lege, audi*. The same comparative brevity takes place in the English language, as in the words, "go," "come," "do," "say," "bring," "love," "teach," "read," and "hear," which never stand by themselves except in the imperative mood. Even when the idea expressed by any verb, in either language, is introduced as an object regarding which an assertion is to be made, the word employed is longer than the imperative. In Latin, the syllable *re* is in this case added to those which constitute the imperative. From *ama* we have *ama*-RE, and from the other imperatives, *doce*-RE, *lege*-RE, and *audi*-RE; also, *i*-RE, *veni*-RE, *dice*-RE, *fac*-ERE, *duc*-ERE. In English, we prefix the word TO, or add the syllable ING; as, "*To* read or read-*ing* is an improving occupation." "Men of intellectual refinement delight in read-*ing*, or delight *to* read." In some instances, the word is equally short in its application to other uses as in the imperative. Of this the noun "love" is an example, being equally short, and indeed the same word, with the imperative of the corresponding verb. Such instances, however, are rare. Brevity, therefore, appears to be an original character of imperatives; a circumstance conformable with the theory, that they ought to be considered as original modes of speech, and not as abbreviations of affirmative sentences. The affirmative form, instead of illustrating the imperative mood, renders it cumbersome, and destroys its characteristic animation.

Apparent exceptions.

To those who have not previously considered this subject, the brevity of imperatives may appear, in point of fact, liable to some exceptions. The Chinese language is said to have no imperatives. That language, however, in so far as we can judge from our scanty knowledge of its structure, seems to owe this apparent defect to affectation and refinement, which have induced men in speaking to prepare the hearer by means of distant and respectful circumlocutions, instead of using direct imperatives, in order to avoid the apprehended indelicacy of dictating an abrupt change of direction to his thoughts. This modification probably took place after men had learned to keep their own objects and their own influence out of view, and to appear solely attentive to the convenience and pleasure of others. In a light nearly similar we are to consider those forms in the languages of modern Europe, originating in ceremony, by which single persons are addressed in the plural number.

Another question may here be asked, Why does this alleged brevity of the imperative not extend to the third person, and the plural number? Why are the words, *amato, amate, amatote*, and *amanto*, comparatively long? Would not this fact seem to intimate that the circumstance of being imperative does not of itself determine this brevity of form? To this we answer, that the word called the third person of the imperative, is not properly an imperative as directed to the person addressed; it expresses either a simple wish, or specifies some *consequence* of an action which the speaker wishes him to perform. The command is then learned by inference, and not conveyed in the word. The imperative in the second person of the plural number is, indeed, a real imperative; but it is to be observed, that it is not of so early natural origin as the imperative singular. It requires a particular arrangement to render it applicable. It implies not merely a wish that a certain action should be performed, but a knowledge that it is capable of being performed by a plurality of people, and that their concurrence in it will promote the same object, or fulfil a variety of objects that are alike desirable. Hence it probably deserves to be considered as equally remote from the original imperative with the other uses of the signs of locomotion.

The relation which imperatives bear to assertions.

Since, then, imperatives are not to be considered as contracted affirmations, it remains to inquire in what relation they stand to sentences of the latter kind? Whether these are originally two distinct species of sentences, merely agreeing in the general character which is common to all language, that of being intended to produce appropriate thoughts in the person addressed?

All language IMPERATIVE.

In tracing the nature and origin of human language, it appears to us, on the whole, most strictly agreeable to the natural history of our species, to consider all lan-

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guage as IMPERATIVE, that is, as always implying the imperative of a verb.

This applicable to nouns.

Even when we merely mention an object by making use of a noun, an imperative is implied, desiring the person addressed to think of it. Some more particular intentions on the part of the speaker may be left to be inferred from the occasion on which it is uttered, or may be expressed by some circumstances of manner, or conveyed by means of some further verbal sign; but the noun itself, in the moment of utterance, always implies the general act of demonstration, that is, the imperative of the verb "look," or "think."

Assertions reducible to imperatives.

Assertions may be advantageously reduced to the imperative form, and may be considered as originally and essentially partaking of that character. Imperatives, we have remarked, are deprived of their characteristic animation when reduced to assertions. Assertions, on the contrary, preserve more completely that interest which originally belongs to them, when viewed as imperative directions for regulating the volitions and active thoughts of others. Our opinions proceed from impelling causes which bear a resemblance in their nature to the motives which prompt us to action, and assertions resemble the exhibition of such motives to other persons.

Is the copula reducible to an imperative?

But if each single word possesses an imperative power, it may be asked, in what respects that power can be ascribed to the copula "is?"—When the intention of assertions is considered, this copula will be found equivalent to the imperative of the verb "believe." An opinion asserted by means of it does not retain the simple character of one which remains quiescent. Hence it is always expected to be of a nature fitted to interest the person addressed, and possessing a just claim on his attention. Without this, the declaration is regarded as unmeaning. Keeping this circumstance in view, we shall find nothing forced or exaggerated in representing the "is," in English as equivalent to "believe," and the *est* in Latin to *crede*.

When sentences constructed by means of this copula are not intended for conveying information, but for exhibiting pleasing objects already known, or objects of imagination, as in poetic description or fictitious narrative, the copula has the power of the imperative "contemplate."

Objections answered.

One objection might be made to this theory, that *est* being placed betwixt two nominatives, cannot be equivalent to a word which governs nouns in the accusative. If such an objection should occur, it is sufficient to observe that the cases of nouns are refinements of language, intended for marking in a convenient manner certain uses of the words and certain analogous connections which are formed among them in the composition of sentences, but that our present inquiries relate to a period of language much earlier than such contrivances; and, where the meaning can be shown to be the same, diversities arising from these causes does not fall under our consideration.

It might, however, be objected to the whole reasoning here employed, that, if all sentences appear to be imperatives, there is no meaning in supposing those words which are usually called imperatives of verbs to be the earliest parts of speech, and in deriving from that consideration the brevity of their form. These particularities should at least imply that they differ from other imperatives. The nature and consequences of this difference require therefore to be pointed out. When we use the imperative of a verb of action, the name of the act expresses our ultimate wish, viz. the wish that the person addressed should perform it. Its name is originally contrived for this particular purpose. When we use it for other purposes, these require to be stated; and even the mere absence of the imperative use is denoted by the additional signs which we have already mentioned as distinguishing the infinitive of the verb. When we direct a person to think of objects of other kinds, each object may admit of being expressed by a very brief sign. But, for the most part, various circumstances require to be specified. Our intentions respecting any object admit of considerable latitude, and are to be particularized on each occasion by the indication of a connection betwixt that object and some others, or betwixt it and some voluntary effort which we dictate to the individual addressed. These relations, being various, require signs to distinguish them; and these signs, being generally in the form of terminations, give rise to the greater length of the words. But even in those instances in which the word used for an imperative suffers no change in its form when converted into a noun or any different part of speech, it cannot, like an imperative, stand alone to form a sentence. Though not lengthened by the addition of a syllable, it requires to be accompanied by some other word.

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Objection answered.

We have maintained that every noun implies an imperative act of demonstration, or a call for attention; but it may be objected, that, as this is necessary to all language, and does not serve to distinguish one word from another, it cannot be said to be contained in the word, though implied in the act of speaking. Speech may have an imperative character, and yet it may not follow that its materials consist of imperatives alone. The names of surrounding objects may not be necessarily considered as expressive of different imperative acts, like the imperatives of different verbs. When we resolved the copula "is" into an imperative, this, perhaps, appeared an excessive refinement, and a strained attempt to give exclusive support to a particular system. It may appear sufficient for the maintenance of our fundamental theory to keep in mind that a note of attention is implied in the act of speaking. If these views seem to our scientific readers more just than those which have been here suggested, we shall not, on so abstruse and so nice a point, urge any farther argument, but leave the preceding observations to their deliberate reflections. We have endeavoured to make as near an approach as possible to the formation of a general theory on the nature of sentences. But the views which we have given are not all essential to those that are to follow. The latter will, we hope, exhibit evidences of their own, independently of the consent of our readers to give to those contained in the present Chapter, a strict application in every particular to the parts of speech.

Varieti[es] the obj[ect] o[f] langua[ge]

Language must be regarded by all as an instrument by which we direct the thoughts of one another. It has thus an undoubted imperative character, and this character receives subordinate variations depending on the mutual relations of the speaker and the person addressed, with reference to the subject upon which it is employed. It includes four forms of influence, which have been already alluded to, and shall now be enumerated. 1st, We influence one another to exert the powers of voluntary motion. This gives rise to *Imperatives* in their acknowledged form. 2d, We direct the attention of one another to all the varieties of objects already mutually known. This gives occasion to the contrivance of *Names* to represent them. 3d, We influence one another's opinions and state of knowledge. This gives rise to the words which are particularly subservient to *Assertion*. 4th, We influence one

and in e[ach] general forms o[f] sentenc[es]

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another to communicate specific information. This gives rise to *Interrogatives*.

Though we have already given some account of the differences of words as subservient to these different uses, there are many varieties, as well as many analogies of form and use among them, which have not come under our consideration. The analysis of these will throw light on the general faculty of speech, and will furnish some rules for preserving us from mistakes in language, and from mistakes of greater importance regarding the diversified subjects to which language is applied. The remaining Chapters of this article will be occupied in investigating the differences which are commonly considered as constituting the different parts of speech.

CHAP. III.

Of the Parts of Speech.

Parts of speech different in different languages.

These have been variously enumerated. Grammarians have not only differed in their arrangements, but in the number of parts of speech which they have allowed. The character of a particular language may, in some instances, determine the propriety of an arrangement in so far as concerns itself alone. The Latin language has no word exactly corresponding to the article ὁ, ἡ, το, in the Greek, and *the* in English. Those therefore who consider these words as the only definite articles in these two languages will consider the Latin language as possessing no such word; the circumstance denoted by it in other languages being left to be inferred from the connection.

Differences of opinion as applied to all languages.

But, independently of any difference originating in causes of this kind, some have called in question the propriety of certain distinctions maintained by others, whether as existing in the same language, or as common to all. Some parts of speech reckoned by the generality to be distinct have been ranked together by a few individuals under a more comprehensive head.

Mr Tooke and Mr Harris.

This generalization has been carried the greatest length in Tooke's *Diversions of Purley*. This author reckons the *Noun* and the *Verb* the only essential parts of speech. He does not, however, acquiesce in the views of Mr Harris, who sets out with a binary division of the subject which has the appearance of being similar. Mr Harris considers the adverb, the preposition, and the conjunction as merely subsidiary and inferior materials which connect the other parts of speech, and give ornament and fulness of expression to the whole; while Mr Tooke considers them, in every instance in which they are used, as equally essential with nouns and verbs, and refuses them a separate rank only because they are possessed of the same character with one or other of these parts of speech. He considers their only peculiarity as consisting in an abbreviated form, which has originated in the efforts of mankind to express their thoughts with celerity.

We have already observed that Mr Tooke founds his doctrine of the distinction of all words into nouns and verbs on this principle, that language implies "the signs of ideas," and also a "separate instrument for the purpose of communication." This separate instrument he calls the verb. He considers every verb as implying a noun, and also as implying something more, though he leaves the problem unsolved, what is that definite circumstance which, when added to the noun, makes it a verb?

Theory here advanced.

We coincide with this author in so far as he maintains that language consists of the signs of ideas, together with certain contrivances for connecting these so as to answer the purposes of language. We adopt from him the valuable suggestion, that the verb contains the name of an idea, and, in this respect, comprehends the character of a noun, together with some additional circumstance; but we are obliged to give this suggestion a much wider extension, and to consider all the parts of speech, the noun itself included, as consisting of two parts, one of which is the sign of an idea, and the other a sign of a definite place which that idea is to occupy in the order of discourse. Instead of saying with this author that the verb is *quod loquimur*, and the noun *de quo*, we would say that both the one and the other contain the name of an idea, and also a mark of some specific application, arising from the present occasions of the speaker. Both express certain objects *de quibus loquimur*, while the *quod loquimur* is the result of the collocation of the words thus mutually adapted.

Division of this subject in some measure optional.

Such differences of mutual adaptation furnish the only good foundation for a distribution of the parts of speech. Great nicety in our subdivision is not essential to the explanation of their nature. We may, independently of this, point out the circumstances in which any part of speech to which we happen to give a separate name approaches to various others, or differs from them in its character. We shall therefore, without condemning the plans of others, adopt the division and arrangement which appear to us, in the mean time, most convenient. Even where a dispute may arise about the propriety of a particular distinction, in consequence of a slight difference in the obvious form of some words, which may have led into an erroneous conception of their nature, this is worthy of being noticed, for the purpose of assigning to it its due share of importance. Useful information may be derived from the detection of deceitful resemblances and deceitful differences, as well as from processes of analytical science apparently more profound. To content ourselves with showing that other persons were misled by them, and reprobating the errors which they embraced, is a plan of conduct neither fitted to promote scientific inquiry nor liberality of feeling.

CHAP. IV.

Of Nouns.

Sect. I. *The Nature of the Noun.*

Differences in the extent of meaning given to the term Noun.

The word *Noun* in our language, as well as the corresponding words used by grammarians in other languages, signifies "a name." Nouns are, for the most part, defined to be "words which denote *objects* or *substances*." Some consider them as including substantives and adjectives; substantives denoting substances, and adjectives denoting qualities. Others regard these two sorts of words as deserving a separate rank in language, and therefore restrict the meaning of the term "noun" to substantives. The words to which these different appellations are assigned agree in some respects, and differ in others; and the propriety of ranking them together or separately will depend on the definition given to the noun. Mr Tooke considers both substantives and adjectives as nouns, and as in fact the same sort of words, only that the adjective contains, besides the name of the object, a sign that it is to be coupled in language with some other. We shall, on the present occasion, restrict the term noun to the substantive, and shall use these terms indiscriminately, sometimes preferring the latter as better fitted to prevent any ambiguity on the part of the reader, created by the general usages of grammarians.

Erroneous distinctions.

We may trace in the prevalent method of describing the nature of the noun, as distinguished from other

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founded on erroneous views of language.

parts of speech, some of the hurtful effects of the opinion entertained by grammarians, that the history of language implies a history of human knowledge and thought. Condillac maintains that languages are analytic methods, and are necessary both for giving an account of our thoughts to our own minds, and conducting us to ideas which otherwise we could not have possessed. He thinks that the investigation of them furnishes us with convenient means for the analysis of thought, and he conceives it a radical mistake to regard them merely as the instruments of communication. Conformably with this notion, that author, like many others, considers the different parts of speech as expressions for different kinds of thoughts. We hope gradually to exhibit, in the sequel of this article, an ample collection of facts in refutation of these opinions. We shall, in the mean time, illustrate their fallacy, by pointing out the fallacious character of the metaphysical speculations with which, as applied to the noun, they have been associated.

Are nouns, or substantives, the names of substances?

Substantive nouns have been considered as the names of substances. The word "substance," is derived from *sub* and *stare*, because they are considered as beings existing under the qualities perceived by the senses, and giving these qualities support. It is granted by every person who endeavours to go a step farther back in this speculation, that the nature of a substance, as separate from its qualities, and which metaphysicians, for the sake of distinction, denominate a *substratum*, is unknown. Notwithstanding this, such words as "stone," "earth," "wood," and "iron," are regarded not as the names of particular instances and forms of hardness, weight, visibility, colour, and other qualities which are perceived, but of substrata which possess these qualities.

Doctrine of the French grammarians.

Some grammarians, following a similar theory, have represented the distinction betwixt substantives and adjectives as having for its foundation a difference existing in nature betwixt *things* and their *manner of existence*. Things are said to be substances which exist by themselves, but the manner of existence of things is said to form accidents which only exist in consequence of the existence of substances. This is the opinion advanced by the authors of the *Grammaire Generale et Raisonnée*. Words which signify the objects of thought are, in that work, distinguished into those which signify substances, and which are substantives, and those which signify accidents, and contain at the same time a notification that there is some substance to which these accidents belong. These last words are adjective nouns, or, to express each by a single word, the former are called nouns and the latter adjectives.

Nouns sometimes the names of qualities.

It is, however, an obvious fact with regard to nouns, that many of them are the names of qualities. Such are the nouns, "hardness," "blackness," and "whiteness," which have as much the character of substantives in their use in language as the words, "iron," "wood," and "stone."

Explanations of this fact.

In order to surmount this difficulty, these have been regarded as a secondary or improper kind of substantives, and the ideas expressed by them as not originally entitled to be expressed in that form. They have been considered as originating in a figure of speech by which qualities are treated as if they were substances. The authors of the last mentioned Grammar ingeniously attempt to solve the difficulty, by describing the qualities thus designated as *subsisting by themselves in language*, being so used as to have no need of another noun, although they are, in their own nature, mere accidents. A very little more inquiry would have led these writers to the true doctrine on the subject, that the mode of treating the sign of an idea, and the idea itself by means of it, in language, is the sole foundation of the peculiarities of the substantive noun.

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Discussion of the doctrine of a substratum.

The difference betwixt a substance and its qualities, and the whole doctrine of a substratum, seem to be mere assumptions of an excessively inquisitive species of philosophy. The only real objects of our knowledge are qualities. It is vain to tell us that the qualities are merely the media by which we obtain a knowledge of the substance. Our ideas of the qualities themselves are clear and precise; but we never find that our knowledge of them conducts us one step towards the knowledge of the substratum. The doctrine of the existence of the latter ought therefore to be rejected as an unfounded assumption, and the objects which we call substances ought to be considered as consisting entirely of definite assemblages of sensible qualities. We cannot, indeed, disprove the existence of a substratum, nor can we prove that this substratum is not the cause of the qualities, and the bond of their union. Nature contains riches to which the human understanding has no access. But we must have some intelligible description before we can entertain any idea of it, and we must have some proof of its existence before we can reasonably believe in it. If any person should assert that every particle of earth contains a miniature of the planetary system, we should understand his meaning, and it would not be in our power to disprove his assertion. But we should undoubtedly reject it as unsupported by evidence, and ascribe the belief of it on his part to extreme credulity, a passion for singularity, or some other of the sources of self-deception by which men are so often misled. But the doctrine of a material substratum is not merely destitute of proof; it is unintelligible. The word is pronounced without any appropriate meaning. It is not probable that a notion of this sort obtains among mankind at large. It is probable that the vulgar never think of any substratum containing the sensible qualities which they perceive, and that their ideas of matter are restricted to qualities which are the solid and real objects of their knowledge. The doctrine of a substratum has been invented by men in quest of subtleties; and it seems to have been supported by the other error already mentioned, that the structure of language exhibits an analytical view of our thoughts, and that different kinds of thoughts must be expressed where different kinds of words are used. Man is liable, in such inquiries, to give way to a precipitate curiosity, which leads him to frame hypotheses on subjects beyond his reach. He does not repose in his actual discoveries, but labours to account for what he knows; and, rather than leave this unattempted, he explains what he really knows by something which he does not know, and thus infallibly renders it more obscure. He imagines that he obtains solutions of his difficulties, while he only indulges a confused and mystic feeling associated with the use of particular words.

This doctrine not proved, and even unintelligible.

Qualities the only objects of knowledge.

When several qualities are observed to be constantly united in nature, a strong association is formed among our ideas of such qualities; but if we make a careful analysis of mental phenomena, we shall find that, in pronouncing the name of any material being, certain sensible qualities, more or less vaguely conceived, are the only objects of our thoughts.

This dissertation on our ideas of substances may appear a deviation from the subject of Universal Grammar. But, since grammarians have supposed these ideas to be closely connected with the theory of nouns, it

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seemed necessary, in order to do justice to our subject, that we should shew the fallacy of the common doctrines from the nature of our thoughts, as well as from the structure of language. The views which we have stated lead us to no vague or perplexing conclusions. The fact of the uniformity of the definite combinations of certain material qualities, is in no degree deprived of its solidity or interest, though we decline to admit the hypothesis of a substratum. The rejection of this hypothesis will assist our physical, as well as our grammatical studies. It will relieve us from the embarrassment of the understanding which sometimes takes place when particular qualities are found in a detached state. Those who are unpractised in the accurate exercise of thought, and have been led astray by words, have, in the outset of their physical inquiries, found it difficult to conceive that a body which is felt yet not seen, as the air, has an existence equally substantial with other matter. They have also considered light, which implies an object of sight unaccompanied by any object of touch, as on this account more difficult to be understood than earth, stones, and other substances which are both tangible and visible. The most rational proceeding is to satisfy ourselves with such qualities of tangibility and visibility as we can ascertain in any of their peculiarities and relations, whether they are observed in a state of conjunction or of separation.

(No disadvantage arises from the rejection of a substratum, but the reverse.)

Thus, when we attempt to trace the supposed differences betwixt substances and qualities, we find no foundation for a distinction into two kinds of objects, and much less for a distinction in the kind of terms by which such objects should be expressed. This is the same conclusion to which we are led in tracing the history of nouns. We find that the same kinds of ideas are designated by them as by adjectives.

(The general origin of the peculiarities of the noun.)

If the distinction betwixt nouns and other parts of speech cannot be founded on the place which the objects expressed by them occupy in nature, it must rest entirely on the manner in which they are introduced with relation to the other words with which they are conjoined. It depends on the rank which the word occupies in a sentence, and which the thought excited by it is intended to occupy in that mental series which we wish to produce.

(Inquiry wherein this consists.)

How, then, are we to define the noun so as to distinguish it from the other parts of speech? Shall we, with Mr Tooke, consider it as the "mere name of an idea?" Shall we consider the verb as a part of speech more complicated in its nature, by containing "some circumstance in addition to the name of an idea?" And shall we be induced to extend a similar character of complication, in a smaller degree, to the adjective? This mode of proceeding might at first appear plausible. But, on closer reflection, we shall find that no word, not even a substantive noun, exists as the mere name of an idea, that there is always a demonstration of some further definite use to which it is to be applied. This we know to be the purpose of the variations called cases. Even the nominative case has a peculiarity which does not consist in the want of any such demonstration. The syllable *us* in *dominus*, denoting the nominative case, informs us that the noun is to be connected with a verb of assertion. The genitive case, and all the others in like manner point out some definite use of the noun. If we separate these terminations, and consider them as distinct signs, and regard the radical syllables as containing the essence of the noun, (as in this example the syllables *domin*,) we shall still retain the name of the idea, but we shall have nothing to distinguish the noun from the other parts of speech. If a verb is deprived of all the parts which are intended to connect the idea which it represents with the other ideas expressed in a sentence, we shall, in like manner, retain the mere name of an object. In *domin* we have the radical syllables of the verb *dominor*, as well as of the noun *dominus*.

(An attempt to describe the nature of the noun.)

Taking the noun with all the terminations incident to it, we might still be supposed desirous of giving it a definition. In its different forms we have a variety of uses to which it is applied. With these in our view, we may now ask, what circumstance is common to them all, which does not belong to the same etymon in the form of a verb. It will not be easy to give a formal definition of this. It appears to us to consist in the degree of conspicuousness which the word has in a sentence, and the ascendant interest which the idea expressed by it is intended to have in the mind of the person addressed. The noun is a name for the central object of interest. When we come to consider the different cases, it will be made to appear that they refer us to degrees of importance different from one another; but they all agree in expressing ideas nearer to the central object than those expressed by the other parts of speech; or, at least, this will be shewn to be their original destination. This may seem a very imperfect definition of a particular part of speech: it expresses, however, nothing but what is true; and the same truth will be more fully developed in other instances, as we proceed with the discussion of the various kinds of words. Although no formal definition has now been given of the noun, the purpose of a definition is ultimately answered when it is described by means of a comparison with other words, the only objects from which it requires to be distinguished.

When no termination is affixed to the radical sign, the distinction betwixt its application as a noun and as a verb is designated by its mode of connection with other words in the sentence. When the general idea expressed by the word "love" is exhibited as the chief object of interest, "love" is a noun, and the purposes of speech require it in that use to be connected with some sort of verb, as "love is a pleasing emotion." It is thus fully distinguished from the *verb* "love," which is known to be a verb from having a noun connected with it as introductory. In such sentences as, "I love," "you love," "they love," the subject of discourse is always denoted by a substantive noun. Other substantive nouns may indeed be introduced as subordinate to that which signifies the subject chiefly spoken of. The differences of these relations will be afterwards attended to. In the mean time we shall regard this general purpose as giving origin to that part of speech. In the noun the name of the idea has also greater latitude in the uses to which it is applied. It is a sign by means of which the same idea may, in the progress of discourse, be represented repeatedly, and in a great variety of aspects.

Sect. II. *Concrete and Abstract Nouns.*

Nouns are either concrete or abstract. A concrete noun signifies a congeries of qualities habitually presented together in nature. An abstract noun signifies a quality separately conceived.

(Nature of concrete nouns.)

The words "man," "woman," "wood," "stone," "house," "city," are examples of *concrete nouns.* They are the same that have been considered by grammarians and metaphysicians as the names of substances, that is, of substrata possessing definite qualities. The qualities and the substances have been supposed to

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Concrete nouns.

be firmly conjoined; hence the name concrete, by which their nature is expressed, is derived from the Latin words *con* and *cretus*, signifying "grown together." Though the hypothesis of a substratum is rejected, the term *concrete* is perfectly well adapted to represent a congeries of qualities which have become associated in the mind in consequence of certain specimens of them in nature being habitually found in conjunction. The name of a person well known to us suggests some or all of the qualities by which he is distinguished, such as his appearance, the sound of his voice, and the particulars of his personal character. The name of any well-known river, hamlet, field, or other inanimate object, suggests, in like manner, the distinguishing characters of each. The same thing is even done, though in a different way, by concrete terms of more general application, such as the words "river," "mountain," and "city." Sometimes one quality of the object, and sometimes several, occur to the mind as associated with the word; sometimes merely a vague impression of a scene in which we expect to find certain qualities which are the objects of our remembrance. The limits within which the expectations connected with words of this sort are confined constitute their precise meaning, or mental definition.

Names of habitual groups of qualities.

The scene by which we are continually surrounded consists of groups of sensible qualities, which are various in extent, and variously combined. This diversity gives origin to a diversity of terms. Terms are rendered necessary on account of the subserviency of many surrounding objects to our first wants, and their importance as instruments of mutual assistance among men. When they are present, we may, by merely looking or pointing at them, direct to them the attention of one another, and, when they are absent, we may think of them independently of any names. But, when one man wishes to execute any purpose regarding them in their absence by exciting the ideas of them in the mind of another, he requires signs to represent them; and from the familiarity of the mind with these objects the contrivance of names becomes a very early operation of the social individual.

Abstract nouns.

Abstract nouns are those which signify qualities separately conceived, such as "whiteness," "roundness," "softness," "form," "magnitude," "beauty." The nature of these nouns, and of the objects which they designate, has given rise to controversy. Some have denied that they express definite or separate ideas, because qualities never exist by themselves, but are always attached to some substance; and because it is impossible even to think of the qualities without thinking of the substance. It has, for example, been declared impossible to think of whiteness, blackness, redness, straightness, or hardness, without thinking of a *thing* or substance which is white, black, red, straight or hard. In so far as this doctrine implies the impossibility of thinking of qualities without the substrata, it has been already discussed, and must be laid aside by every person who recollects that the substratum is regarded, even by those who believe most firmly in its existence, as the most difficult to be apprehended of all material objects. Those who imagine that they think about substances to which such qualities as have now been mentioned belong, merely think more or less obscurely of other qualities with which they have a strong inclination to connect those which happen to be named. Each quality is an independent object of knowledge; but the ideas of different qualities are strongly associated in the mind, and the activity and versatility of its operations produce a proneness to conjoin each one that comes into view with others conceived to be collateral. During the first evolution of our senses, our knowledge is acquired by attending to single qualities. Persons who are born blind or deaf, and consequently have none of the ideas imparted by that sense which is deficient to mingle with their other ideas, retain through life a separate conception of certain material qualities which, by the greater part of mankind, are constantly associated with others. When a person, under these circumstances, happens to recover the deficient faculty, the ideas which it conveys are at first separate, and it is only by experience that the habit of associating them with others is gradually produced. This process has been illustrated in the history of persons born blind from an opacity in the crystalline lens of the eye, and cured by surgical operation, at a period of life when their mental faculties were so far unfolded as to enable them to describe their sensations. In mankind at large, the combinations of sensible ideas are formed long before language is attended to; and on this account the structure of language affords no analytical view of the process. If it did, the names of single qualities would be the simplest words, and the names of the assemblages which we denominate matter or substance would be comparatively compound. The reverse of this is the case. The names of habitual assemblages of objects are less compound, because the utility of assigning names to them is of prior suggestion. Single qualities are later in becoming leading subjects of discourse, and hence their names are later in assuming the form of substantive nouns. "Whiteness," "blackness," "redness," "hardness," "straightness," "roundness," are not so short as many names of objects, which comprehend one of these qualities in combination with several others. "Egg" is a shorter word than "whiteness," "soot" than "blackness." Even the names of single qualities, comprehend in their original formation a general mark of reference to some congeries of which they are supposed to form a part, and the name is subordinate in discourse to the name of some such congeries. "White" is the name of a quality, and contains a reference to some congeries to which it is described as belonging. The separate consideration of the quality is a subsequent object of interest; therefore the term for it is of subsequent creation, and an additional sign to denote this separate consideration is attached to it. This sign is the termination "ness." From "white," we have "whiteness;" from "red," "redness;" from "round," "roundness;" from "great," "greatness." Different languages have different terminations adapted to the same purpose. From the Latin *magnus*, we have *magnitudo* in Latin, and "magnitude" in English.

Controversy on the subject.

Can qualities be separated in thought?

Some have denied that we can have any ideas of separate qualities. It must be granted, as has been already observed, that the human mind has a strong propensity to conjoin different qualities mutually as objects of thought, and thus form conceptions of compound individuals. We mentioned, however, that it ought to be recollected that a person whose sensibilities are only as yet beginning to be unfolded has separate perceptions of the different qualities. It is now further to be observed that any person, even one whose habits of association are most inveterate, may direct his *chief* attention to one particular quality. Others may indeed involuntarily intrude in combination with it, or he may have occasion to think of the relations in which it stands to others; but this one in particular is distinguished as the chief object of his attention, and is also thought of with constancy, while the others with which it is accidentally associated are both less attended to and in themselves varying. We therefore see no impropriety in saying that this is a separate ob-

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ject of thought. We are certainly entitled to regard it as a separate subject of discourse. It is this alone that gives origin to such terms, and confers on them all their meaning and utility. If the present were a proper occasion for entering on such disquisitions, we might show that even the names of concrete objects do not always excite in the mind the same constant and definite ideas which are, on mature consideration, attached to them. When a concrete noun implies many ideas, we do not think of the whole of them. When it implies very few, we think of something else with which we suppose them to be in contact. It is seldom that the mind is occupied with the full meaning of any word to the total exclusion of other ideas. Very little difference, therefore, exists betwixt our mode of conceiving the objects signified by concrete and those signified by abstract nouns. The comparatively complicated form of the latter arises from the comparative recency of the period at which a distinction becomes requisite for denoting single qualities as the principal subjects of discourse.

Sect. III. *Particular and General Nouns.*

Nouns are either particular or general. Particular nouns, or proper names, are those which are applicable only to individuals. General nouns (commonly called general terms) are those which are applied to a plurality of objects possessing a mutual resemblance.

Origin of general terms.

When human knowledge becomes somewhat extended, it is impossible to conduct language by means of proper names alone. Individual objects are too numerous to receive distinct names; and, if these were imposed, it would be impossible for the most tenacious memory to retain the nouns of any language. A sense of this inconvenience has been supposed by some grammarians to have given origin to the expedient of arranging objects in genera, each genus including all the individuals which resemble one another in certain particulars, and which on that account receive one common name. Such are the words "tree," "field," "house," "bird," "horse," "elephant," "man," "woman." This history of general terms, however, is not agreeable to fact. Mankind have a *native bias* to give the same name to objects which are nearly alike. They delight to show, in this manner, that they recognise in a new object a character similar to that of something previously known. They prefer the use of words habitually significant to the coining of terms entirely new. This tendency is observed very early in children. They apply the same words even in cases in which the resemblances of objects are not sufficiently strong to render the general application of a term satisfactory. A child introduced for the first time to the sight of an uncommon animal, such as a camel, gives it an appellation borrowed from some familiar object. First, observing its majestic size, he calls it a horse; next, the form of its head, he calls it a sheep; and, by passing from one designation to another, he shows a powerful inclination to apply to it some general term. The application of common names is always most constant where the mutual resemblances of individuals are greatest. When they are perfectly alike, it is as natural to give the same name constantly to them all as to give the same name at all times to an individual.

Are they always originally proper names?

It has been said that all terms are at first proper names. But the name which we first apply to an object is proper only when we are acquainted with no other object resembling it, or when an individual so frequently claims our separate interest, that a name to distinguish it from all others is absolutely necessary. This last circumstance is the foundation of the application of proper names from the very beginning to all our familiar friends, notwithstanding the obvious mutual resemblances of human beings. Under other circumstances, we no sooner perceive resemblances than we form general terms, or, which is the same thing, give a general application to such terms as we possess. With regard to the greater part of nouns, it is probably nearer the truth to say that general terms are first in order, and that men, finding it convenient to designate individuals by single terms, subsequently create proper names, than to maintain that a sense of the inconvenience arising from the mere multiplicity of proper names gives rise to the abridged method of forming general terms. By a tenacious disputant, it might be contended that we become acquainted with objects one by one, and that therefore, if a name is given to the first object of our knowledge as soon as known, it must be a proper name; but this speculation supposes man to form words much sooner than it is possible for him to do, that is, before he possesses any variety of knowledge; a state of things which precludes all occasion for language as well as the possibility of articulation.

The creation of proper names.

General ideas.

Do they exist independently of general terms?

Here it will be requisite to describe the nature of general ideas, a subject which has given rise to much controversy. Some have maintained that no such ideas exist; others, that they owe their existence to the previous formation of general terms. The chief argument against the existence of general ideas is deduced from the fact that, when we endeavour to think separately of the circumstance which is common to all the individuals of a genus, we can obtain no distinct image. To think of "man in general" is said to be impossible. The man of whom we think must be tall or short, naked or clothed, fair or dark, lively or dull. In like manner, if we endeavour to form a general idea of "a tree" by contemplating nothing but what is common to all trees, the image no longer resembles any tree.

Difference betwixt external objects and ideas.

The denial of the existence of general ideas has sometimes been accompanied with a misconception arising from the confounding of two things which are in themselves distinct; the existence of ideas in the mind, and the existence of external objects. It seems to have been tacitly taken for granted that the same laws which regulate external objects should apply to the ideas which the mind entertains concerning them. All external objects are individuals, and therefore it has been supposed that all our ideas of them ought to be particular. External objects retain during the lapse of time their individual identity. The names assigned to them have therefore been supposed to retain one constant meaning in our minds, and this constancy has been regarded as the foundation of our ideas of particularity. Hence proper names have been supposed to be peculiarly exact in their meaning. But the fact is, that, even when we think of the same individuals in nature, our ideas at one time are different from what they are at another. They depend on the state of the mind and on the point of view which we take of the object, independently of any change to which its real qualities are liable. If particularity implies invariableness, our ideas, as existing at a specified instant of time, are the only ones that can be regarded as particular. Ideas of the same external object existing at different times, though resembling each other, may also in some respects differ; and however nearly they may coincide, they are always distinct facts in the mind. When two ideas of the same external object entertained at different times are placed together and called one idea, this idea is general in its nature. Thus proper names have not such a steadiness in the ideas which they excite as has been ascribed to them. We shall further find that the ideas attached at any particular moment to a general term, are not so vague as has been supposed. They have a distinct character; they form a definite affection or state of mind, and that state of mind is a particular or individual fact. Individuality, however, as relating to the idea in the mind, does not form the foundation of any sort of words, because words are understood from time to time, and are considered as retaining the same meaning independently of the fluctuations of human thought. The foundation of this supposed constancy is, that the ideas attached to them have always a mutual similarity. They differ from one another, but this difference has its bounds both in proper names and general terms. The ideas attached at different times to proper names differ according to the situations and aspects in which objects are viewed, and according as the mind takes in the whole, or only a part of any object represented. It is evident that the ideas attached to general terms are subjected to the very same variations. They are also liable to variations peculiar to themselves, arising from the dissimilarities subsisting among individuals of the same genus. This cause of diversity seems to have been exclusively attended to in the inquiries instituted into the subject of general terms. Yet it is not always greater than the other. In some instances it has no effect. This takes place wherever these diversities are so slight or so void of interest as to escape observation. Such are the differences betwixt one *fly*, one *swallow*, or one *mouse* and another. The general terms applied to these objects excite no greater variety of ideas than is liable to be excited by the proper names of individuals belonging to the respective species. It is of importance now to remark, that even general words significant of classes of beings among which prominent distinctions exist, along with the similarities which form the foundation of the general application of the words, are to be considered as retaining from time to time the same meaning, because the ideas which they excite are variable only within certain bounds. Some definite idea is therefore strictly attached to each term. This may be considered as a detached thought, in so far as it may be made the only, or at least the leading, object of attention. We may think of the objects signified by any term as one genus, and investigate their common properties. The versatile nature of the human mind makes it prone to mingle its ideas of these properties with various others, and these others are for the most part such as are combined with the character of the genus to form particular individuals. But the general property may be principally thought of, as well as solely designated.

All ideas of objects, in one sense, particular.

In another sense general.

The ideas attached to both kinds of nouns subject to variations which have their limits.

General ideas do not arise from words.

With regard to the opinion of those who allow the existence of general ideas, yet maintain that they owe their existence to the formation of general terms, it seems to us completely incongruous. A term is invented for the purpose of expressing an idea. The recognizance of a resemblance among a plurality of individuals is the foundation of a general idea, and this always exists before any general term is invented, and before any term which was formerly a proper name receives a generic application.

Degrees of generality.

The resemblances among objects have various degrees of extent. Some genera are much more comprehensive than others. Some include subordinate divisions into more limited genera. The word *genus* as technically used in the arrangements of natural history, represents one stage of subdivision: those immediately subordinate to it are called *species*. If it is found convenient to subdivide these, the subdivisions are called *sub-species* or *varieties*. Those which are more comprehensive than genera are called *orders*. Others still more comprehensive are called *classes*. The most general division of all is into *kingdoms*, called the animal, the vegetable, and the mineral kingdom.

The multiplication of general circumstances contributes to particularity of description.

In the greater part of objects, however, the resemblances pass gradually into one another. One object resembles many others, each in different respects and in different degrees. Every point of resemblance and of difference has a generic name, because many exemplifications of all of them occur. In consequence of the endless variety of existing combinations, we may designate a particular object by enumerating the general properties which meet in it to form its character. It is thus that we describe either a limited species or a single individual. This may be done without giving it an appropriate name. We never pursue a system of classification to its utmost extent, so as to give characters to all the subdivisions that might be formed. However near we have brought any two objects together by the limitations of our specific characters, it is still possible to find out some circumstance in which they differ, either in their intrinsic nature or their external relations; and, if upon this, in union with their other characters, we were to establish a term in our subdivisions, the gradations would be so much extended as to become equally numerous with individuals. Thus classification would produce no compendiousness of plan. It would give rise to as many names as there are individuals, besides encumbering us with the names of all the subdivisions. But we have no motives for proceeding in this manner. In most instances, the peculiarities of individuals, or of very limited species, do not sufficiently interest us. When they excite occasional interest, they are designated as possessing certain specific assemblages of qualities expressed by general terms, and our descriptions are aided by the employment of clear references. To designate the properties of interesting genera, species, and individuals, is a great part of the object of written language. It often happens that not only sentences but books are made subservient to the description of one object. Many others are indeed introduced for illustrating the relations sustained by the leading one; relations which undoubtedly constitute part of the character of these others, and more or less promote the elucidation of all.

Names of single qualities always general.

The terms which designate single qualities are always general. The cause of this feature in language is worthy of investigation. The fact itself has given rise to an idea, that single qualities are not individuals; that they are mere modes applicable to different individual substances; or that, if each quality is an universal individual, it is moveable in its relations with other qualities. But single qualities, wherever they come under our knowledge, are in reality different individuals. The whiteness of snow, and the whiteness of bleached linen, are different objects. The whiteness of one piece of linen is a separate object from the whiteness of another. It is the similarity, more or less perfect, of the objects in all instances of whiteness, that gives rise to the general name of the colour; and it is for no other reason that one common name is given to concrete assemblages of objects possessing a mutual resemblance whether in arrangement or in kind. It is for the same reason that a plurality of objects receives the name of "stone," "mountain," or "field." Yet, however exactly coincident the colour of one object may be with that of another, and however hopeless a task it may be to attempt to distinguish them, except by the differences of their association with other qualities, the colour is in each case a separate individual. It has no proper name; because, while our attention is attracted by it, we are at the same time presented with other qualities (that is, other objects) closely conjoined with it, and it is the combined scene that fixes our attention. It is to the combined scene that we apply a name, in consequence of the joint interest which we and others take in it. The only interest that we have in marking a separate quality of this scene is to point it out as a circumstance in which it resembles others. Hence it is only when we perceive similar objects, that we give this single quality a name. Thus the word in its very creation is general. The exactness of the resemblance which different exemplifications of single qualities have to each other is another reason why generic terms alone are applied to them. Although different objects, they are not intrinsically distinguishable, and the idea which we apply to a plurality of instances of them resembles, in its constancy, the idea attached to the same individual.

[margin: Cause of this fact.]

Even when any congeries of objects has a quality (or, in other words, comprehends an object) altogether peculiar, we give it no distinct name. If it is known to other persons, we refer to it by means of the concrete name by which the group of which it forms a part is known. If it is a peculiar sensation, as some of those which arise from disease, the only description that we give of it to one who has not experienced it, consists in a statement of its total dissimilarity to every other. Even when a kind of qualities belongs to a limited range of assemblages, (or, in other words, a limited species of substances,) we borrow the name of the quality from the name of the concrete assemblage of which it forms a part. The taste peculiar to an apple, an orange, a pear, or a cucumber, although forming each a peculiar class of tastes, has for its only designation a reference to the species of fruit with which it is connected.

Sect. IV. *Etymological History of Nouns.*

[margin: Uncertainty of etymology.]

The transmissions of words from one language to another are so much varied that it is not easy to trace the derivation of all. The simple sounds of which they are composed are but few; for, though the modifications of pronunciation may be infinitely multiplied, these variations do not exhibit distinctions of origin and of meaning. On the contrary, we find sounds which are very dissimilar mutually exchanged in the transmission of a word from one dialect to another. The sounds, therefore, that are inconvertible into others, or the collections of sounds which, though mutually convertible, are never exchanged for any that are different from them, are reduced within a small compass. In reviewing the history of languages, we might at times suppose that almost all sounds are mutually convertible, and, in despair of finding satisfaction from etymological researches, acquiesce in this account of them, *Les voyelles sont pour rien, et les consonnes pour peu de chose.* Such researches are most secure from fallacy when we trace the mutual concordance of languages which are historically known to be akin. When we grasp at the resemblances among the languages of nations which can scarcely be supposed to have ever been connected by mutual intercourse, we are in danger of mistaking for actual derivations instances in which a coincidence has accidentally taken place amidst the sparing number of short combinations which can be produced among a few elementary sounds.

We must therefore in many cases abandon the investigation of the origin of oral signs, as concealed by the total want of documents, or other means of tracing them. In some cases, however, the natural relations of objects to certain sounds discover the origin of words; in others, an evident leading analogy enables us to trace the same radical signs through different languages. In both of these fields of research, we have an opportunity of discerning some important mental operations concerned in the formation and application of languages. We shall therefore take notice of a few general varieties in the derivation of nouns.

[margin: Natural origin of some words.]

Some nouns shew an evident adaptation of sounds naturally connected with the objects which they denote. Whether these sounds have been received into one language from another, or owe their origin to the immediate suggestion of nature, is a matter of little moment. The principle which produces an adherence to the use of them is in both cases the same. Among these we may reckon the nouns *cuculus* in Latin, and *cuckoo* in English, evidently intended to imitate the note of the bird which they signify. The Latin *perdrix* for a partridge is a near imitation of the sound made by that bird when disturbed in the field. Of the same kind are some nouns descriptive of particular sounds. We may take for examples, the words *corn-craik* for the land rail, *peesweep* for the lapwing; *hubble-bubble* for a noisy smoking instrument; also such words as *hiss, splash,* and *splutter.* Though some of them are provincial, and others are reckoned extremely vulgar, they exhibit one feature of the tendencies of mankind in the creation of signs.

[margin: Nouns frequently derived from verbs of motion.]

Many nouns are derived from verbs of motion. This is the case not merely with such as signify certain motions in the abstract. Many concrete nouns are also formed from such verbs, in consequence of the selection of qualities or objects to be concreted being originally suggested by some relation to the voluntary motions of mankind. Of these we have an ample list in Tooke's *Diversions of Purley.* That author seems to consider the circumstance of so many names of objects being derived from verbs as leading to important general conclusions, although these are not specified. This feature of etymology evidently arises from the interesting nature of the voluntary motions of our species. From this cause, as we have already remarked, the earliest and simplest form of words of motion is that of the imperative; a wish to receive assistance from the activity of others being the earliest motive for speech. The interesting character of these motions also appears in the prevalent etymology of names for external objects. Though the objects themselves are previously known, our first motives for contriving signs to represent them arise from their known subserviency to the directions which we mean to give to the actions of others. Their connection with these actions affords a principle by which the surrounding scene of things is divided into groups. "Fruit" is derived from the Latin word *fruor,* to enjoy, the participle of which is *fruitus* or *fructus.* It signifies "aliquid *fruit*-um," or something enjoyed.

[margin: Causes of this. Examples from the Latin language.]

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A "debt" is aliquid *debit*-um.
"Rent" aliquid *rendit*-um.
"Tribute" aliquid *tribut*-um.
An "act" aliquid *act*-um.
"Expence" aliquid *expens*-um.
"Merit" aliquid *merit*-um.
"Accent" aliquid *accent*-um.
"Fate" aliquid *fat*-um.

Examples from the French.

"Alley" is formed from the French verb *aller*, to go, meaning a sort of passage. "View" is from *vû*, the past participle of the verb *voir*, to see, and signifies something seen. "Destiny," *une chose destinée*. The derivation of all these words is sufficiently obvious.

From English and Saxon roots.

Mr Tooke has with great ability traced to a similar origin many English nouns in which it was not formerly suspected. "Spot" he derives from the verb *spit*, of which he considers it as the past participle. The noun "gate," from the verb *go*, or *gae*; "road," from the verb *ride*, signifying a place that has been *rode* upon. "Head," according to him, is from *heav ed*, and means a part elevated. "Heaven" is from the same verb, and similar in its original meaning, though different in its application. A "flood" is something which has *flowed*. "Bread" is grain which, in one step of its preparation for food, has been *brayed*. "Weft" is the past participle of the verb *weave*. The "haft" of a tool is the part *hav'd*. A "hilt" is a part *held*. "Brood, breed, and brat," are from the Saxon verb *bredan*, to cherish. "Hand" from *hentan*, to lay hold of. "Fang" and "finger," from *fingan*, to take. "Truth" comes from the verb to *true*, and signifies that which a man *tru-eth*, or believeth. "Birth" is that which *bear-eth*: "Growth" that which *grow-eth*: "Wealth" that which *weal-eth*: "Earth," that which a man *ear-eth* or plougheth.

Some of Mr Tooke's etymologies, tending to the illustration of the same general remark, have been disputed; but the etymologies substituted on these occasions generally turn out to be of a similar nature, deriving the names of substances from verbs of motion.

Nouns in *ment* and *tion* both concrete,

When a concrete noun is intended to convey the impression of a connection betwixt an object and any voluntary human act, the etymology is for the most part intentionally obvious. Thus from the verb command we have the noun "commandment," for a sentence employed in commanding. From accompany we have "accompaniment;" from judge "judgment," or opinion; from invest "investment." A great number of nouns of this description derived from Latin verbs, terminate in *tion*; as "fraction, sanction, conflagration, collision." Some terminate in *ance* or *ence*; as "resistance, inheritance, science, prudence." We have others from the same language with different terminations; as "lecture," from *legere* to read. From the English verb know, we have the noun "knowledge." Sometimes nouns are formed, by adding to a verb the termination *ing*, as "landing" from land, and "fighting" from fight. Sometimes the use of the word as a noun is not indicated by any particular sign, but merely by the scope of the sentence. The words "love," "fight," "stand," "fold," "tie," "fly," "escape," are used both as nouns and as verbs.

and abstract.

Nouns of a similar structure, and sometimes the very same nouns, are used to express the abstract ideas comprehended in verbs. "Government" expresses either the abstract idea of the act of governing, or the concrete ideas of a particular instance in which this act is exercised, as "the British, the American, and the Turkish governments." Even the more general expression "a government," is concrete, while "government" is abstract. A similar two-fold application may be made of the nouns "reflection," "understanding," "judgment," "pleasure," "love," "decision," "repetition." We may speak of "love" in general as an affection of the mind; or, a swain, in speaking of his mistress, may call her "his love." We may speak of "judgment" and "reflection" as faculties of mind, or we may call the sentiments resulting from their employment, "judgments" and "reflections." It was, at one time, common in our language to employ different forms of the word on these two occasions. We had, for example, "excellence" and "dependence" in the abstract; and "excellency" and "dependency" in the concrete.

Derivation from adjectives.

Many nouns, both concrete and abstract, are derived from adjectives. Instances of concrete nouns of this origin, we have in the word "white," for the white of an egg, and in the appellation "black, or negro," for a man of a black complexion. On the same principle, articles of merchandise are called "goods." Regiments are distinguished by the designations of "the blues," "the buffs," or "the greys;" and showy persons are denominated "beaux and belles." These words denote collections of ideas, or qualities, each under a designation borrowed from one of the most conspicuous. Hence they are described by Mr Tooke as specimens of subaudition, one quality being mentioned, and the rest which form the individual understood.

Many of them approach in their nature and etymology to nouns which are derived from verbs by passing through the medium of the participle, a part of speech resembling in some respects the adjective, and often considered by grammarians as in no respect different from it.

Abstract nouns also, or the names of single qualities, are derived from adjectives. This is done in our language by the addition of the termination *ness* as in "goodness," "whiteness," "brightness," "redness." Whether or not this termination is originally the same with the French word *nez*, signifying nose, and with the termination "ness," as applied to projecting points of land in such proper names as "Inverness" and "Sheerness," we shall not stop to inquire. Whatever is its derivation, it has the same meaning with the word "quality." Whether it was, at any former period, a separate word under a different extent of application, is a question of inferior importance. A termination regularly used as a sign has all the distinctness of a separate word, though written more close to another connected sign, and sometimes involving a greater rapidity of pronunciation.

Abstract nouns derived from adjectives belonging to other languages are various; some terminating in *tude*, as "gratitude," "magnitude;" others in *ty*, as "purity," "propriety;" or in *ence*, as "prudence," "science," and "patience."

Some abstract nouns are derived from compound adjectives owing their origin to previously existing nouns. "Loveliness" is derived from the adjective "lovely," which comes from the noun "love." We have, in like manner, "faith, faithful, faithfulness;" "boy, boyish, boyishness," and many other exemplifications.

Abstract derived from concrete nouns.

Sometimes an abstract is derived from a concrete noun, by means of a termination, as "boyhood" from "boy," and "neighbourhood" from "neighbour."

Abstract nouns applied as concretes.

Nouns originally abstract are often applied as concretes. A female possessed of the qualification of beauty, is called "a beauty;" a person of a strange character, "an oddity;" and a curious object, "a curiosity."

Mr Tooke endeavoured to prove by the etymology of nouns that abstraction was not an act of the mind, but only an operation in language, and that the whole operation consisted in subaudition. We have found his account of the subject applicable to nouns derived from words signifying single qualities and used as designations of compound objects, while the other qualities are understood. But all these nouns are concrete. Mr Tooke does not acknowledge any difference betwixt these and the nouns which grammarians distinguish by the appellation *abstract*, such as "beauty," "elegance," and "prudence." Without even remarking that they had ever been considered as of a different nature, he includes them in the list of those which imply the operation of subaudition. He considers *providentia*, "providence," as the neuter plural of the participle *providens*, and meaning "provident things," *i. e.* expressing one quality with the subaudition of others. This subaudition is indeed more general than it would have been in the word *providens*, if such a word had been used for "a provident person." He probably considered it as a mode of contriving a word capable of being adapted to every example in which the property denoted is found. But the opinion of this author is not stated with the explicitness due to its singularity and its importance. We must confess that it seems to us totally unfounded.

We have already observed that it is in our power to make single qualities the principal objects of thought, and that no greater difficulty exists in thinking of them exclusively than in making the idea represented by a proper name, at any time, the full and only object of thought. The etymology here advanced by Mr Tooke appears in itself fanciful. Nouns in *antia* and *entia* are the only ones which give it any shadow of countenance. The genius of the Latin language does not incline to the use of other neuter plurals as names for separate qualities. In English, indeed, we say, "the agreeable," "the picturesque," "the sublime," "the beautiful," instead of "agreeableness," "picturesqueness," "sublimity," and "beauty." We also adopt the Latin expression from Horace, "the *utile*" and "the *dulce*." But whatever the etymology of the nouns called abstract may be, the manner of their signification is that which we have already stated.

SECT. V. *The choice of Designations, and the nature of the Pronoun.*

WHEN a compound object is designated by a noun which expresses one of its qualities with a subaudition of the rest, there is evidently no reason why the same quality should always be selected for a designation. Every such object resembles in some one quality a number of others, and admits of being placed in the same class with them. In a different quality it resembles a different set of objects. Hence it may receive various general designations. The choice which we at any time make of a designation for it depends on the design which we have in view in distinguishing it from others. The same human being may be called "a man," "an African," "a slave," "a negro," or "a fool;" or he may be designated by some occasional temporary circumstance; he may be called "a debtor," "a creditor," "a patient," "a culprit," or "a witness." In using any one of these terms, we wish to call into view the very same individual, with all the parts and qualities essential to him, but designated by one of these as the most appropriate to the point of view in which the tenor of our discourse leads us to represent him. Those who regard his proper name as his chief designation will consider the others as occasional substitutes for it. But even that name may be common to him with some other men. If he has two names, (which is the case with Europeans,) a personal and a family name, he will have one of these in common with several other persons, and the other in common with a different number; and it is by the combination of the two that he is distinguished. But this very combination may happen, in some instances, to be applicable to another person equally well known to us. We must then add a third mark of distinction, such as one depending on differences of age, country, or profession. Any designation becomes completely distinctive or not according to the occasion on which it is employed. It is probably most accurate not to consider one as substituted for another, but to consider each as rendered proper on particular occasions, when a complete and interesting distinction is thus formed.

These considerations will lead us, by a direct road, to a proper estimate of the *personal pronoun*, which many grammarians have reckoned a separate part of speech, and have defined to be "a word that is used instead of a noun." Its whole office is to point out an individual by an occasional mark which distinguishes him completely from all others. It is often shorter than the name of the individual, and this seems to have led some to conceive that it is contrived for the purpose of abbreviating discourse. But it does more than this; it points out the person referred to in the most interesting temporary relation.

The *first* personal pronoun *I*, denotes "the immediate speaker" as distinguished from others by this circumstance in preference to any other character that he may bear. The *second* denotes "the party addressed" as characterised by the present circumstance of his being addressed. This character is preferred to any other that he may bear, as distinguishing him from other persons. The *third* personal pronoun has been erroneously defined to be a mere negation of the other two. This is not implied in it. When Cæsar, describing his own actions in his Commentaries, uses the third person, sometimes employing his own name, at other times *ille*, he shews that these designations are applicable to the person who speaks or writes, as well as to others, although it is most natural for all men to use peculiar words for themselves as speakers. Among some nations it is considered as treating the person addressed more delicately, and tending less to look him out of countenance, to call him *he* than *thou*. The Italians say, *Come sta*, literally, "How does he do," instead of, *Come state*, "How do you do;" and the French, in like manner, say, *Monsieur comment se porte-t-il.* A rustic girl in this country meeting a familiar friend, says, with a kind of mirthful respect, "Where is she going?" for "Where are you going?" It is also to be remarked, that a mere negation of the circumstance of being either the speaker or the person addressed would never afford a sufficiently distinctive character, and therefore could be of no use as a designation. The real office of the third personal pronoun is to designate an individual by the circumstance of "having been lately mentioned," or "much nearer to the thoughts both of the speaker and the hearer than any other who could, on that occasion, be referred to by a similar circumstance." It is thus sufficiently distinctive at the moment to prevent ambiguity.

To have a closer illustration of the nature of the pronoun, we may observe that some designations are much

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Singular opinion of Mr Tooke.

Designation of the same object various.

The pronoun is a noun, not a substitute for one.

Meaning of the first and second personal pronouns.

Erroneous description of the third.

Its real office.

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Designations different in degrees of permanence.

more durable than others. The designations "man," "king," "Dane," "Indian," "sailor," "soldier," are of a permanent nature. Some are founded on more limited external relations, and are seldom used with propriety except in particular connections, as "father," "brother," "friend," "enemy." These generally require mention to be made of the object to which the individual bears this particular relation. Others are merely temporary and occasional, as "plaintiff," "defendant," "speaker," "hearer," "buyer," "seller," "assistant," "opponent." All these words are used on particular occasions with as great propriety as the names, or any other designations of the persons spoken of. Of this last occasional kind are the words called personal pronouns. They distinguish individuals by the temporary characteristics now enumerated.

Personal pronouns the least permanent.

Origin of the prevailing doctrine.

What then has led grammarians to assign to these words a separate place in language under the name of pronouns, and to describe them as possessing the peculiar character of being the substitutes of nouns?—The only circumstances in which they differ from other appellations are, that they are shorter and more familiar. Their shortness has probably made them appear unique, and their familiar recurrence has made them appear of peculiar importance. The frequency of their use, though worthy of attention, is a quality attached to words in various gradations. In this instance we have perhaps the acmé of frequency, because the pronouns are founded on the very circumstance of the use of language. Language always implies a speaker, who to himself appears important, and a person addressed, who, in order to be operated on with advantage, has a prominent interest assigned to him in our discourse.

Their brevity.

Their frequent use.

Etymology of pronouns.

It is probable that pronouns are of very early origin. Attempts have been made to trace the etymology of the first and second in some languages to a word signifying the hand, or some other object near and inseparable. It is sufficiently natural to suppose that persons who have words to represent such objects, and no personal pronouns, might resort to such expedients. But it is equally supposable that certain sounds might, in the very first instance, be applied to this use, on the same arbitrary principles which must have regulated the pristine application of the greater part of articulate sounds.

If no pronouns were in use, a speaker would probably point to his own body in speaking of himself, and to that of the person addressed in speaking of him. On this account some philosophers have considered it as the peculiar nature of the pronouns to be "substitutes for that pantomimical act." But the act of pointing is also used in designating other objects that are presented, especially if the speaker and hearer have no language in common.

General characteristics of the personal pronouns.

The personal pronouns combine a great degree of generality in their use with a well-marked particularity in the instances of their application. The word *I* may be applied to any person, but only by one speaker, viz. that person himself. The quarter from which the sound proceeds determines its exact application. In the same manner *you* may be applied to any one individual, but only when the words are particularly addressed to him, and this circumstance gives us on every occasion an unerring indication of its use. *He* may be applied to any *man*, *she* to any *woman*, *it* to any *thing*, and by any individual. But they imply no reference to the present use of language. They imply some previous mention of the object referred to, and this must be well understood in order that their particular application may become intelligible. They have exactly the same meaning with the word "foresaid." Some assistance is given towards the ready understanding of their application by distinctions founded on personality and sex. The pronoun *it* is distinguished from *he* and *she* by the absence of personality; *he* from *she* by the circumstance of sex.

Vague use of the term pronoun.

The term pronoun, as used by grammarians, is on the whole productive of confusion and ambiguity. It is extended to some adjectives, which are called pronominal adjectives, or adjective pronouns. Such are *ille*, *hic*, *alius* in Latin, and *this*, *other*, in English. The word "other" has evidently the same meaning with "different," although neither the English word "different" nor the Latin word *diversus* is ever included in the list of pronouns.

Sect. VI. *Genders.*

In the following Sections of this Chapter we shall consider some prevailing marks which accompany the application of the noun, and which adapt it to particular purposes.

Distinction of sex influences language.

As our own species comprehends the most interesting subjects of discourse, any common distinctions found among them appear worthy of being pointed out. The situation of the two sexes in society, and their general habit and appearance, afford the most remarkable distinction, and the implication of this naturally accompanies the mention of individuals. Even when it would not be sufficiently interesting to be mentioned, provided a separate word were required for the purpose, it is sufficiently important to determine some part of the names by which persons are designated. The Greeks and Romans effected this by differences of termination. The English language has current proper names exclusively applicable to a particular sex. Similar differences are implied in the names given to domestic animals, and sometimes to animals of other kinds.

Some languages injured by excess in the application of the...

But language has not always stopped at this reasonable point. The active imaginations of those by whom it has been modified have, from vague analogies, ascribed sex to objects destitute of it. In Greek, Latin, and French, this is done in very numerous instances. In French, the genders of nouns are not easily distinguished by their terminations, yet a particular gender is uniformly attached to each, and regulates the termination given to every adjective agreeing with the noun. The details of the genders must therefore be studied by every person who wishes to speak the language with sufficient accuracy to preserve him from ridicule. These circumstances render that language of difficult acquisition.

In the Hebrew, Italian, Spanish, and French languages, there is no neuter form, so that every object must, in the syntax of words, be either masculine or feminine.

Speculations on the cause not important.

Attempts have been made to account for this prevalent arrangement, which appears in itself so absurd. But no explanation has been given that is sufficiently steady in its application to afford material assistance in facilitating the acquisition of any language. Names of objects which are masculine in one language are feminine in a second, and neuter in a third. Names of objects of the same kind, and even nouns that are synonymous, differ in their gender in the same language. Those who take pleasure in tracing these whimsical proceedings in the formation of language, will find some ingenious remarks on the subject in Harris's *Hermes*, and Tooke's *Diversions of Purley*.

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The English, the Persian, and the Bengalese languages are free from the embarrassments of arbitrary genders. In English, indeed, a few objects destitute of sex have a phraseology applied to them borrowed from sexual distinctions. But this is on rare occasions; and, as no marks of gender are attached to our adjectives, the inconvenience now stated does not occur. The whole difference in the adaptation of other words consists in the use of the personal pronouns *he* and *she*. This application of words denoting sex only partakes of the nature of poetical personification. It does not consist in such an adherence to gender as affords a basis for grammatical rules. The sun is called *he* on the same principle on which we might compare that luminary to a king, for the splendour which surrounds him; to the cherishing father of a family; or to a presiding mind, by which extensive systems are regulated. The moon is called *she*, on the same principle on which it might be compared to an eminent female who does not overawe by an oppressive effulgence, but diffuses a mild radiance, productive of a gentle pleasure.

Sect. VII. *Number.*

That accident of nouns which we call *number* is a sign for representing the exemplification of a general idea in more than one individual. It does not apply to proper names. A proper name is in its nature descriptive of only one object, and therefore essentially singular. As soon as it becomes susceptible of plurality, as when we speak of the twelve Cæsars, or the seven Jameses, it ceases to be a proper name. Spain is the proper name of a country, and Spaniard has by some grammarians been called the proper name of a people; but the latter is a generic word characterizing any one of a great number of persons by their connection with Spain. When a name is applicable to two individuals, these are to be considered as constituting a limited genus. This circumstance may not depend on any inherent character, but may be an accident occurring in the transference of proper names. The name is originally intended, in both instances of its application, to be completely adequate to distinguish an individual from all those with whom he might have been confounded. But, when the two individuals chance to meet in the same place, or to be mentioned near to one another in discourse, they must be distinguished. If the name of both is Scipio, they are to be considered as a genus coinciding in this trivial circumstance of their history, that they have received the same name.

Some nouns which are general in their acceptation do not admit of a plural, because the objects which they signify are not permanently portioned into individuals. This is the case with nouns which express such plastic materials as are capable of being easily arranged in pieces of any form or size. We have examples of it in the names of the different metals, as "gold," "silver," "iron," and "brass," words which are never used in the plural. The plural word "irons" is not applied to pieces of the metal, but to instruments formed of it. The noun "stone" is also the name of a material of which variously shaped objects may be formed; yet it has a plural in frequent use, because nature divides it into masses which are not easily reunited so as to become homogeneous. These objects have therefore more of the character of permanent individuals. Such words as "gold," "silver," "clay," "dough," may be said to have neither singular nor plural, and to be entirely independent of number. We cannot prefix to them the word *a*, which is the sign of the singular, with any greater propriety than we can invest them with the plural form.

Etymologies of the plural number.

In most languages, nouns receive alterations in their spelling for the expression of plurality. These sometimes consist in the addition of a letter or a syllable, sometimes in the substitution of one for another. Such alterations, however, are not absolutely necessary. Number might be pointed out by separate words, or might be inferred from the connection. Many English words have no distinction betwixt their use in the singular and in the plural, such as "sheep," "grouse," and "deer." Some Latin words are the same in singular as in the plural in one or more of their cases. *Fructus* signifies "fruit" or "fruits." *Res*, "thing" or "things."

In Bengalese.

It is not easy to discover by what circumstances a community, during the formation of its language, has been influenced in choosing its mode of expressing plurality. Some grammarians have thought that much satisfaction would be obtained if we could always trace the plural termination to some separate word signifying a *collection*. The addition of a term of this sort is the mode of expressing plurality in the Bengalese language. *Projaa* signifies a peasant, *lok* people: and *projaa-lok* signifies peasants.

Hypothetical origin of the plural in Hebrew and its dialects.

The authors of Rees's *Cyclopædia* derive the plural sign in Greek, Latin, and the modern languages of Europe, from a word in the Hebrew language המון, which signifies multitude. They suppose that this word was at first subjoined to the singular word, and that afterwards, for the sake of brevity, the Hebrews designated plurality by retaining only one of the letters, *m*; the Chaldeans, Syrians, and others, by retaining the *n*. Thus the plural was in Hebrew *-im*, in Chaldean *-in*, in Arabic *-oon*, and in Persian *-aan*. This theory further supposes the letters *n* and *s* to have had the same origin.

In Greek, Latin, and more modern languages.

The Chaldean *-in*, therefore, is supposed to have become *-es* in the formation of many Greek and Latin plurals. From the same source they even wish to derive the *s* which forms the plural terminations in English and French; while the Italian language is considered as following in all nouns the analogy of the second declension of the Latin by adopting the terminating vowel *i*. The same authors might have added, that this *i* of the Latin and Italian is the vowel letter of the Hebrew plural *im*, (ים.). This vowel does not, indeed, happen to belong to the independent word המון, which they consider as giving origin to the plural sign; but we find it used in Hebrew not only along with the letter *m* for a familiar sign of plurality, but also by itself (י.) And it was sufficiently natural that a language derived from the Hebrew should adopt this plural sign.

Estimate of such hypotheses.

This whole style of etymology, however, is questionable. It has indeed the authority of Horne Tooke's approbation. One great principle of that author was, that terminations were originally separate words; and another principle was, that the alterations which take place in the progress of language have an abbreviating tendency. But terminations ought to be considered as equally independent signs in this form as if they were separate words; and when any idea is of perpetual occurrence in language, as that of plurality is, it is natural to expect that the sign used for expressing it should be originally brief. Signs, however, are often changed. With some people, the mere circumstance of being long familiar renders both words and terminations of words apparently stale, and they apply themselves to the contrivance of others in their stead. These others are generally derived from sounds previously used for ideas somewhat akin.

Probable origin of the English plural in *s*.

The English plural termination may, we think, be traced with greater probability, as well as greater beauty, to a later origin than that now mentioned. Our terminating *s* seems to have arisen from a syllable which was once applied to signify a more extensive modification of the uses of the noun, and was gradually varied, in the improvement of our language, for the purposes of more precise distinction. It was anciently the syllable *is*. "Towns," the plural of town, was *toun-is*. The same syllable was also used for what we call a genitive. "Father's" was *father-is*, or *fader-is*. It is only among those who are inordinately attached to the present habitudes of our language that the termination *is*, in these two applications, will be considered as necessarily of different origin. The sign for the genitive and that for the plural are only different exemplifications of one sign which in its meaning includes both. It was simply a term of relation synonymous with the English preposition "of," i. e. "with respect to." "Bees," for example, signifies relating to the bee; "bees wax," wax connected with the bee; "two bees," a repetition or doubling with respect to the bee. "Scot," is a designation for a native of a particular country. "Scotis," or "Scots," means relating to such a native. Two individuals are "two Scots;" a "Scotswoman," a woman relating to Scot; and, in the same manner, the word might be used in such phrases as, "the Scots court," "Scots customs," "a Scots dress." The meaning of the letter *s* in these different instances is not different: it is only general; and, therefore, susceptible of different specific applications. Any particularity in the application intended was, in the first instance, left to be inferred from the connection; and, afterwards, some slight differences in its orthography, pronunciation, or both, were adopted, and appropriated to the different applications. We have "Scot's" for the genitive; "Scottish," or "Scotch," for the descriptive adjective; while "Scots," if used at all, is restricted to the plural.

Our plural form receives other applications.

This derivation of the English plural from a more general modification of the noun will acquire confirmation when we reflect that, in spite of the strictness of formal grammatical rules respecting the plural number, we often use the same form of the noun which denotes plurality, on different other occasions. We speak, for example, of introducing a knife "lengthways," though the way is only one. "Edgeways" is used in the same manner. The word "otherways," now changed to "otherwise," is a similar example. "Sides foremost" is a common provincial phrase in some parts of England. We speak of going "up stairs" or "down stairs" where there is only one stair, meaning up or down with respect to stair. Some of the English even speak of going "up streets" and "down streets." A boy in tossing a halfpenny calls "heads or tails," though it has only one head and one tail. If to the question, "Have you any pens?" a person should reply, "yes I have one;" the answer would be condemned by some as ungrammatical, because one pen is not plural, and a person who has only one cannot be said to have "pens." Yet we have a constant tendency to this mode of speaking. Common sense, adhering to the powerful analogies of language, bears down the authority of formalizing systems, even in cases in which she does not possess sufficient dialectic knowledge to vindicate her proceedings. The word "pens" in this instance is merely general. It is independent of all ideas of number. It is no more restricted to plurality, so as to exclude the singular, than it is restricted to two, four, or any particular number. Had the word "pen" been used in the question now alluded to, it would have been considered as exclusively singular. But it was necessary to use one of these forms of the noun, in order to represent the genus independently of number. To prohibit the employment of any form of the noun in a manner thus general, would imply an extreme obstinacy of artificial regulation in no degree conducive to accuracy. The want of a *separate* form for this general application of the noun, independently of number, sometimes gives rise to the following awkward circumlocutions in proclamations and legal writings: "If any *person or persons* shall transgress in the manner underwritten, *he or they* shall be subjected to the following punishments."

Plural in *en*.

Another English plural is formed by means of the termination *en* as in oxen. Such plurals were much more common at a remote period of the English language. *Housen*, for example, was used for "houses." They abound in the modern German, which owes them to the same source. This syllable, like the one already mentioned, was originally of a more general application, signifying "of or relating to." The application of it which is most abundantly retained in English is for the descriptive adjective, as "wood*en*, earth*en*, gold*en*," words the same in meaning with the phrases "*of* wood, *of* earth, *of* gold." The old English language was little varied in its modifications. The syllables *is* and *en* both expressed the general circumstance of relation betwixt the idea expressed by any noun to which they were attached and some other. They were applied indiscriminately to relations of every kind, and the occasions of discourse were trusted to for the suggestion of particular ideas. A desire of improving the language amidst the multiplicity of relative ideas which arose from intellectual improvement, led our ancestors to appropriate one termination to one subdivision of that general meaning, as well as to produce a still greater particularity, by varying the modes of writing the termination. The English thus made a nearer approach to the copious and refined languages of classical antiquity. The final *s* and the termination *en* came to signify important distinctions, *en* being used to form the descriptive adjective, and *s* for expressing various relations, including that of plurality. Wood*en* is the adjective: wood*s* is the plural. The word ox is an instance in which the *en* is retained as the plural sign, and the *is* (in ox*is* written ox's) is the genitive. We say a "drove of ox*en*" for the plural: "an ox's gall" for the genitive. Here we have a specimen of the simple but effectual expedients to which mankind so readily recur in order to express the varieties of their thoughts.

Sect. VIII. *Cases.*

General account of cases.

Cases are changes of form to which nouns are subjected for the purpose of denoting annexation. Some of them are more general than others. The marks of annexation are external to the name of the object, and might therefore be expressed by separate words. But they are often attached to the name in the form of terminations. This circumstance, though not affecting their meaning, occasions a particularity of aspect in certain languages in a written state, by abridging the number of words, and also a particularity of sound when a language is spoken, because a termination is placed after the name of the object, but a preposition before it. The cases often express circumstances so general and so evanescent, that no separate word to represent them has ever been used. On this account, it

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is convenient, even in a philosophical treatise, to consider them in conjunction with the noun.

The Nominative not mere name.

The *Nominative* has been represented by some as implying nothing more than the name of the idea expressed by any noun, and therefore the least complex of the cases. But it always has a reference to a verb, and this verb for the most part follows it in the same sentence. It often happens that, compared to the other cases, it is short, and that the others are distinguished by the addition of one or more syllables. Of this we have instances in the Latin nouns *vir* and *sermo*. But it more frequently happens that the nominative has a peculiar termination, and that in the formation of the other cases this is left out, and its place supplied by different terminations affixed to the radical letters. The radical letters of *dominus* are *domin-*, and the *-us* is as much a separate sign as the *-i*, *-o*, *-um*, *-e*, *-orum*, *-os*, and *-is*, which form the other cases. *Dominus* is therefore something more than the name of an object. It would be contrary to the analogy of language, and of all the operations of the human mind, even the least correct, to suppose that the syllable *-us* has no original meaning. We may pronounce it a superfluity, if the definite application of the noun which it expresses can be understood without it. Yet we have no right, on this account, to pronounce it destitute of meaning. It is in fact a sign of connection with another word of definite character and use, the verb.

It a sign of connection with the verb.

We have farther to observe, that the nominative gives the noun a higher rank in a sentence than the other cases. It differs from them in a manner nearly resembling that in which the noun differs from the other parts of speech. It expresses the central or focal idea, to the description of which the other words in a sentence, including the other parts of speech and nouns in the other cases, are subordinate.

Sign of the ascendant importance of the object in discourse.

Apparent exceptions accounted for.

The sentences which may appear exceptions to this doctrine are very numerous. This is occasioned by the general pursuit of that variety which gives elegance to language, and by the presence of other circumstances which preserve the importance due to the leading subject of discourse. By some writers the hero of a biographical narrative is mentioned in the nominative case more uniformly than by others; but by none is such a rule invariably followed. Suetonius probably follows it as often as any writer, and thus gives his biographical delineations a more concentrated force. Yet this author, in relating the death of Julius Cæsar, introduces the persons by whom he was killed in the nominative case in preference to Cæsar himself, thus making them apparently the most important subjects for a time. ASSIDENTEM CONSPIRATI *specie officii circumsteterunt: illicoque* CIMBER TULLIUS, *qui primas partes susceperat, quasi aliquid rogaturus, propius accessit: renuentique et gestu in aliud tempus differenti ab utroque humero togam apprehendit, deinde clamantem, "Ista quidem vis est"* ALTER CASSIUS *adversum vulnerat paulum infra jugulum.* 'The conspirators, under pretence of shewing 'Cæsar respect, stood up around him as he sat. Then 'Cimber Tullius, who had undertaken to commence the 'deed, approached nearer to him, with the apparent design of making some request. As soon as he observed 'that Cæsar, by a wave of his hand, declined conversation, 'and put him off till a future time, he laid hold of him by 'the toga on both shoulders an act which made Cæsar exclaim, "This is downright force." At that instant one 'of the Cassii wounds Cæsar in the neck.' In the relation of these circumstances Cæsar might have been mentioned in the nominative case, thus: 'Cæsar was surrounded by 'the conspirators affecting to pay him respect, was approached by their chief Cimber Tullius, who pretended to 'make some request, and, on waving his advances, was 'seized by the toga on both shoulders; but as he exclaimed, "This is downright force," he received a direct thrust 'of a mortal weapon from the hand of one of the Cassii.' This mode of writing would keep the mind of the reader more constantly fixed on the person who is the chief subject of the narrative as a whole; but it would often render language insupportably monotonous. The author, therefore, relieves the attention of his readers, by assigning in some of his details a subordinate place to the principal personage. His importance is always maintained by the ultimate tendency of the narrative, as well as by the advantage of being more frequently than any other subject mentioned in the nominative. After the historian has, in the manner now described, varied the current of his language, he is enabled, with gracefulness as well as force, to introduce the chief subject in that mode of diction in which he will hold, by means of the nominative case, the most dignified rank in the sentence. After these details of the conduct of the conspirators, Suetonius thus proceeds: CÆSAR *Cassii brachium arreptum graphio trajecit: conatusque prosilire alio vulnere tardatus est. Utque animadvertit undique se strictis pugionibus peti, toga caput obvolvit: simul sinistra manu sinum ad una crura deduxit, quo honestius caderet. Atque ita tribus et viginti plagis confossus est; uno modo ad primum ictum gemuit, sine voce edito.* 'Cæsar seized the arm of Cassius, pierced it with his writing style, then endeavoured to rush 'forward, but was prevented by another wound. Finding himself assailed in every direction with drawn 'swords, he covered his head with his toga, and in order that he might fall with the greater decency, drew 'the lap of it with his left hand over his limbs. Thus 'he fell, stabbed with twenty-three wounds. He emitted a single groan when he received the first; but met 'his fate without uttering a word.' The peculiar propriety and force of these latter sentences, and a slight character of inversion of which we are sensible in reading those which precede them, are proofs of the superior rank of the nominative case.

The Vocative. Its early use.

The *Vocative* case, or that which is used in naming the person addressed, comes next in order, not merely from its frequent coincidence in form with the nominative, but from its being probably of earlier origin in the proper names of persons than any other form of the noun. It is peculiar to nouns which designate persons, because it applies only to beings capable of hearing what is said. In these, however, it seems to be prior in the order of nature to the nominative. The Latin vocative, wherever it differs from the nominative, inclines to greater brevity. *Virgilius* was addressed *Virgili*, *Minutius*, *Minuti*, *Dominus*, *Domine*, and *Filius*, *Fili*. In this characteristic the vocative case of the noun resembles the imperative of the verb. Being the earliest use of the word, it is its shortest form.

The other cases.

When we enter on the consideration of the *Genitive*, *Accusative*, and *Dative* cases, especially the two last, it is found difficult to assign to each an invariable meaning, however general. In particular phrases their uses are steady; but no principle strictly universal seems to regulate their application. The most comprehensive that we can adopt is found liable to exceptions. The most likely way to discover their original meaning is to observe the prevailing application of each, and also to enquire if there is any circumstance of application, however limited, which is peculiar to one. It is thus also

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that we shall be most likely to trace the species of idiom which has given origin to such exceptions as occur. Some have proceeded in a contrary direction. They have first attached to the particular case a plausible general meaning, and then exerted their ingenuity to show that this meaning would be found applicable to instances which at first appeared most distant from it. But these modes of explanation might easily be applied to account for any possible substitution of one case for another, and therefore are erroneously considered as illustrations of a principle, while they are exceptions to a rule.

General remarks on the oblique cases.

It has been common to consider the different cases as intended to express different sorts of ideas, or different relations existing betwixt the objects named. On mature reflection, we find it more conformable to the general aspect of the facts, to consider them as referring rather to the different parts of speech with which the noun is connected, and the different degrees of importance which are assigned to the idea in the present use of language. These circumstances may sometimes arise out of permanent relations; but this does not uniformly take place, and therefore the cases do not depend on them. This opinion derives presumptive evidence from the illustrations already given of the nominative and the vocative.

Our attention will be chiefly directed to cases as exemplified in the Latin and English languages. The Greek cases follow different rules, a comparison of which with those of the Latin language might suggest some interesting conjectures respecting their original uses; but they would lead us into details too extensive for the limits of this article. The Latin language, when it borrowed its cases from the Greek, deviated from the parent language in the extent which it assigned to each. A different conception seems to have been attached to the use of them. This appears in a particular manner from the addition which they have given of an ablative case, which does not depend on a subdivision of one of the others, but is in some of its uses substituted for the genitive, in others for the dative of the Greeks.

The variations and exceptions to general rules which are so often practised in the use of the cases diminish their importance in the doctrines of universal grammar. Such distinctions as they imply might have been in most instances dispensed with. The discussion of them partakes more of the character of an inquiry into the conjectural history of particular dialects than of an investigation of the radical principles of language; and the length to which that discussion sometimes extends is due rather to the difficulty than to the importance of the subject.

The Genitive

The *Genitive* case, though sometimes governed by a verb, as by the verbs *potiri, fungi, meminisse*, and *angi*, sometimes by an adjective, such as *similis*, appears to have been originally applied in the Latin language to signify a relation betwixt the idea expressed by a noun and that contained in *some other noun* in the same sentence. The English preposition *of* corresponds so exactly to it, that any observations made on the one are equally applicable to the other. Attempts have been made, both by means of etymological derivations and explanations of existing phrases, to represent the word

not expressive of specific relations.

of as signifying some specific relation, as, for example, possession or origin. These attempts, however, have failed. We find it expressing every sort of relation that can exist betwixt the ideas contained in two nouns. This circumstance implies no ambiguity. It arises from the mere generality of the sign. When it is too general for expressing our meaning, we add some more specific ideas. In the article GRAMMAR of the *Encyclopædia Britannica*, it is justly observed that *injuria regis* may mean either "an injury inflicted by the king," or "an injury received by the king." The specific idea intended to be conveyed, must either be inferred from the connection, or pointed out by some additional sign.

How distinguished in its use from the other cases.

The genitive case though thus general, and supposed by some to have in the Greek language derived from this circumstance its technical name πτωσις γενικη, ought not perhaps to be considered as more general than the others. It is distinguished from them by the circumstance of being employed to show that the word put in this case is subordinate to a noun. Nothing more than a general relation betwixt the two ideas is expressed; but the connection thus established has something particular in its adaptation to the purposes of discourse. The ideas thus connected could not exchange places, nor are they of equal importance in the sentence, as they would be if conjoined by means of the word "and." "The man of virtue" and "the virtue of the man" do not mean the same thing. The ideas expressed by the words man and virtue are indeed *connected* in *both* of these phrases; but when we say "a man of virtue," it is intimated that something further is said of "the man." When we say "the virtue of the man," it is intimated that the subject on which we enlarge is "the virtue." Both of these are different from a connection formed betwixt two nouns by the word "and;" which intimates that they are on equal terms in the assertions which are made.

It indicates the subordination of an idea in discourse.

Exceptions and anomalies.

Such instances as we mentioned of the genitive being put after verbs and adjectives are so rare that they may be considered as exceptions in which a stretch is made to give these governing words the power of nouns in the use of language. Every word resembles a noun in containing the name of an object or idea. It is only in relative importance in the syntax of sentences that nouns differ from other parts of speech.

Exceptions of a different kind are also found. Nouns are in some instances annexed to other nouns by marks different from those which form the genitive; e. g. *homo a secretis*, a Latin phrase for a "secretary;" and in English we have the phrases "father-IN-law," "cousin BY the mother's side." This last phrase is seldom employed without the use of the verb IS preceding it, which gives a different turn to the whole phraseology, and has the power of introducing a greater variety of words than can be annexed solely to the noun. Such exceptions as we have now mentioned are equally rare with the former; a circumstance which shews the nature of the genitive case to be almost peculiar.

Genitive in the Hebrew language.

In the Hebrew language, the placing of one noun after another is often the only sign of the genitive. *Jein* signifies wine, *Helbon* is the proper name of a mountain, and *Jein Helbon* is the expression for "wine of Helbon." Sometimes it is expressed in a manner which must appear remarkable to those who are not acquainted with any analogous language. The change indicating this mode of annexation is made on the governing noun, which is then technically said to be in its *constructed state*, while the noun in the genitive case undergoes no change. *Dábar* signifies word, and *Elohim* God; but there is no separate word for *of*, nor is any change made on *Elohim*, to make it equivalent to "*of* God." *Dábar* is put in its constructed state by being changed into *debár*, which signifies *word of*. *Debár*

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Elohim is "word of God." In like manner, *gedolim* signifies "great men," *haghir* "the city." Great men of the city is not *gedólim haghir*, but *gedolei haghir*.

In English.

In English, as has been already observed, the genitive case is sometimes expressed by the termination *s* with an apostrophe, as in the first line of Paradise Lost, "Of *man's* first disobedience, and the fruit." It is thought by some grammarians an improvement in nomenclature to call this form of the noun an adjective of possession derived from the noun. This distinction makes no difference of doctrine. That mode of describing it seems to have been inconsciously suggested by the circumstance of its being, like the adjective in English, placed before the noun to which it is subordinate. But nothing more than the meaning of any genitive is signified by the adjective noun itself, as will appear when we come to treat of it. The English *s* has, with regard to its etymology, been considered by some as an abbreviation for *his*. But this (or the equivalent syllable *is*) is evidently an original sign in our language, at least independent of such words as *his;* and the latter is evidently derived from the pronoun *he* by having this sign attached to it.

The genitive case is sometimes expressed in English, as it is in Hebrew, by the mere juxtaposition of the nouns, with this difference, that the governed is placed before the governing noun; as in "cart wheel," "corn field," "garden wall." Some of these phrases are of more frequent recurrence than others. Sometimes the two words thus conjoined have, both in spelling and pronunciation, been run together into one, as in "timepiece," "statesman," "footman." Others of them are frequently connected in writing by a hyphen, to denote that they are scarcely to be considered as one word, yet not so much separated as two words generally are. In other instances, they are kept as distinct in a sentence as any other words. The meaning is not affected by this variety, and is so clearly expressed by simple juxtaposition in this order as never to admit of ambiguity. Here we have one fact by the consideration of which any inordinate predilection for the individuality of words may be reduced within just bounds.

The ultimate effect of the genitive.

The chief ultimate purpose for which the genitive case is employed is, to add a particular circumstance for completing the description of an individual, or of a species of objects, already characterised by a term which is in itself too general for the purpose. "Man" is a general word. "A man of genius," "a country man," are instances in which the genitive is used to point out a relationship for designating a limited species contained in the genus "Man." This may be done when an individual, or a species, is introduced as the subject of discourse; as, for example, "A man of genius differs from other persons in his feelings and habits;" or it may be introduced into the predicate of a sentence, and form a part of some new assertion, as, "Bacon was a man of genius."

The other cases are distinguished from the genitive, by denoting an annexation to some part of speech different from the noun.

The Accusative and Dative.

The *Accusative* and *Dative* have by some been considered as very nearly alike. By others some differences have been stated betwixt them depending on differences in the objects, motions, or relations represented by the governing word. Attempts of this last sort have proceeded on principles which served to explain a limited set of phrases, while they were totally inadequate to explain others.

The Accusative.

The most obvious circumstance which distinguishes the *Accusative* case in Latin from the genitive is, that it is governed not by nouns, but by active verbs and certain prepositions. It is by attending to the different occasions on which it is employed, and tracing the properties which uniformly adhere to it, that we shall make the most convenient approaches to an explanation of its use.

Does not always signify the reception of energy.

Sometimes it represents an object to which some action or motion passes, or in which it terminates, as *Hæc studia adolescentiam alunt, senectutem oblectant.* This character, however, has been ascribed to the accusative in phrases in which it will not apply. When the verb "to love" governs the noun signifying the object of that affection in the accusative, it expresses no transition of an act. The person who is loved may be ignorant of this passion, and totally unaffected by it. When we speak of "loving all mankind," we do not speak of any action which terminates in that extensive range of objects. This remark applies to all transitive verbs expressing emotions of mind that have a reference to external objects, as "to hate," "to dread," "to respect," "to esteem." These affections may be productive of acts by which the objects of them are affected; but such acts are not implied in the affections themselves. They are excited by the objects named in the accusative, but they terminate in the individual mentioned in the nominative. To represent them as terminating in the beings called their objects, is a mere fiction: it applies only to the range of ideas of the individual mentioned, not to the actual relative energies of the different objects. Some other verbs governing the accusative are expressive of quiescent qualities, which do not affect any object different from that to which they belong. Yet these qualities imply a reference to other objects, and the mention of this reference is absolutely necessary. These other objects are put in the accusative case. Such are the verbs "resemble" in English, and *similare*, or *simulare*, and *referre*, when used in that sense in Latin. Here, as no transition of any act or motion from one object to another takes place, the accusative cannot be considered in any respect as expressing such a transition. It will give but little satisfaction to say in reply, that, though nothing of this kind exists, yet it is figured in the speaker's mind, and that even in such a proposition as this, "a benevolent man loves the whole human race," we imagine a benignant emanation proceeding from the benevolent man to influence the whole species. This is an evasion of the argument. It is in like manner an evasion, rather than an explanation, to say that a person who asserts that one man "resembles" another, seems to consider such a man as influencing the state and relations of the other. This is an unconscious acknowledgment that the conceptions of the speaker, or the transitions of his thoughts, and the transitions which he studies to produce in those of the hearer, are the foundation of the use of the accusative case. This is the view which we consider as on all occasions the true one. Such mental transitions have a certain degree of rapidity which corresponds more closely with the idea of an action terminating in an object named, than with the greater part of our associated ideas. On this account the regimen of the accusative case is more frequently applied to signify these than any other trains of thought.

The use of this case does not depend on the kind of idea expressed by the governing word.

When the accusative is governed by prepositions, these prepositions prepare us for a transition equally rapid with that of the active transitive verb. In order to shew that this regimen does not depend on the *idea expressed* by the governing word, we shall take this op-

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portunity of stating a circumstance which might otherwise appear an anticipation of our observations on the verb: to wit, that some verbs which are completely synonymous in the ideas which they express, are totally different in the transitions of ideas which they are intended to create in the mind of the hearer. The verbs "to speak," and "to say," signify precisely the same act. Their difference consists in this, that the verb "to speak" does not intimate an intention to state what was spoken, but the verb "say" always does. When we say "Cicero spoke," we may probably rest satisfied with mentioning the act in connection with the agent. Our hearer may, if prompted by curiosity, ask what Cicero said when he spoke? But, if we use the phrase "Cicero said," we pledge ourselves to give some account of what he said, or to subjoin the accusative of some noun, such as the word "nothing." If we do not proceed further than the words "Cicero said," the person who hears us asks the question now mentioned in a different tone: he reminds us that we have stopped short in our discourse, and have not fulfilled the promise implied in the use of the verb "to say."

The Dative.

The *Dative* case might easily receive a plausible explanation in a large proportion of the phrases in which it is employed. But a difficulty has arisen, in consequence of the approximation which some of its uses seem to make to that of the accusative. Some verbs which govern the accusative are synonymous with others which govern the dative. An example of this exists in the verbs *lædere* and *nocere*. *Antonius nocuit Ciceroni* is equivalent to *Antonius læsit Ciceronem*. But though these phrases are synonymous, it is possible that the words of which they respectively consist are not equivalent. It is possible that in one of the phrases a greater share of the meaning may be contained in the verb, and less of it in the governed noun. This is rendered probable from one circumstance, that there are no verbs which admit of either case indiscriminately, so as to form with them two synonymous phrases.

Words governing the accusative with the dative.

We ought first to attend to those phrases in which a verb governs one noun in the accusative, and another in the dative. This may be a verb of *giving*, as in *Dedit mihi dextram*, or a verb of *declaring*, as in *Narras fabulam surdo*. One difference seems here to take place, that there is a more ready and rapid transition to the idea expressed in the accusative, than to that expressed in the dative; and the idea which is expressed in the accusative is more necessary to the completion of a significant phrase than the other. *Dedit dextram* and *narras fabulam*, though both evidently incomplete sentences, are not quite so deficient as *dedit mihi*, or *narras surdo*. The verb is so contrived in the arbitrary application of words, as to lead the hearer to expect with greater rapidity and impatience the idea which is subjoined in the accusative, than that which is in the dative. When the dative is placed first in order, as in the phrase *dedit mihi dextram*, we are sensible of a degree of inversion, or a short suspension of the governed word most nearly connected with the verb. This mode of speech is contrived for the sake of variety and elegance, or for the convenience of dwelling on the idea expressed in the accusative, by attaching to the noun some additional parts of speech; as, *Narras mihi fabulas gigantum incredibiles*.

In the use of verbs of giving and declaring, a difference in the *actual relations* of the *object* mentioned in the accusative and that in the dative case is evident; but in verbs of *comparing* no difference of this sort is necessarily implied. The sentences, *Comparo Virgilium Homero*, and *Comparo Homerum Virgilio*, may be used for conveying the same meaning in exactly the same manner as to thought. The interest taken in one of the objects compared may not be greater than that taken in the other, and the transition made to the two may be equal in its degree of rapidity and deliberateness. At the same time, if there is any such difference of interest, it seems natural to put that object to the description of which the comparison is principally subordinate in the accusative, and the other in the dative.

Words governing the dative alone.

These facts may furnish some illustration of those phrases in which a verb governs the dative case alone, for example, the verbs *nocere*, *favere*, *placere*, and *resistere*. The English verbs into which these are translated are equally transitive, and govern the same form of the noun, with those which correspond to Latin verbs governing the accusative. But in the Latin language it is probable that they are not so completely transitive, and resemble in their genius those English verbs to which nouns are subjoined through the medium of the preposition *to*, as the verbs "yield," and "submit." Thus the translation of *obedire* by the verb "submit" would be more accurate than by "obey" in so far as regimen is concerned, although the former of these English verbs, as applied to the expression of ideas, may be less nearly co-extensive with the Latin word. It is conceivable, that a verb which is originally not used transitively, may be more easily made to govern the dative than the accusative, whether it is employed in its simple state, or in composition. The verb *resistere*, for example, is derived from *sistere*, which signifies to stop or remain fixed, and does not prepare the hearer to expect the mention of any other object affected. This state, however, admits of being also mentioned as an impediment to the progress of another. The name of this other may be subjoined with a slight degree of ceremony; and a semi-transitive verb may be formed signifying that fixed state, together with an intention of mentioning the object impeded. The machinery of prepositions or other intervening words, for the introduction of the latter object, are dispensed with; yet the verb is made to govern a case which implies some slight degree of ceremony in the mental transition intended.

Analysis of the dative and its governing verbs.

We have heard it suggested that a verb which governs a single noun in the dative implies in itself the force of a noun governed in the accusative; that *resistere*, for example, has the force of the phrase *obstaculum opponere*. Whether this suggestion has any truth in an etymological point of view, or is in any degree to be considered as a probable account of the sentiments originally attached to such verbs, we shall not stop to inquire. But a translation of some phrases, on this principle, into the English language, will afford us a clear analysis of these two cases, as well as of the verbs which respectively govern them, and yet are otherwise synonymous. The English language expresses the dative by means of the preposition *to* prefixed to the same form of the word which constitutes the accusative; just as if, in Latin, the dative case were wanting, and the meaning of it always expressed by the preposition *ad* with the accusative. This would certainly shew a more leisurely and ceremonious transition than the accusative without a preposition. Both these sentences, *Nocuit Ciceroni*, and *Læsit Ciceronem*, may be translated, "He did harm to Cicero;" but, in the first, the force of the preposition "to" is contained in the dative *Ciceroni*, and, in the last, it is contained in the verb *læsit*.

Antonius	*nocuit*	*Ciceroni.*
"Antony	did harm	to Cicero."
Antonius	*læsit*	*Ciceronem.*
"Antony	did harm to	Cicero."

Thus the verb which governs the accusative is more completely prepared for the intended transition than that which governs the dative. This view of the cases is not, we confess, in the present instance, supported by the comparative brevity of the Latin dative and accusative, which is in favour of the dative. It depends for its proof on the use of them in language. Their comparative brevity, however, in the English language, contributes to the illustration of our views, especially as it consists in a difference of the entire word *to*, and therefore is less liable to be ascribed to accident.

…rmedi- …a betwixt …t. accusa- …ti and …t or any …oer case …n a go- …ning …position.

The Latin dative appears, on the whole, to be appropriately employed where the verb has a degree of transitiveness intermediate betwixt those which govern the accusative and those which do not govern any case. The latter may express actions in themselves transitive, though they have not been formed for the purpose of transition, but merely for attaching the accident implied in the verb to the subject mentioned in the nominative. After such verbs the object affected may be introduced, but it requires, even in the Latin language, an intervening preposition; we say, *Lutetiam* VERSUS *contendit*, and, AD *prælium progressus est*.

The intermediate character of the dative case betwixt the accusative and the use of a governing preposition is confirmed by this circumstance, (especially as it is apparently accidental,) that, in the English language, which has no termination or peculiar form of the noun for expressing the dative case, it is sometimes expressed by the preposition *to*, and at other times by the noun in the same form which constitutes the accusative. We say, "I sent a letter *to him*," or, "I sent *him* a letter." "Give *him* the money," or, "Give the money *to him*."

…e Abla- …e.

The *Ablative* case of the Latin language has been often considered as possessing a variety of powers. Sometimes one of these, sometimes another, has been selected as its original characteristic. Those who first assigned this case its present name, have considered its original or at least its most conspicuous application, as equivalent to the English preposition *from*, representing the object expressed by the noun as the point of commencement of motion. The author of Grammar in Rees's *Cyclopædia*, describes it as denoting the instrument or medium by which an action is effected, and, of course, considers its meaning as most clearly expressed in such sentences as *scribo calamo*, "I write with a pen." This account of that case, however, will not apply to every sentence in which it occurs. We suspect that any detailed attempt to make instrumentality the universal characteristic of the ablative would involve the subject in inextricable confusion. The writer in the *Encyclopædia Britannica*, impressed with the hopelessness of all attempts to reduce the meaning of the ablative to any one species of relation, describes it as implying nothing more than the simple mention of concomitance. The noun which is put in the ablative may either represent a cause, an instrument, some circumstance of manner, a portion of time, or some other relation; but any one of these is inferred from the nouns employed, and from the evident mutual relations of the words composing the sentence, and not simply from the ablative case. These aids to the meaning are also rather to be regarded as limiting the generality of the case than as correcting any ambiguity. The objection to which this theory is open is, that it is too general to indicate a distinction betwixt this and the other cases of the noun. All the circumstances brought together by words in a sentence may be represented as concomitant. Something further seems necessary for the purposes of precision. The peculiarity of the ablative seems to be, that it is the only case which expresses a concomitant circumstance *by a noun alone*. It is an abbreviating contrivance for dispensing with the introduction of another verb. *Scribo calamo* is used instead of *scribo et habeo calamum, calamus est mihi*, or *moveo calamum*. The pen is merely mentioned in the ablative to supply the place of these circumlocutions.

…rieties … opinion.

It expresses concomitance by the noun alone.

The manner.

In an example quoted by the last mentioned author, *templum clamore petebant*, clamour is represented only as concomitant with the action of going to the temple. These mere concomitances are called by grammarians the manner.

The cause.

When we say *palleo metu*, fear is merely mentioned as a concomitant circumstance with the paleness. Yet it is intended to signify, from the natural connection betwixt paleness and fear, that the latter is the cause, and the inference is instantly made. It is because such inferences are drawn with the utmost readiness, and without any sensible interval of time, that grammarians have been deceived into the belief that the meaning inferred is fully expressed by the ablative case.

The ablative absolute.

The expression of this variety of concomitant circumstances by the ablative without the intervention of an intermediate word, for the sake of connecting the noun with the preceding words, has obtained for some of its uses the designation of *the ablative absolute*; as in the phrases *Illo mortuo; Caio et Cassio consulibus.* It might be considered as absolute in its other uses, as in the annexation of cause, manner, instrument, or time. When an historian says *hoc anno floruit*, it is from the word *annus*, and not simply from the ablative case, that the idea of time is inferred by the hearer.

Attempts are sometimes made in the English language to follow the Latin idiom of using nouns in a form thus absolute; and the nominative or simple form of the noun, is employed instead of the ablative; but when we express the cause, the manner, or the instrument, we always introduce definite prepositions; hence it is translated in our language sometimes *in*, sometimes *by*, *with*, or *from*, and its meaning is rendered more special than in the original Latin. It is scarcely necessary to mention, however, that even in Latin it may also be preceded by prepositions, though it does not necessarily require them. We may say either *se gessit summa cum prudentia*, or *summâ prudentiâ*.

Governed by verbs.

Some verbs govern the ablative as a single case, that is, with the apparent meaning of the accusative. These are chiefly neuter or deponent verbs. They seem to have originally been of the intransitive kind, and afterwards made to govern a noun in this slightly connected and least dependent of the cases. As *gaudere* "to rejoice," *gaudere felicitate alicujus* "to rejoice, the happiness of another being a concomitant event," which evidently would not be mentioned in this connection except as the cause of the joy. The verb *fruor* in all probability, was originally passive in meaning as well as in form, and is capable of being translated "I am privileged," or "I am rendered happy;" *fruor vita*, "I am rendered happy in life," or "I enjoy life." *Potiri viribus*, "to be made rich by, or to possess, power."

By adjectives.

The ablative is sometimes subordinate to an adjective, as *inops ratione*, "needy with respect to reason," translated "void of reason."

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By prepositions.

It is also governed by certain prepositions. Among these there are some that are also used in such a manner as to terminate the meaning without being followed by any noun; for example, *clam* "privately," and *palam* "openly." *Clam Cæsare* is "privately as to Cæsar," afterwards translated "without the knowledge of Cæsar." It is indeed true that even such prepositions as govern the accusative are sometimes used in the same manner as adverbs, that is, without any subjoined noun. This is the case with *juxta* and *contra*. But some difference may here be perceived; *juxta* and *contra* always refer to some specific object previously mentioned; *clam* and *palam* may be wholly general.

The syntax of the ablative compared with that of the accusative.

Some illustration of the ablative as compared with the accusative case may be derived from this consideration, that all the prepositions which denote that an action or motion terminates in the object signified by the governed noun, govern the accusative, as *ad* "to," *contra* "against," *in* "into;" they have thus a general analogy to active transitive verbs; while all those which denote that the object signified by the governed noun is the point at which motion commences, govern the ablative, as *a* and *ab*, "from," *e* and *ex*, "out of;" and, finally, those which denote fixed posture or condition are in their regimen distributed betwixt these two cases. *Ante* "before," *apud* "at," *secus* "along," *citra* "on this side of," and some others, govern the accusative; while *cum* "with," *pro* "for," *præ* "before," govern the ablative. But, though no uniform circumstance of syntax marks these last mentioned prepositions, some motive must have directed the persons by whom the language was modified to prefer in each instance one of the cases to the other. If we should suppose that they were derived from pre-existing verbs, the regimen would depend on the genius of each original verb. Prepositions governing the accusative are those which are most completely prepared for a transition of thought to the noun, and thus possess the most complete active energy. *Juxta*, for example, may be held equivalent in force to *jungentia* "joining," *apud* to the word "accompanying," *contra* to the word "opposing." Those which govern the ablative must have been considered as more passive, leading by a more leisurely transition to the subsequent noun. *Cum* might be considered as equivalent to "accompanied." The meanings of these prepositions may be expressed either in an active or a passive form. *Circum* may be analysed into "surrounding," and thus it governs the accusative. If it had originated from some such passive participle as "penetrated," it would have governed the ablative. This variety of syntax might sometimes be founded in etymology, and sometimes the result of arbitrary fancy.

The ablative wanting in the Greek.

The Greek language has no case corresponding to the ablative. The use of the genitive is in that language extended in such a manner as to include it. The Greek genitive seems to have a greater similarity to the Latin ablative than to the Latin genitive, as the ablative is the least dependent of the two, and possesses the most general application. In Latin it is in some instances governed by a noun; a circumstance which we have not before mentioned, as it takes place only in particular phrases, as *vir egregiâ sapientiâ*, or *vir egregiæ sapientiæ*. The Greek genitive is governed by prepositions like the Latin ablative; and the noun in the absolute state, which in Latin is put in the ablative, is in Greek in the genitive. In this latter language therefore we are left to infer from the connection whether the meaning of the genitive case or one of those applications which in Latin are assigned to the ablative is attached to it in each particular instance. The only meaning proper to it is the general one of concomitance; and it may be either a concomitance with an object expressed by a noun, or, like the ablative, it may be concomitance with an idea expressed by an adjective, a preposition, or a verb.

The cases in the French and English languages.

In the French and English languages, the noun is subjected to very few variations corresponding to cases. We have the genitive in *s* with an apostrophe, which is sometimes called the possessive case. In the pronouns "I," "thou," "he," and their plurals, we have one variation, consisting in a case equivalent to the Latin accusative, and technically called the objective case; as "me," "thee," and "him." It is by means of this form, preceded by the prepositions "of" and "to," that the genitive and dative in Latin are translated; and by different other prepositions suited to each occasion, we express a variety of relations which in Latin are indiscriminately, and with less particular meaning, expressed by the ablative. In the French language, the nouns *je* and *tu* have in like manner *moi* and *toi* for their objective cases. *Moi* in that language is even used where the nominative would be used in English, as *c'est moi* for "it is I." Hence some have described *moi* as a complete noun, being a nominative as well as an objective form. In the use of the English language, persons who have not been taught to adhere rigorously to grammatical rules, sometimes say "it is me," instead of "it is I." It is probable that this was originally a legitimate use of the word, and that the establishment of a contrary rule has proceeded from a forced application of a Latin idiom. Even *moi* in French is not used as a nominative to a verb. The French do not say *moi parle* or *moi fais*. It is only that sort of nominative which follows the substantive verb. (We do not here speak of that subsequence in mere arrangement which indicates interrogation, and depends on inversion, in which the nominative always follows the verb, as in *suis je*; and we do not think that any attentive reader would have taken such an exception against our views, though we had not stated this circumstance. Those who would have been so disposed may object to several others which the limits of this article do not allow us to defend against every slight exception. We here speak of that form of the noun which follows a substantive verb, after that verb has been introduced by its proper nominative.)

On the noun following the substantive verb.

This application of the noun after the substantive verb is peculiar, and might with as great propriety have a peculiar form assigned to it as those which are expressed by cases. It has not an appropriate form, because it is of less frequent recurrence. In Latin, it is put in the nominative. In French it is put in the objective case, being treated as a state of the noun introduced (or governed) by the substantive verb. In English we now adopt the Latin idiom. But, while our language was unfixed, it certainly would have been equally natural to have followed a similar usage to that of the French.

CHAP. V.

Of Adjectives.

Sect. I. *The Nature of the Adjective.*

Adjectives do not differ from substantives in the ideas expressed.

The impropriety of considering adjectives as intended to express our ideas of qualities, in contradistinction to our ideas of substances, has been already pointed out. The only objects known to us are qualities, and therefore this distinction has no foundation in nature. Qualities habitually conjoined, and forming definite assemblages, comprehend the whole of our concrete ideas, called ideas of substances. We have words to represent these assemblages, and words to represent single qualities. But this does not constitute the distinction betwixt substantives and adjectives. Both kinds of ideas are indiscriminately expressed by these two parts of speech. The adjective, like the substantive or noun, is the name of an object. The circumstance which constitutes its peculiarity is, that it also contains an intimation of the subordination of the idea expressed by it to the idea expressed by a noun in the same sentence. It has in fact the same application with the genitive case of the noun. Sometimes these two parts of speech may be shown to be synonymous. The words "Peter's," "Solomon's," "Cicero's," are by some called genitive cases, by others adjectives of possession. The words "Aristotelian" and "Ciceronian" are reckoned adjectives by all, and also such words as "Roman" and "Grecian." All of these equally contain the name of a person or country, with an intimation that it is to be connected with some other idea expressed by a noun in the sentence. We shall soon see the similarity of use betwixt these adjectives and such as discover less composition in their structure. We shall also see the cause of their apparent difference.

...es the ...ective ...e a full ...resenta- ...n of any ...ect?

Some have asserted that the adjective by itself expresses no idea. This opinion has arisen from the circumstance that it supposes some other idea expressed by a different word. But this is in reality an addition to its meaning. Every idea expressed by a substantive may also be expressed by an adjective, and *vice versa.* The idea expressed by "man" is also expressed by "manly;" and the idea expressed by the adjective "good" is also expressed by the substantive "goodness."

Perhaps it will be alleged that, when we use the adjective, we do not give a full representation of an object, but merely refer to it by mentioning a quality founded on some connection with it; that the words "Roman," "English," "Ciceronian," do not imply the full meaning of "Rome," "England," and "Cicero." In answer to this we must observe that the greater part of words in a sentence are merely introduced for reference. Sometimes, where many words are used, and many objects of thought mentioned, those which are mentioned on their own account are comparatively few, the greater part of the words, including the nouns employed, being merely introduced for the sake of reference. "A Roman senator," and "a senator of Rome," mean exactly the same thing; therefore the ideas contained in the word "Rome" are also contained in the word "Roman."

...w an ...ective ...ned ...n a pro- ...p name ...mes ...eral.

Those whose reflections are in the habit of suggesting more subtile arguments, may object that the word "Rome" is a proper name, while "Roman" expresses a general quality. This, however, is the same objection in a different form. A part of the word "Roman" is a proper name. The generality of such adjectives arises from the variety of occasions on which proper names may be used. Their application in connection with other words thus becomes general, and the same thing may be said of any form of a noun that implies definite connection with other words. The adjectives "Roman," "Grecian," "French," "English," "Alexandrian," "Ciceronian," "Foxite," "Pittite," contain the names of individuals, but they become general from being applicable to many objects. A relationship to an individual becomes a generic quality.

The least complex adjectives.

There are, however, adjectives which express the possession of general qualities founded on no reference to a particular individual. These adjectives have less appearance of composition than those now mentioned, and are always shorter than the substantive nouns used to represent the qualities as separate objects. "Good," "bad," "hard," "soft," "light," heavy," are shorter words than "goodness," "badness," "hardness," "softness," "lightness," and "heaviness." It is from the aspect of words of this sort that grammarians have concluded that the adjective does not express a complete idea. They are never derived from the general name of the quality. It has been imagined that the ideas which such adjectives express are *essentially* general, that they have no corresponding objects possessed of an individual existence, and that, when substantive nouns, such as "goodness" and "badness," are derived from them, a forced effort is made to treat qualities in language as if they were substances. The just conclusion was not drawn, that substantives and adjectives, as mutually distinguished, are forms fitted for certain purposes in language, and not signs founded in any differences in the nature of the external objects signified.

Reason of the simple structure of some adjectives compared to the corresponding substantives.

The reason of the comparative brevity of words signifying general qualities, when in the form of adjectives, has been already hinted at. Individual instances of these qualities have no separate interest attached to them, and therefore the words expressing them contain an intimation of their annexation to some group. The names of groups, even though generic, are in the first instance so contrived as to be fitted to become the names of leading subjects of discourse; and ever after merely require a proper introduction to render them distinctive signs for individuals. It is at a more advanced period of human thought that single qualities become separate objects of attention, and then it is natural to create names for them by the composition of words previously in use.

The adjective, like the genitive case of the noun, is a word subordinate to a noun by which it is introduced. Sometimes it is employed to remind us of one of the ideas contained in the noun, as when a poet speaks of "fleecy clouds," "the azure sky" and "verdant foliage;" or when a historian, under impressions of indignation at any series of outrageous conduct, uses such expressions as "the infamous Robespierre."

Ultimate effect of adjectives.

The most usual effect of adjectives is, to reduce within a more limited range the application of a general term, by the addition of a circumstance which belongs only to a limited part of the genus which that term expresses. "A man" means one individual belonging to a certain class of beings. The words, "a good man," represent one belonging to a limited part of that class. An additional circumstance, attached by means of another adjective, would limit the meaning still more: and an accumulation of adjectives of this sort is capable of affording a combination of sufficiently limited occurrence for any purpose of distinctive description.

Varieties in the degree of subordination of the idea expressed by the adjective.

The subordination of the idea contained in the adjective to the noun with which it is coupled is in some instances less strict than in others. On some occasions the ideas expressed by these two parts of speech might exchange places without any material alteration in the meaning of the compound designation thus formed. "A written libel" is equivalent to "a libellous writing;" "a false assertion," to "an asserted falsehood." Although the purposes of connection in discourse require one of the ideas thus nearly equal in importance to be expressed by a substantive noun, the choice is left to the option of taste and convenience. In other instances in which they may be made to shift places, when the

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ideas which they express are the subject of a sentence, a corresponding change is required in the predicate, in order that the identity of the meaning may be preserved. The sentence, "a good man is a happy man," may be converted into "human goodness is conducive to human happiness."

An anomaly.

It sometimes happens that the adjective expresses the idea which is intended to be the principal, and to which that expressed by the substantive noun is subordinate; as in the Latin phrase *ab urbe condita ad (urbem) liberatam*. In the translation of such phrases, the idea that is primary is expressed by a substantive noun, and the subordinate one by an adjective. The primary ideas introduced in this phrase, by the prepositions *ab* and *ad*, are the "building" and the "deliverance;" hence it is translated, "from the building to the deliverance of the city." Such idioms are to be considered as arbitrary inversions of the parts of speech, and do not invalidate the original subserviency of the adjective to the substantive noun, as well as of the genitive case to the noun by which it is introduced.

The adjective is very often employed as the predicate of a sentence. It then conveys, by the help of the substantive verb or copula, information of a connection betwixt the idea conveyed by it and the leading subject expressed by the nominative prefixed to this verb. As in the sentences "Cicero was eloquent," and "Solon was wise."

Sect. II. *The Etymology of Adjectives.*

A great proportion of adjectives derived from verbs of motion.

Amidst the obscurity in which etymology is involved, it would be difficult to trace all adjectives to other parts of speech, and thus prove that none of them are original. But many of them which might be supposed from their appearance to be simple have been shown to be derived from verbs, and these verbs are expressive of motion.

Sometimes the adjectives thus derived signify qualities *produced* by particular motions The adjective "left," in contradistinction to right, is from the verb *to leave*. The left hand is that which we leave or decline to use. "Tight" is *tied*; "full" is *filled*; "loud" is from *low'd*.

Sometimes the adjectives thus formed merely contain an *allusion* to the motions from which they are derived, as "odd" from *ow d*; "straight" and "strict" from *stringere* to pull; "blind" from the old verb to "*blin*," or stop; "bold" from the verb to *build* or establish. "Brown" is from the verb to *bren* or burn. "Lewd" is the participle of the verb to *lew* or allure. "Profligate," an adjective used to depict a character destitute of all rectitude of principle, is derived from *profligare* to defeat.

Some derived from concrete nouns.

Adjectives expressive of single qualities are sometimes derived from the names of habitual assemblages in which such qualities are conspicuous. The colour "yellow" is in Latin *flammeus* or *luteus*, because it is the colour of flame or of clay. The English word "yellow" is derived from the Saxon verb *geæigen* to burn or flame. *Viridis* in Latin, is from *virere*, to vegetate; and "*green*" in English from *grenian* to grow.

From the analogies in etymology disclosed by the researches of Mr Tooke, it would appear that verbs expressive of human motion have been the roots from which almost all adjectives, as well as substantives, have been derived This fact tends to illustrate the views given at the beginning of this article, on the principles which regulate the progress of the human mind in the formation of language.

Some adjectives contain an intentional allusion to the nouns and verbs from which they are derived, and something more is recognized in them than the current signs for annexed qualities. Such are the adjectives, "*man*ly, *gentleman*like, *prince*ly, *nation*al, *provinc*ial, *world*ly, *earth*ly;" also "*earthy*, *hilly*, *stony*." The substantives are here fully expressed, and the terminating syllable denoting annexation is capable of being separated.

Some adjectives evidently compounds.

Sometimes this last is merely a general sign of connection; at other times it signifies something more specific, and then the adjective is to be considered as formed by the combination of another adjective with a noun. Thus, "faithful" does not mean simply "connected with faith," but "full of faith," and, if analyzed into the genitive case, it would not be represented by the phrase "of faith," but "of fulness of faith." A "gentleman-like youth" is not "a youth of, or connected with, gentleman," but "of the resemblance, or likeness, of a gentleman." Where several synonymous adjective terminations exist, though all general in original meaning, different specific applications may be afterwards appropriated to them Thus "earth-*en*" means made of earth, "earth-*y*." abounding with earth, "earth-*ly*" connected with the earth In some examples we find both parts of the compound word restricted in their meaning. If *ly* means "like," the etymological meaning of the word "earthly" must be "similar to earth;" yet the word is employed solely to signify "connected with the system of our earth" in contradistinction to the invisible world.

There seems to be a constant tendency amidst the fluctuations of language to coin new adjectives, by derivation from substantive nouns, for the sake of producing greater liveliness of expression. When such a word as "manly" is first used for describing an individual, the hearer more readily imagines to himself a "man" with all his suitable qualifications for the illustration of the quality named, than when such epithets as "bold" or "firm" are employed.

Participial adjectives.

Some adjectives derived from *verbs* contain an equally palpable allusion to the parent words as those do which are derived from nouns, and thus bring more fully into view the motions or actions which they denote. The most remarkable adjectives of this sort are also called participles. They resemble other adjectives in every feature which has yet been mentioned; but many of them imply an additional characteristic, which will come into view when we treat of the verb. The participle expresses the meaning of the verb, together with its subordination to the idea expressed by a substantive noun. The words, "pining," "thriving," "dazzling," are as completely adjectives in meaning and use, as "weak," "strong," and "bright." Sometimes it contains the addition of a particular modification of connection. There is generally a difference betwixt the participle in *ans* or *ens* and that in *us* in Latin, and betwixt the participle in *ing* and that in *ed* in English.

Inflection of adjectives.

The adjectives of some languages are subjected to variations corresponding with the cases, numbers, and genders of the substantive nouns to which they are attached. These are terminations. They are extraneous with regard to the meaning of the adjective, and are merely convenient marks for designating, in complicated sentences, the noun with which each adjective corresponds. They served, in the Greek and Latin languages, to obviate that ambiguity which must have been the consequence of the inversions of the order of words which the writers of these languages, especially the poets, perpetually practised. This circumstance, though merely accidental, has probably formed the ground on which grammarians have proceeded in calling the adjective a sort of noun. The declensions have given it a similarity of aspect to the substantive noun. The metaphysical reason for adhering to this nomenclature assigned by Mr Tooke, that both equally contain the name of an object, seems not to have occurred, and labours under the disadvantage of applying also to other parts of speech.

Sect. III. *Degrees of Comparison.*

grees of parison n common to all ctives.

Many adjectives are subjected to variations which indicate a comparison of the degree in which a quality is to be attached to different objects. There are adjectives which do not admit of this variation, because there are qualities which do not admit of degrees. Such are some of those which denote figure; as, "circular," "quadrangular," and "triangular." Adjectives subjected to degrees of comparison are those which express qualities which admit of being more or less intense. No language is without separate words to signify comparison. But an expression of that act is so frequently required, that it has been found convenient to combine the sign of it with the adjective, in the form of a termination.

T com- m divi- n.

Three degrees have been enumerated; the positive, the comparative, and the superlative. But the positive form is the simple state of the adjective, and should not be called a degree of comparison.

The comparative degree is formed, in Latin, by adding the syllables *ior* to the radical letters of the simple adjective; the superlative by adding the syllables *issimus*; as *mitis, mitior, mitissimus;* in English, by adding the syllables "er" and "est," as, "meek, meeker, meekest." When the euphony of our language does not admit of this mode of formation, the same thing is expressed by prefixing to the simple adjective the adverbs "more" and "most." Several grammarians have described the meaning of these degrees of comparison as consisting in this, that the comparative expresses a comparison betwixt two objects, i. e. a comparison of one with another one; while the superlative expresses a comparison with many, i. e. with the whole of a class. But we find that the comparative degree may be employed for comparing an object with many others as well as with one; as when we say, "He was *wiser* than all his teachers;" "Charity is *better* than a thousand sacrifices." The superlative degree, in its turn, may be used when only two objects are compared, as, "James is the *wisest* of the two." The difference betwixt these two sorts of expression, which should rather be called *forms* than *degrees* of comparison, is, that the comparative considers the subjects compared as belonging to different classes, while the superlative, compares them as included in one. When we compare two men, if we oppose the one to the other, we use the comparative, and say "that he is *taller* than that other;" but when we place the two together to form a group, and point out the superior rank which one of them holds in this group, we say, "He is the *tallest* of the two."

T diffe- n e be- n the c parative a super- L e.

In like manner a comparison in which more than two are concerned may be expressed either by the comparative or the superlative. The comparative is thus used when we say, "Greece was more polished than any other nation of antiquity." Here Greece is considered as not belonging to the class mentioned after the words "more polished." For this purpose these nations are designated by the term *other*. "Greece was none of those *other nations;* it was more polished than they." The same idea is expressed by the superlative when the word *other* is left out; "Greece was the most polished nation of antiquity." We here assign it the highest place in the class of objects among which we number it,—the nations of antiquity. A similar option is left in conveying such sentiments as the following: "Mr Fox spoke more forcibly than any other member of the House;" which may also be thus expressed, "Mr Fox spoke the most forcibly of all the members of the House."

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The comparative is indeed sometimes used instead of the superlative where there are only two in a group; as when we say in Latin, *senior fratrum,* and in English, "the elder of the brothers;" "the wiser or the taller of the two." The frequency with which the comparative form of the adjective is employed in comparing only two, has misled some technical grammarians to state it as a principle, that this is the only proper form where no more than two objects are concerned, even although they should be represented as belonging to the same collection or class. But, though habit has admitted some instances of this phraseology, it is an error to form such a rule, and it is injudicious to check any tendency to use the superlative in its original application.

Sect. IV. *Numerals.*

The numerals are adjectives in meaning as well as in form.

Numerals have the same relation to the substantive noun as adjectives, and therefore belong to this class of words. They express a modification or limitation of the idea conveyed by some substantive. Their peculiar object is to denote the degree of frequency with which any sort of thought contained in a noun is repeated; that is, the frequency of the exemplification of a general idea.

Sign of the singular.

In English, the singular number is sometimes merely distinguished from the plural by the want of the terminating *s*, as "the house" for the singular, and "the houses" for the plural. At other times the word "one," or the word "an," or "a," is prefixed. "An" and "a" have been called by grammarians indefinite articles, but in this there is no propriety. They merely signify unity, and this is expressed by them in the most definite manner. In the French language, they are always translated by *un*. They ought, therefore, to be called numeral adjectives. They cannot be prefixed to plural nouns, being peculiar to the singular, or the exhibition of an idea without repetition.

The words "some" and "several" are used as general plural adjectives. There are others implying the result of a general comparison with respect to number; as, "few" and "many." But these words do not describe the frequency of the repetition with precision, and for this purpose language is furnished with corresponding numeral adjectives. One added to one, forms a number which has the separate name "two:" one and one and one, or two and one, have the name "three:" one repeated once more, or a repetition of two, forms the number called "four." Our idea of number, as a separate subject of thought and of language, has no existence previous to our experience in numbering individuals. This gives rise to the observation of a general feature in the acts of the mind called numbering; and hence the generalization of numbers. Words signifying a particular degree of repetition become applicable to all acts of

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the mind in which an idea is repeated with the same frequency.

Etymology of numerals.

The general words expressive of numbers are derived from the names of particular objects; though, perhaps, we can seldom succeed in tracing them. As the two sides of the body exhibit pairs of organs, two eyes, for example, and two hands, the word for "two" might arise from the most interesting of these pairs. Perhaps the numeral *tres*, "three," has been borrowed from the idea of vibration, and owes its etymology to the verb *tremo*, or some older verb of the same meaning. The two words are at least evidently akin. The words first used to express the succeeding numbers might be suggested by the first two or three, with the help of a sign intimating *reduplication*, as in "two," "four," and "eight," or *addition*, as in "five," "six," "seven," and "nine."

Decimal numeration.

Numeration by *tens* has, with very few exceptions, taken place in every part of the world. This has been suggested by the numbering of the fingers, which form an assemblage familiar to us from our childhood. The word for "ten" would therefore be borrowed from the word signifying "hand," or "fingers." Δεκα in Greek, and *decem* in Latin, evidently spring from the same root with δακτυλος and *digitus*, a finger. The combinations of tens with one another, and the addition of the words for the different units, are prominent processes in the words employed among the ancients as well as the moderns for the higher numbers, and in the marks invented to express them compendiously in writing.

Sect. V. *The Article.*

The article in all respects an adjective.

There is one adjective which, from some peculiarity, has been generally reckoned a separate part of speech, under the title of "the definite article." The English words *an* and *a* have been called indefinite articles, but their nature has been shown to be that of numeral adjectives. The words ὁ, ἡ, το, in Greek, *the* in English, *le* and *la* in French, and the corresponding words in other languages, have been called the definite articles; but they have every characteristic of the adjective. They have even corresponding inflexions in those languages in which adjectives are inflected. Their general meaning, and the purpose of the speaker in using them, are the same with those of the adjective. They represent an idea or quality subordinate to an object expressed by a substantive noun. This quality consists in a reference to some previous mention, or to some knowledge previously possessed of an object. A historian, after having named and described a variety of objects, speaks familiarly of them by using their general names preceded by the adjective *the*, as, "the army," "the town," "the battle," "the siege," and "the truce."

One of its uses.

Another use.

Another use of it is, for attaching a speciality by means of a genitive case, or another adjective, or some of those phrases which we shall afterwards show to be equivalent; as, "*the* King of Prussia," "*the* governor of Malta," and also, "*the* French nation," "*the* Italian territory," "*the* Christian religion." Where no speciality is attached, it means, "known by former mention," or, "mutually understood betwixt the speaker and the hearer." Where it is followed by the genitive or another adjective, it means, "to be known or distinguished by this mark."

Some classes of objects are never mentioned without the use of this adjective, as, "*the* French," "*the* English," This phraseology has arisen from the habit of prefixing the words French and English to more general nouns, as, "the French or English people." We say, "the French are gay;" "the English love the pleasures of the table." We have, indeed, equivalent expressions without the article in the words, "Frenchmen," and "Englishmen."

It does of itself make the meaning of a noun finite.

The only circumstances which have led to the idea that the article was a distinct part of speech, seem to be the same which we have mentioned of the pronoun, viz. its brevity, and its frequency. It is a mistaken notion to consider it as possessing the power of distinguishing the application of a generic name to an individual from the use of that name in a less definite acceptation. It has not this power in a greater degree than other adjectives. If we speak of "the man," we no more distinguish any individual than when we say "a man," and not so much as when we say, "a wise man." It is only after an individual has already been distinguished that the adjective "the" characterises him, by referring to that description. It is of very general and familiar application; because any object may be mentioned as already known, or may be introduced with a view of being characterised by some special mark. Like every other adjective, it becomes fitted to particularise the intended object in proportion as it is used with skill and propriety.

Etymology of *the*.

Mr Tooke (vol. ii. p. 60.) derives "the" from the Saxon verb *the-an*, "to take," of which he supposes it to be the imperative. "The man," accordingly, means "take man;" and implies a direction to the hearer to select an individual from the rest of the class. This is its meaning when the object is first introduced for the purpose of being described. When afterwards used for reference, it must mean "taken" or "selected."

Analogous adjectives.

Very nearly allied to the adjective "the" are the words "this" and "that," which have been denominated by grammarians adjective pronouns. "That" is considered by Mr Tooke as also derived from *the-an*, "to take;" and as, in fact, its past participle. In actual application "this" means "near," and "that" "at a distance." Another adjective "yonder," signifies, "at a considerable distance," or on the other side of something referred to. "This" and "that" are either prefixed to nouns, as "this man," "that thing," or are used by themselves, as "this is good," "that is indifferent." In the last form of speech there is a subaudition of the noun; or the adjective may be considered as converted into a substantive noun, in the same manner as we have shown that many substantives are created. Like them, it expresses one quality, with a subaudition of the rest. An adjective used with the subaudition of a substantive, is very nearly akin to a substantive formed from an adjective by subaudition.

CHAP. VI.

Of Verbs.

Sect. I. *The Nature of the Verb.*

Complicated appearance of the verb.

The verb, as exhibited in elementary grammars, especially those of the Greek and Latin, is much more varied than any of the other parts of speech. Some ingenious attempts have been made to trace its complications, and to analyse its different forms. We find the offices performed by words called verbs to be various, and it would be satisfactory to discover the cause of the application of one common term to words so diversified.

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Queries on improper nature.

The following are the queries which this subject suggests. Does the verb perform any office which is peculiar to itself, and is this common to every word which, in the present practice of grammarians, receives the appellation of verb? Are there more points of coincidence than one in the application of the various forms of the verb? Is this coincidence in office strictly universal? Or are these different offices sometimes united in one verbal sign, while only one of them is performed by others? Are the offices performed by the respective words called verbs thus different among themselves? Are there any functions common to the verb with some other parts of speech, though more advantageously and more frequently performed by verbs than by these others? Does this circumstance render it advisable in any instance to retain the name of verb, even while the office performed by it is not peculiar? Or ought scientific accuracy to concur with convenience in leading us to alter in this instance the nomenclature of the parts of speech? These questions can only be answered by investigating the nature and use of every sort of word which, in the habitual language of grammarians, is denominated a verb, and making a comprehensive survey of their applications, in order to assign to all of them respectively their just rank in universal grammar. We must therefore suspend the discussion of the leading problem implied in the title of the present Section, and leave the reply to be gradually unfolded in the sequel of this Chapter.

One important form of the verb, the imperative, created by the earliest occasions for the invention of language, has already come under our notice. We have found imperatives to be the shortest of all words, and to consist of the roots from which the greater part of other words derive their origin. But, since we have considered all language as imperative, that subject does not form an appropriate commencement to our inquiries into the peculiar nature of the verb; and in fact it scarcely requires any additional observations to those already made on it. Many verbs from their meaning do not admit of direct imperatives, (to wit, those which do not signify the voluntary acts of mankind,) yet possess many forms in common with active verbs.

We shall first consider those forms of the verb which are subservient to affirmation, or, as it has been sometimes termed, *predication*, for the sake of including negations.

Sect. II. *Verbs as subservient to Assertion.*

Assertion a frequent, and peculiar to the verb.

Assertion or affirmation is the act peculiar to the verb, being never performed by any word which grammarians have referred to a different part of speech. That part of the verb by which it is most evidently and most frequently performed is called the *Indicative*. By means of it we convey information. This, though not the original object of language, is by far the most frequent application of it, especially in an improved state of society. It proceeds from that great characteristic of our species, the love of knowledge, implying an inclination to convey it to each other. It is by means of affirmation that language becomes the instrument of the most important improvements in human thought and in the character of society. An inquiry into its nature must therefore throw considerable light both on thought and on language.

Nature of assertion.

In affirming, we connect different ideas together, and thus dictate an arrangement which we wish such ideas to assume in the mind of the person addressed. To this object a particular part of spee c is devoted; but that part of speech often consists of a word which contains a sign of various other ideas. When we say "the man walks," the word "walks" contains the name of a particular motion, at the same time that it expresses a connection betwixt that motion and the object denoted by "the man." Mr Tooke considers the verb as containing a noun and something more; and he proposes it as a question worthy of the attention of philosophers, what is that circumstance which, when added to a noun or the name of an idea, makes it a verb? The answer to this, in so far as the indicative is concerned, is, that it contains a sign of asserted connection betwixt the object expressed by that noun or name and some other object which is also mentioned in the sentence. But we have other signs of connection which are never considered as giving a word the nature of a verb. The genitive case implies a sign of connection betwixt the object expressed in that case and some other; the adjective performs a similar office; but there is a difference betwixt these signs of connection and that implied in the indicative of the verb.

Analysis of sentences of assertion.

The nature of these two sorts of signs, and the difference betwixt them, will be most clearly perceived by attending to the structure of those languages which enable us to resolve the indicative of every verb into its constituent parts by affording distinct signs for each. In English "the man walks" may be resolved into this sentence "the man is walking." The termination *ing* implies a connection similar to that expressed by the genitive case or by the adjective, while the word *is* gives the sentence the character of assertion, and fits it or conveying new information.

For the sake of possessing appropriate terms on this part of the subject, it will be convenient to borrow the technical language of logicians, who call a sentence a *proposition*, consisting of three parts, a *subject*, a *predicate*, and a *copula*. In such a sentence as we have now mentioned, each of these parts is expressed by a separate sign. "The man" is the subject, "walking" the predicate, and "is" the copula. The author of Grammar in Dr Rees's *Cyclopædia* maintains that "is" does not express assertion but connection. Connection, however, is often expressed by words of very different import: therefore that term is less appropriate to the copula than assertion.

Sect. III. *The Substantive Verb.*

The copula has been denominated the *Substantive Verb*, and it undergoes a variety of changes, called inflections, corresponding to the changes incident to other verbs.

Mr Harris's account of the substantive verb.

The radical nature and common use of this verb is not, as Mr Harris supposes, to express existence, but to assert a connection betwixt one object and another. The author now mentioned has been unfortunate in his mode of describing the use of this verb. He pronounces it an undoubted axiom, that "an object must first be, before it can be any thing else;" an opinion in all points of view untenable. In the first place, it is not necessary that the subject spoken of should have an actual existence. We can speak of supposed as well as of existing objects. In the next place, an assertion that any object which has existence is something else, implies an absurdity.—What then is an assertion? Do we by means of it assert an object to be the same that is implied in the term used for an introductory designation? This is not the case; it would form an

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unmeaning truism; and the predicate is generally a different word from the subject. In this act we neither assert the subject to be the same, nor to be something else. The office of assertion consists in pointing out a relation betwixt the subject and some other idea. The word "gold" has one meaning, and the word "metal" has a different one. When we say "gold is a metal," we do not intend to say that the words "gold" and "metal" have the same meaning, but that the qualities expressed by the word "metal," are connected with the object called "gold." When we say "sugar is sweet," "wormwood is bitter," our intention is to produce in the mind of the person addressed a connection betwixt the ideas which have been previously attached to the word "sugar," and the further idea of "sweetness," and betwixt the ideas attached to "wormwood," and the idea of "bitterness." Sometimes nothing may be previously known concerning the subject of the proposition. We may speak of sugar and of wormwood to a person who has never heard of either. In that case the terms are only introduced as signs requiring the person addressed to attach to the one of them the idea of sweetness, and to the other that of bitterness, as contributing to those compound ideas of which he may afterwards consider the words as significant. The idea expressed in the subject must always be different from that expressed in the predicate. This is the case even though the expressions used would on a different occasion be synonymous. When the sentence "London is the capital of Britain" is uttered, if the hearer had any ideas about London, he is desired to connect with these the further circumstance of its being the capital of Britain: if he had no idea on the subject, except that London was a name written or pronounced in a certain manner, he is desired to connect this word as a name with those which form the predicate of the sentence. Sometimes, by a figure of speech, the same word is used for the subject and the predicate: for example, "Home is home." In the employment of this figure, however, it will be found that such a word as "home" in these two situations has a different set of ideas attached to it. The meaning of this sentence is, "Home, though often thought and spoken of with indifference, is, when made the subject of reflection, connected with feelings which interest and attach us."

The ultimate effect of assertion.

The substantive verb radically indicative.

The substantive verb differs from verbs of motion in being radically indicative in its character. Assertion is the cause of the contrivance of it. It does not originate in the imperative mode, any further than an imperative effort to command attention is implied in all language. The use of the substantive verb is, to direct the thought of a person to the connection of one idea, or one assemblage of ideas, with another, and thus to indicate congruities, incongruities, and relations of all kinds. The substantive verb is employed in the imperative conformably with the usages of other verbs. We say, "be wise;" "be ready to do your duty;" but this imperative has always an awkwardness and a want of emphasis, compared to that of the active verb. An active imperative may be considered in such phrases as understood. It seems an absurdity to desire any person or thing *to be*, or even simply to be connected with another object, or to be endowed with a particular character. The imperative radically implied in such sentences is a command or solicitation to use such *exertions* as tend to the production of a certain state. *Sis probus* means *fac ut sis probus*, cause yourself to be good; act in such a manner as to support a worthy character.

All the other forms of this verb coincide in meaning and emphasis with the corresponding parts of other verbs.

The peculiar character of the indicative of the substantive verb is, to express in a separate word that general act of the mind which is common to all verbs in the indicative mood.

The pr[edi]cate in[tro]duced [by] this ver[b].

The *predicate* of a proposition may either be an adjective noun, as "Cicero was *eloquent*;" "Solomon was *wise*;" or a participle, as, "the man is *walking*;" "the boy is *riding*." A substantive is applied with equal frequency to the same use as "Isaac is *a philosopher*;" "George is *a king*;" "Alexander is *an emperor*." A connection betwixt the ideas expressed by these substantive nouns and those attached to the *subjects* of the propositions, is then asserted by means of this simple verb. The verb still merely serves the purpose of a copula. The noun becomes an adjective by its situation.

Origin [of] this ver[b].

Dr Smith infers from the generality of the character of this verb that it must have been the result of much thought, and could have been formed only after refinement in metaphysical science had made considerable advancement. For this inference, however, there is not sufficient foundation. The acts exerted in all assertions have a character mutually similar, and are therefore called the same act; and nothing is more natural than to express the same act or similar acts by the same sign.

Suppose[d] no dept[h of] reflectio[n].

The early attempts of a child to speak are often made without the use of the substantive verb. He says, "That bread good," instead of ' that bread *is* good." He possesses the ideas of bread and of goodness, and, by pronouncing the one in immediate succession to the other, he attempts to convey the impression which he has received of their mutual connection. The same mode of speaking may be supposed to take place among a people whose mutual communications are few and crudely executed. But, as the juxta-position of nouns may also be applied to other uses, a separate sign is afterwards introduced for indicating assertion; and no depth of metaphysical knowledge is required to induce men to use the same sign on every similar occasion. Although some risk of error attends the intellectual exercise of retracing and analysing the progress of our mental operations, and hence metaphysical mistakes and difficulties have been handed down from age to age, no hesitation or impediment occurs in the employment of the faculties for the common purposes of speech. The human mind has always proceeded without embarrassment in contriving signs for its communications. The formation of a general word is equally easy with that of a significant general termination for shewing that words are applied to similar uses. A termination expresses some point of mutual resemblance in the application of words. The same thing is done by a separate word, and a separate word may be uttered with equal facility. The forms, in fact, which are common to all other verbs are exactly synonymous with the pure substantive verb. All other verbs consist of the signs of ideas, coupled, as we have observed, with the sign of adjection, and the sign of assertion; that is, the meaning of the participle with that of the copula.

Sect. IV. *The Neuter Verb.*

Natur[e of] the ne[uter] verb.

Some languages have verbs which contain the meaning of an adjective and the copula condensed in one word, and which have no further characteristic in the construction of sentences than these parts of speech when separately expressed. Perhaps this is not the

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case with every language, and there are probably none in which such verbs abound. In the Latin language, *rubere, virere, calere, frigere*, are instances. In English we have the verbs "to glow," "to blush;" but we for the most part express such ideas by using adjectives with the substantive verb in a separate state. The verbs now mentioned are called *neuter* verbs, in consequence of the absence of certain qualities which we shall find other verbs to possess.

Sect. V. *Assertions made by Verbs of Motion or of Action.*

Origin of ...s of ...ion.

It has been already observed that the first object which a man has in view, in using speech, is to excite to action. Were mankind destitute of vocal language, they would imitate the particular actions which they intend the person to whom they speak to perform. This is always done by persons who wish to converse while they are not acquainted with any common language. The case is necessarily the same with dumb persons. In tracing the origin of the words by which particular actions are represented, and the establishment of them as conventional signs, we find no general principle to guide us. The motive for using a particular sound is of so casual a nature that its history is lost before it receives an established application. The want of written documents, and the total inattention to retrospective analysis, which exist in a state of society so rude, involve the origins of words in obscurity. Etymology can only trace a word from one application to another, and follow its variations through the different languages into which it has been adopted. Even this exercise is liable to deceptions which it is difficult to avoid. Yet it must be allowed that, when conducted with caution, it may prove extremely useful, by discovering analogical principles of transition, which elucidate this department of human art.

After men have learned to employ words for exciting one another to those actions by which reciprocal services are performed, the extent of the uses to which language may be applied must be soon more fully perceived. Men contrive to describe to each other various surrounding phenomena. Some of the most interesting of these consist of the actions of their fellow creatures.

...root ...l in the ...erative ...ives ...r applications.

The same sign by which we desire a person to perform a particular action, is naturally retained as a symbol of that action in describing any series of events of which it forms a part. After we have used the words "come," "go," "stand," "sit," "run," as imperatives, we spontaneously apply the same words, either in the same form or with some slight addition or alteration, in affirmative sentences, such as "John stands," "John sits," or "John runs."

It has been already remarked that these indicative forms may be resolved into the copula with a participle, and are equivalent to "John is standing," "John is sitting," and "John is running." The connexions expressed by the participle are observed in the operations of the solitary mind before we are capable of using language, and form an extensive series of relations among the objects of our knowledge. But the earliest use that arises for connecting the significant words is the conveyance of information. On this account the copula and the participial sign are not originally separate, but condensed into one word with the name of the action specified. This early date of the condensed phrase is the cause of a comparative simplicity in the indicative form. It is prior in formation to the participle. We have occasion to say that a man "walks," sooner than we have occasion to use the compound designation "the man walking" as the subject of a different proposition. It follows *a fortiori* that the simple indicative is prior to that indicative which is formed by the participle and the copula. The division of it into these two parts might make the indicative appear more complicated in metaphysical analysis, and some might be disposed, on this view of the subject, to consider the usual indicative as a species of contraction. But this is not its character. The act which consists in the union of the meaning of these two signs is spontaneous, and of an early origin. On this account the indicative has even less complexity of form than the participle.

...ertion ...arlier ...than ...ple adion.

Sect. VI. *The Active, Passive, and Middle Voices.*

It most frequently happens that, in describing an event, whether consisting of a voluntary human action or not, we have occasion to bring into view, by means of a noun, some object which has a conspicuous concern in it. The occasions on which no inclination to do this exists are but few, and the events which are described in a manner so simple are not of the most interesting kind. They occur in Latin in the use of such verbs as *ningit* and *pluit*, "it snows," "it rains." Each of these verbs, without any nominative, contains a full account of an event.

Some verbs of no voice.

When we describe an action which has an intimate connection with some other objects, we generally have occasion to extend our description by the mention of the object or objects so situated. We may either mention one or more of the agents who perform the action, or an object affected by it. If the noun expressing this object is put in the nominative case, it becomes the leading subject of the sentence.

Origin of voices.

When the nominative is the name of an agent, the verb is said to be *active*. When it is the name of an object affected, it is said to be *passive*. (This mode of expression is somewhat illogical. It is the noun that becomes active in the one instance, and passive in the other. The difference of these two uses of the verb is, that they give these differences of character to the noun. We shall, however, adhere to the established nomenclature as established by common usage, and possessing the advantage of a convenient briefness.) There are not in every language two separate forms of the verb for these two applications of it. In modern English, some verbs are used in the same form in an active and in a passive application. We can use the verb "cut" in any one of the three following ways: "They *cut* the tree;" "These tools *cut* smoothly;" "Fir *cuts* more easily than oak." We say, "Look at that person's face;" also "He *looks* well;" "Drink some wine;" and "This wine *drinks* pleasantly."

Distinct forms not always required.

Some grammarians, impressed with the prominent distinction existing in the Latin language betwixt the verb in the active and the passive voice, would insist that "to drink" and "to cut" are essentially active, and therefore that the phrases "fir cuts easily" and "this wine drinks pleasantly" are ungrammatical. But we shall probably entertain a more enlarged as well as a more correct idea of the verb, by conceiving that those which we call active verbs are in their earliest application of no particular voice, though, from the agent generally appearing in the mind of the speaker more important than any object acted on, the active application of them is the most frequent. The original indicative of

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the verb thus points out a connection betwixt an object and an event without specifying the nature of this connection. The circumstance of agency or any other may be safely left to the inferences formed by the understanding of the hearer.

Different contrivances for a passive form.

In other instances, it is found convenient to contrive a mode of expressing by some slight alteration in the form of the verb the circumstance of being the object acted on. An expression of this sort, if found to harmonize with the genius of a language, may be afterwards universally adopted; and the original form of the verb will then be limited to the active application. In such languages the distinction betwixt the active and passive voices will be most constant. This happens in the Latin language, and in the active and passive voices of the Greek. But, where the contrivances adopted for this purpose are in point of convenience less fortunate, they will be more varied and less strictly adhered to. Much will be left to urgent occasion or individual taste. Of this we have instances in the middle voice of the Greek verb, and in several phrases in the modern languages of Europe.

In French.

The French apply the verb in a passive acceptation, by introducing the same object as the nominative and the accusative to it, as *Le vin de Bourgoigne* SE BOIT *partout*, literally "the wine of Burgundy *drinks itself* every where." A verb thus used has been called a reciprocal verb, and it appears particularly appropriate when the same object is the agent and the object affected, as in the phrase "he prepares himself." Yet it is not necessarily limited to such occasions. *Le vin boit* does not mean "the wine performs the act of drinking," but "the wine has some connection with the act of drinking." The nature of that connection is here indicated by the accusative *se*. The phrase *le vin se boit* may be thus analysed, "The wine is concerned in drinking, by being the liquor which some one drinks." But we find that in English, when we say "the wine drinks pleasantly," the kind of connection betwixt the wine and the act of drinking is left to be inferred from the nature of the subject. This is of itself sufficiently prominent to prevent ambiguity, notwithstanding the incomparably greater frequency of the active application of that verb.

In Icelandic and Latin.

In other instances, a slight addition or a mere alteration is used for denoting the passive. In the Icelandic language, *æg elska* signifies "I love," *æg elskast* "I am loved." In Latin, we have *amo* for "I love," and *amor* for "I am loved." The expedients adopted in different languages will depend on the previous state of each. When a language already possesses a word expressive of suffering or being acted on, it will be natural to employ this, or some part of it, in union with the verb to denote the passive. It is not improbable that the letter *r*, which distinguishes the passive voice in Latin, is derived from *res* "a thing," or some previously existing word of similar import. The radical letters *am* signify "love;" *am-o* "I love," i. e. "I have some general connection with loving." *Am-o-r* "I am connected with loving as the *thing* or object loved." The letter *r* runs through all those forms of the passive voice which are produced by inflexion, with the exception of the second person plural.

The preterite tense of the passive verb in Latin is made up of a compound phrase, consisting of the participle with the substantive verb. The participle employed is derived from the past tense. *Amatus* is most probably a contraction for *amavit-us*, and derived from *amavit*. The past tense is thus converted into a part of speech resembling the adjective; and the effect of the past is exhibited as a quality which is to be connected or adjectived to some other idea expressed in the form of a substantive noun. The introduction of the copula forms an indicative or asserting sentence. This shows that assertion was not early appropriated to that particular sort of connection betwixt actions and other objects.

In English.

The best passive form of the verb which the English language possesses is in the preterite tense, and yet it is of an equally compound nature with this part of the Latin passive. We adopt the sign of past action in the form of an adjectived quality, and complete our assertion by inserting the copula. "Destroyed" is the past tense of the verb "destroy." "The enemy's troops *destroyed* the city" expresses the active voice: "The city is *destroyed*" expresses the passive.

We have no good contrivance for a passive voice in the present indicative. *Domus œdificatur* cannot be literally translated into our language. When we say "The house is built," we assert the completion of an action. The nearest approach which we make to it in respect to tense is by the phrase "the house is building;" but here we confound the voices, at least we employ a word which in respect of voice is general, as the participle in *ing* is most commonly used in the active voice. Some of our southern neighbours choose to express their meaning by the phrase "the house is being built," which is no farther appropriate to the present tense than as the same combination never happens to be used for the past. It labours under the disadvantage of an awkward verbosity, which prevents it from being generally adopted, or sanctioned by the authority of persons of taste. Another effort has sometimes been made to supply this want by prefixing the letter *a* to the present participle, and thus converting it into a passive present, as "the house is *a*-building," but this has not succeeded in meeting with a permanent adoption. A strictly appropriate phrase has not been found absolutely necessary, because a slight alteration in the form of our sentence enables us to dispense entirely with the passive form of the verb. We can say "the building of the house goes forward," or "the work people are engaged in the building of the house." No inconvenience is experienced in expressing our meaning; it is confined to our attempts to translate Latin sentences literally into English.

Substitutes for the passive voice.

In the French language the passive voice is much less frequently used than in English. That language has a resource which few others possess for introducing the object acted on after the active verb without the mention of any particular agent, as it has a nominative of a very general application, *on* or *l'on*, signifying merely "some being or beings real or imaginable." This is prefixed to the active form of the verb, and the object acted on is conveniently made to follow in the accusative (or objective) case. *On le dit*, "some being or beings say so," is translated with propriety "it is said."

Our language is equally defective in a passive voice for the future as for the present. If the sentence *domus œdificabitur* is translated by the phrases "the house will be built," or "the house will be building," or "a-building," or "will be being built," we shall find these forms to labour under the same disadvantages with the attempts already mentioned to give a translation of the words "*domus œdificatur*." Yet we experience equally little inconvenience in this as in the former instance,

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because a moderate skill in varying the turn of our sentence enables us to convey our meaning clearly without the use of a passive voice.

Impersonal verbs.

A neuter voice might be formed consisting of a separate word to signify that an action takes place, in a manner similar to the words *ningit* and *pluit*. We might have a single word for "there is," or "there was a walking;" in French, *l'on se promene*. In Latin, the passive voice is sometimes used in this neutral or impersonal manner. *Ambulatur* is not passive in any thing else than in form. It means "the act of walking goes on;" *ambulatur ab illo*, "the act of walking is performen by him," for "he walks."

Sect. VII. *Regimen of the Active Verb.*

Origin of the regimen of verbs.

Some actions are of such a nature that the object affected by them is always interesting, and, in the earliest use of language, such actions are never related without immediate mention of an object thus affected. It also happens on such occasions, that the manner in which the object is affected is evident from the nature of the action. Of this nature are the actions expressed by the verbs "to make," "to build," "to cut," "to strike," "to kill." Such verbs in the Latin language generally govern the accusative case, intimating the most rapid transition from the idea conveyed in the governing verb to that conveyed in the noun. The noun governed may, in consequence of its own regimen, be rendered introductory to further additions both to the form and meaning of a sentence. The verb thus becomes a hinge on which the greater part of the meaning of a sentence turns. The large proportion of verbs which govern nouns in this manner has conferred a conspicuous rank on this part of speech. It is in this respect more powerful than the adjective. Even when adjectives are used as predicates in affirmation, the meaning which they introduce generally terminates in themselves, or leads to subordinate ideas only through the medium of prepositions. We say "this man is good," "that man is just;" also, "this man is good at heart," "that man is just in all his conduct." It is seldom that adjectives in Latin can be admitted to govern the accusative; and even the phrases in which this might appear to take place, such as *Os humerosque similis*, are commonly explained by the subaudition of the preposition *quoad*. These differences betwixt the active verb and the other parts of speech have had a secret influence in leading grammarians to attach great importance to the verb. Its full power seems to reside in this form of it. Verbs of other kinds have appeared to be exceptions, or words to which convenience has assigned a verbal form, though they are not originally entitled to it.

Consequences of its extension.

The governing powers of the active verb are retained by the active participle and the infinitive mood. This fact seems to have led grammarians to consider these forms of words as parts of the verb properly so called. The participle is distinguished from the adjective by regimen alone. Hence those grammarians who call participles real adjectives have always been most fully satisfied with the appellation when applied to the participles of verbs destitute of regimen, such as "thriving," "charming," "surprising," words which are in all respects used as adjectives, though participles in etymology and in form.

The infinitive mood has the same similarity to the substantive noun as the participle has to the adjective. It may become a nominative to a verb, as "to enjoy is to obey;" or an accusative, as "men generally wish *to live* long," but, when introductory to other words, it has a more powerful and ready regimen than the noun. In Latin, it like the verb governs the accusative, and not exclusively the genitive, like the noun. We shall afterwards consider more particularly the participle and the infinitive mood. At present we have merely accounted for the fact that grammarians have reckoned them real parts of the verb.

General reflections on the verb.

It must always have been obvious that this office of the active verb is not common to all verbs, and therefore is not characteristic of this part of speech; and, if the participle and the infinitive mood are to be reckoned parts of the verb, the problem still remains unsolved, what is the true characteristic of the verb? Mr Tooke intimated that he was prepared with some doctrine which appeared to himself satisfactory as a description of the verb, including its infinitive mood. Every philologist must regret that this acute writer did not communicate his views more fully to the world. On this part of the subject, it is possible that they may have been both well founded and original. We are certain that they would have been at least worthy of attention. They appear to have been valuable in his own eyes; they would have been exhibited in a forcible manner if he had chosen to publish them, and might have led the way to a more satisfactory account of the subject. But, as no explanation of this sort occurs on our own most matured reflections, we naturally suspect (however presumptuous the declaration may appear,) that his theory would have either turned out eventually inconsistent with some of the opinions which he has published, or would have been in itself unsatisfactory.

A precise answer to the question in the form now proposed is not of great importance. We have pointed out assertion as one office which is performed by verbs alone. We have pointed out the quality of an active regimen, as belonging to an extensive department of verbs, and have shown that this quality is possessed by parts of speech closely allied to the verb in etymology, and generally numbered among its parts, though not possessing an asserting power. We have shown in what words assertion and a transitive regimen are separate, and in what they are combined. Assertion is separate in the indicative mood of substantive and neuter verbs; the transitive regimen, in the infinitive mood and active participle of active verbs. We have endeavoured to investigate the connection betwixt these parts of speech and the indicative of the verb. In so far as their character is inconstant or complicated, we have stated the causes of these characteristics, and the shades of variation by which they are distinguished. We have shown in what respects the intermediate kinds of words partake of the nature of one part of speech, and in what respects they partake of the nature of another. If the particulars on these subjects are impressed on our minds, our theories will be exempt from ambiguity or confusion.

Sect. VIII. *Intransitive Active Verbs.*

Neuter verbs have no such regimen as has been now described. Hence some have assumed this as a mark of distinction betwixt them and active verbs. It did not however escape observation that some verbs which do not govern any noun signify action, and that therefore the term *neuter* as implying the absence of active

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power, did not apply to them. For this reason these have been retained in the list of active verbs, but distinguished from verbs of regimen by the additional epithet *intransitive*. Their peculiar character has been generally represented as arising from this peculiarity in the nature of the actions signified, that they do not affect any ulterior object. But this is not true in point of fact. The transitive or intransitive nature of verbs of action depends solely on the occasions of mankind in making use of language. Transitive verbs are those which express actions when we have occasion instantly to mention an object acted on. Intransitive verbs describe actions when we are satisfied with stating the connection betwixt the action and the agent. Verbs which admit of no direct regimen, and therefore are termed intransitive, may introduce other ideas, expressed by nouns, through the medium of prepositions. The verb "to strike" is *transitive*, while the verb "to walk" is called *intransitive*; and yet it is evident that in the act of walking one or more objects are acted on as much as in the act of striking. Only it happens that when we speak of striking, it is generally of importance to point out the object that is struck; but, when we speak of walking, our attention is chiefly directed to the act as connected with the agent. In walking, however, a man walks *upon* some object, which supports him; he walks *from* some place, and *to* some other. Each of the phrases "I strike my horse," and "I walk upon the ground," expresses, in a manner equally explicit, a particular act, together with an object affected. The intervention of a preposition in the one case, and the absence of one in the other, imply no difference in the energy of the act related, but only the different degrees of interest excited in the connection of it with the object affected. It might naturally be expected, from the numerous and varied occasions which we have for the relation of events, that, even in describing the same sort of action, we should sometimes have a motive for mentioning an object affected, and sometimes not. For this reason some verbs differ from each other only in their transitive or intransitive application, of which we have already given an instance in the difference betwixt the verbs "to speak" and "to say." In other instances the same verb is used either transitively or intransitively. We may say at one time, "a miller grinds corn;" in this sentence, corn is the object affected by the act; at another time we may speak of the same act as characteristic of the situation and employment of an individual; as in the sentence, "two women were grinding at the mill, the one was taken and the other left." Here no occasion arises for mentioning any object on which the act of grinding is exerted. These however are not two different meanings given to the verb. In both cases it is used in its full meaning, that of describing a species of action. Whether we choose to introduce or omit the name of the thing acted on, depends on the design which we have in forming our discourse. It may or may not be of use to add this circumstance to the description. It makes no more difference in the original meaning of the word than the introduction of a second sentence in elucidation of the subject would affect the meaning of the words in the sentence first employed.

Verbs often intransitive though they signify transitive acts.

Some verbs both transitive and intransitive.

Sometimes verbs which are originally intransitive, and evidently not intended to have nouns subjoined to them, except through the medium of prepositions, are afterwards applied as active verbs governing the accusative, in consequence of the familiarity which the expression of particular kinds of connection acquires from habit. The verb "escape" originally required the preposition "from" to express a certain sort of connection betwixt the act and other objects. Yet we not only say "a prisoner escaped from prison," but, speaking of our own memory, we may say that "names and dates escape us." *Fugire* in Latin, is a verb of the same kind, and the corresponding phrase *me fugit* is used in that language. *Me latet* is of a similar nature. *Ardere* is intransitive, or perhaps ought rather to be called neuter, yet it is made to govern the accusative: *Formosum pastor Corydon* ARDEBAT *Alexin*.

Univer[sal] Gramm[ar.]

In some instances an active verb, which we are in the habit of connecting with nouns by means of prepositions, is used to form a transitive verb by being compounded with a preposition governing the accusative, and evidently derives its transitive power from the preposition. Such a verb, like others which govern the same case, may be used in the passive voice. In Latin we have such words as *initur*, "it is entered on." In English the same thing takes place, though the two words continue separate. The phrase thus formed is treated like a compound word, and made to pass through variations similar to those to which entire words are subjected. Such are the phrases "to laugh at," and "to trifle with:" the preposition and the verb coalesce to form a sort of compound verb, which is used passively in the phrases "to be laughed at," and "to be trifled with." This species of coalescence of words into phrases, subjected to a peculiar inflection, even takes place in instances in which an active verb governs a noun in the accusative, and then leads to another by means of a preposition; as in the phrase "to make a fool of;" for we do not say in the passive "a fool was made of him," but "he was made a fool of." We have many analogous examples; as, "to be made game of," "to be evil spoken of," "to be taken notice of," "to be taken care of." Some even say, "to be paid attention to." This last expression is inelegant, because it shews an unsuccessful grasping at a variety of accommodation.

Intransi[tive] verbs be[come] tra[n]sitive by composi[tion.]

On the *diversity* of regimen of verbs, see our account of the cases of the noun. The subjects are inseparably connected, and under that head such observations as appeared necessary have been delivered.

SECT. IX. *Persons and Numbers.*

VERY little remark is required on the meaning attached to the *Persons* and *Numbers* of the verb. But the nature of their connection with this part of speech may be illustrated by their etymology.

In those languages in which verbs receive separate terminations for distinguishing the first, second, and third persons, such terminations are pronouns, and are equally complete as if they were separate words. The termination *o* in *amo* was probably derived from *ego*, the *s* in *amas* from συ, the *t* in *amat* from αυτος, the *amus* in *amamus* from ἡμεις. These terminations shew traces of being the same pronouns slightly modified. Some philologists who find themselves at one time dazzled by Mr Tooke's plausible etymologies, are at another startled on finding instances to which his principles cannot be applied, and on this ground rashly become disposed to condemn the whole as fanciful. A person under these impressions might perhaps stop us short in the inflections of *amo* with asking the etymology of the terminations *-atis* and *-ant* in the second and third person plural. *Atis* affords no vestige of the Greek ὑμεις, nor *-ant* of αυτοι. It would be too bold to maintain that they are derived from words so dissimilar to

The te[rmi]nation[s] pronou[ns.]

themselves, unless we were able historically to point out the intermediate steps of their transmutation. But difficulties of etymology do not in the least invalidate the general position, that such terminations are real pronouns. *Atis* and *ant* have exactly the same meaning with ὑμεις and αὐτοι. Whether they were derived from words subsequently forgotten, or were applied in the first instance as terminations, they are to be considered as complete signs equally significant with separate words, and differing from the latter only in being placed not before but after the radical letters of the particular verb, and written in closer connection with them. The resemblance of some of the terminations to the separate pronouns is a fact happily adapted to corroborate the identity of their signification; but though no such resemblance existed, just reflection would lead to the same conclusion.

Pronominal terminations attached to other parts of speech.

In speaking of the personal pronouns, we observed that they have all the characters of nouns, and that their whole peculiarity consisted in their frequent use, which has occasioned a convenient brevity in their form. It is to the same cause that they owe the further distinction of being attached to many important words in the shape of terminations. In Greek and Latin we find them attached to the verb. In the Hebrew and Arabic they are attached in the same manner to nouns. *Ism*, the Arabic word for "a name," receives the terminations *-i*, *-ek*, and *-ou* for signifying "my name," "thy name," and "his name."

Inflections of the English verb.

The inflections of the English verb possess a character somewhat different from those used in the Latin language. They do not supply the place of nominatives, but are used along with them. We say "I love," "thou lovest," "he loveth" or "loves." We never say "love" for "I love," "lovest" for "thou lovest," nor "loveth" and "loves" for "he loveth" and "he loves." The terminations in English therefore are not complete pronouns as in Latin; they are only accompanying signs, denoting that a particular sort of word is the nominative to the verb. They might be represented as redundancies, but they are not destitute of meaning and utility. Though not absolutely necessary to guard us against mistake, they contribute to precision. They enable us to expatiate on a variety of circumstances in connection with the object exhibited in the nominative case, before we introduce the verb; and then the form of the verb shows its connection with the person mentioned in the nominative. But as the terminations in English are not so essential as in Latin, they are fewer and less varied. The first person singular, and all the three persons plural, consist of the simple verb with the pronoun prefixed. "I love, we love, ye love, they love." For this, among other reasons, our language admits of less inversion in the order of the words.

Numbers.

The same observations apply to the *Numbers* as to the persons of the verb. The use of them in the imperative mood is conducted in the same manner as in the indicative. In the passive voice they follow similar analogies as in the active.

Sect. X. *Tenses.*

Origin and general division of tenses.

A reference to time is inseparably connected with the narration of events, and therefore many parts of the verb are so contrived as to indicate in their structure a connection with some portion of time in contradistinction to another. The point of reference naturally first assumed is the instant in which the sentence itself is uttered. Hence the first general division of tenses is into present, past, and future. Points of reference may also be selected from the past and the future, and expeditious methods, suited to our various occasions, adopted for expressing relative precedence or subsequence.

References to the division of time into definite portions, as hours, days, weeks, months, and years, are always made by means of nouns contrived for the purpose.

1. *Tense of the Imperative.*

The imperative essentially future.

Before proceeding to the tenses of the indicative, which are the most important and precise, that of the imperative claims some attention. The form most frequently used in Latin and in English has been called the present imperative; but a little attention will shew that imperatives are essentially future. The act to be performed must be subsequent in time to the command. In many instances they may be separated by a considerable interval, without any alteration in the form of the verb employed; as when we say, "come to this place to-morrow." Though sensible of this circumstance, grammarians seem not to have been aware of its importance in demonstrating the tense proper to this form of the verb. Perhaps a vague idea existed that the time of the *giving of the command* ought to fix its tense, but this is obviated by the slightest reflection on the subject, as the act performed by the speaker in every sort of sentence is present. Perhaps the *immediate* nature of the *influence* intended to be produced by the imperative on the mind of the person addressed has, though future, been considered as sufficient to entitle it to the appellation of present. But this influence is in no respect a proper foundation for a distinction of tense. All language is intended to produce an immediate effect on the mind. It is therefore solely with the time of the action or event specified in the verb that philosophical grammar is concerned in tracing the different tenses. The future in English is sometimes used instead of the imperative, as "thou shalt not kill;" "thou shalt not steal." Perhaps grammarians who delight in distinctions would perceive in this phraseology, as compared to the common English imperative, some analogy to the varieties of imperatives in the Greek language, and would denominate the sentences last mentioned future imperatives, in contradistinction to the common form called the present. But in the meaning of the sentences the tense is equally future in both.

Objections answered.

The Greek imperatives.

The Greek language has various imperatives which grammarians arrange along with the different tenses, and distinguish by the names of the present, the aorist, and even the preterite imperatives. But this diversity of form can produce no corresponding diversity of tense, unless this should consist in discriminations in the portions of future time to which the commands refer. We may order a person to begin an action at a particular time; or we may order him to be engaged in some occupation which is supposed to be previously begun; or we may order him to have an action completed. But, with reference to the primary division of tenses into past, present, and future, the imperative must be regarded as essentially future.

2. *The Aorist and Present Indicative.*

The primary indicative implies no tense.

Mr Tooke has remarked that the part of the verb called the present indicative is a simple or general indi-

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cative, and that no tense is implied in it. When we say "the sun rises in summer much earlier than in winter," we assert a fact applicable to past, present, and future. Of the same nature are mathematical theorems and all general propositions. This form of the verb might therefore with respect to tense receive the appellation of a universal aorist. This indeed is the form of the verb used for describing present transactions. The idea of present time is on such occasions attached to the sentence, in consequence of an inference drawn from the nature of the subject.

Sometimes applied to the past,

In some languages it is elegantly used to describe a long portion of past time extending to the present: as in French *Je suis ici trois ans*, and in Latin *Tres annos hic adsum.* But it is also used in describing events which have been completed at a time past, as, "Yesterday, when walking along, whom *do* I meet but my old kinsman:" "I am glad, *says* he, to find you looking so well." Grammarians, never doubting that such indications are essentially of the present tense, have supposed that in such sentences the past is, for the sake of vivid representation, described by a figure of speech as present. The facts now stated shew that such explanations are unnecessary; and if they are in any degree just, or adapted to the conceptions which we attach to this form of the verb, the consideration that this indicative is not restricted to any tense will account for the facility with which we reconcile our minds to a figure of speech which would otherwise appear a distortion.

Sometimes to the future.

We sometimes also use this general indicative in describing future events, and their futurity is pointed out by some other word in the sentence, or by the evident import of the whole. "Next Tuesday *is* the first of April," is a sentence equally proper with "next Tuesday will be the first of April." And we say without any dread of being accused of vicious diction, "To-morrow he *begins* his journey."

Tenses not indispensible.

It would be possible for men to convey their meaning on all occasions by indicatives, without any distinction of tenses. The mention of other circumstances might serve to prevent the hearer from confounding the past, the present, and the future. But a sign of general application, consisting either of a separate word, a termination, or a systematic variation of the verb, is an important convenience.

The true present tense.

We are not altogether destitute of resources for marking with precision the present tense. Every language possesses separate words for the purpose, such as *now* in English, and the corresponding words in other languages. It happens that, in our language, without the use of such additions, we indicate present time by employing the substantive verb with the participle instead of the usual indicative. "He writes" is the indicative without tense. "He is writing" is the present indicative. When we say "He writes a good hand," or "He writes to his relations every month," we restrict our meaning to no particular time. But, when we say "he is writing," we describe a present transaction. This distinction is entirely conventional. The original meaning of this combination of words implies nothing to distinguish it from the simple indicative, as the verb "is," and the termination "ing," are, with respect to tense, equally general.

3. *The Preterite Imperfect and Perfect.*

Importance of the preterite.

The preterite tenses are of great importance in language; and all tenses by which knowledge is communicated imply a reference to past time. To the past we owe our information. Our efficient communications of knowledge consist in references to the past. Though the present exhibits nature as immediately perceived by the senses, which are the inlets of knowledge, it is by means of the past that we are enabled to form a judgment concerning the objects perceived. On our past experience depend all our judgments and expectations regarding the future. If language consisted essentially in assertion, the past tense would be the original form of the verb. Grammarians state this to be the fact in the ancient Hebrew. In that language the preterite is in all verbs simple and uniform, consisting of two syllables, which are formed of three consonants, with two interposed vowel sounds. The differences of the consonants distinguish the verbs from one another, while the vowel sounds are the same in all. Such are the verbs פקד (*pakad*) *visitavit* נתן (*nathan*) *dedit.* The verb in this form is considered as furnishing roots from which all other words are derived. But those who have concluded, from the concurrence of all the facts in other languages, that the imperative is the original form of the verb, will find no necessity for adopting a different opinion of the formation of that ancient language. The imperative is in it equally simple with the preterite, generally consisting of the same consonants, varied most probably by a variation of the vowels. It has, therefore, on this principle, an equal claim to be considered as the root. In some instances it is shorter: in the verb נתן (*nathan*) it is תן (*then.*) Verbs thus formed are on that account denominated irregular. But the fact, in such instances of the greater brevity of the imperative, shews that the Hebrew in this respect does not differ from other languages. The simplicity and regularity of the preterite, however, in Hebrew may be considered as a consequence of the important rank which that tense holds in the most prevalent application of language.

Its simplicity and uniformity in Hebrew.

The English preterite imperfect.

In English, the past tense is formed by a variation on the root of the verb as used for the imperative. This most commonly consists of the addition of the termination "ed." Others are formed by variations of the vowels; as "struck" for the preterite of "strike," "wore" of "wear," "bore" of "bear, "drove" of "drive." "I walk," and "I drive," are assertions in the aoristic or present indicative; "I walked," and "I drove," are in the past. This tense implies that an action was begun, and was continued at some past period. It is called the *imperfect*, because no definite relation to the present state of the event is implied in it, and room is left for supposing that the action may be still continued.

The perfect.

When we mean to assert that an action is accomplished, we introduce before the expression of past tense the auxiliary verb "to have" in the present or general indicative. "I have walked," signifies, "I am in possession of the complete act." "I have (by my own exertions) assured myself of its completion."

Some English verbs have two variations of the radical word for expressing past time, "strive," has "strove," and "striven;" "weave," "wove," and "woven;" "break," "broke," and broken;" "do," "did," and "done." The completed act is expressed by the last of these forms, the words "striven," "woven," "broken," and "done." Mr Tooke considers this contrivance as a redundancy, because one word for past time is sufficient for every purpose. In verbs which have the preterite in "ed," the same word is used for the simple description of an event in a train of progress at some past period, and for being conjoined with the verb "have," to signify that the act is completed. The insertion of that verb is sufficient for marking the distinction. "He walked," and "he has walked," are equally distinct from one another, as "he did," and "he has done." In some verbs in which the preterite is formed by a change of the vowel, the same simplicity is observed: "struck" is used for both these varieties in the expression of past events.

Erroneously analysed.

That form of the past tense which is conjoined with the verb "to have," some grammarians consider as originally and properly the passive participle. In this sentence, "I have driven a nail into the wall," they consider the verb "have" as governing the noun "nail" in the accusative, and "driven" as the passive participle agreeing with the noun. In this form of the past tense the same word is always used as for the passive participle. Therefore the sentence is considered as signifying in etymological analysis, "I have a nail (which is) driven into the wall," transferred by use and common consent to signify that the action is performed by the individual mentioned in the nominative. This theory receives apparent support from the structure of some phrases in the Italian language, which show that the passive participle is really the word employed, as its inflections are varied and made to agree with the noun in gender and number. Such is the phrase *Ho aperte le vostre lettere.* "I have opened your letter." This analysis of such phrases would have great probability, if the facts uniformly corresponded with it. But it is not a constant rule. It is often left even in the Italian to the option of the speaker. We may say *Ho aperto* or *aperte le vostre lettere, e veduto* or *veduta ivi la vostra cortesia.* The French say *J'ai donné,* not *donnée occasion. Il a tué,* not *tués, ses ennemis. Donnè* and *tué* therefore merely signify a past action, and, like any other part of the verb, introduce or govern the subsequent noun. They cannot be considered as agreeing with it like a passive participle. If it is convenient to have a separate name for that part of the verb, it may with sufficient propriety be called a *Preterite Gerund.* The peculiarity of its nature will appear in the most convincing light, when we turn our attention to neuter and intransitive verbs, which, having no passive voice, cannot be said to have a passive participle. When we say "he has gone," "I have come," the words "gone" and "come" cannot be past participles agreeing with nouns, as no nouns are introduced after them. There is no sufficient reason why the introduction of a noun should alter the nature of the word. In the phrase "I have struck," the word "struck" signifies action, and, as a part of the active verb, it may govern the accusative case with as much propriety as any other part of it. When we say "I struck my enemy," and "I have struck my enemy," the word "struck" is in both instances equally active in its meaning. There are certain occasions in which the past participle in the French language is used to agree with the governed noun; but these are altogether peculiar, and cannot give any room for supposing that this is the original construction of this form of the preterite, afterwards transferred to an active meaning; for it only takes place when the substantive noun has been previously introduced, and then referred to by means of the relative *que.* The French say *Il a* TUE' *plusieurs hommes*; but, *Les hommes qu' il a* TUE's. This was a subsequent arrangement, admitted after a long discussion of the French academy. There is some affinity betwixt this gerund and the past participle, though their syntax is not identical. Both signify an event completed. The participle is only the past tense, transferred to the adjective or participial application, by which a past action is treated as a quality introduced for describing an object. Its active application is of prior date, and is in constant use.

The preterite gerund.

The French idiom.

It is not necessary to treat particularly of the other forms of past tenses, as they are regulated by the same principles, whether they are formed of combinations of words, as in the modern languages of Europe, or combinations of syllables, as in the ancient languages. Some observations connected with the general subject of their varieties will be suggested by certain forms of the subjunctive mood.

4. *The Future.*

The future indirectly expressed.

The signification of the future tense requires no illustration. The remarks which we have to make on this subject will therefore be confined to its etymology. Our conceptions of future events are mere deductions from known arrangements in the past or present, tending to modify their character. Hence all the contrivances for expressing futurity, that can be traced to their origin, are founded on the connection in which the future stands to the past and the present as an effect to a cause. They are derived from verbs signifying resolution, obligation, or other preparatory circumstances, and, with respect to etymology, are equivalent to the words employed in such English expressions as "I intend to go," "I must go," "I am likely to go," "I prepare to go."

Its etymology in Latin.

Mr Tooke ingeniously derives the Latin future in *bo* from βȣλειν "to will" or "to be resolved." In *ibo*, for example, *i* signifies "go," *b* (from βȣλ) "will," and o (from εγω) "I." *Amabo* and *docebo* are formed by annexing the same letters to *ama* "love," and *doce* "teach." The future in *am* he considers as an adaptation of the radical letters of *amare*, "to love." *Legam* is thus equivalent to *legere amo, audiam* to *audire amo.* By those who indulge a general scepticism in etymology, or who have other systems to support, these derivations may be thought improbable, and abundant opportunities are afforded of taking refuge in the obscurity of old derivations. It may be said, if *b* means βȣλω in *amabo*, what is meant by the *b* in *amabam*? Such objections can have no further effect than to throw discredit on instances of etymology that are somewhat obscure. Let us therefore attend to some which are of recent formation, and which, as the successive steps of their change are easily traced, are superior to all objection. If general principles of analogy are there disclosed, by which the abbreviating contrivances of language have been conducted, the uncertainty of some antique instances is not to be much regretted. The former will also assist us to judge of the degree of probability to be attached to some etymologies otherwise uncertain.

In Italian.

In Italian, the future tense has undoubted marks of a derivation from the verb *avere* "to have." *Partiro* "I shall depart," is evidently derived from *partire-ho* "I have to depart." This is evinced by the identity of the terminations of the future with those of that verb in the present in all its persons and both numbers. *Ho, hai, ha; havemo, avete, hanno: Partir-o, partir-ai, partir-a; partir-emo, partir-ete, partir-anno.*

In French.

The French future is as evidently derived from the

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present of the verb *avoir*. In the verb *parler* it is *Je parler-ai*, "I shall speak," *tu parler-as, il parler-a, nous parler-ons, vous parler-ez, ils parler-ont*. These are the terminations of the present of the verb now mentioned, *J'ai, tu as, il a, nous avons, vous avez, ils ont*.

In English.

The French language has various modes of expressing futurity by combinations of entire words into set phrases. The verb *devoir*, which signifies to be obliged from duty, is employed for this purpose, as, *Je dois faire cela*, "I am to do that." The same verb continues in other instances to retain its full original meaning. The verb *aller* is used for a similar purpose; as, *Je vais lui rendre mes respects*.

In the English language combinations of this sort are the only futures, and they are often used in such a manner as to express something more than futurity. We have thus a beautiful intermixture of their original meaning with their modern application. The verbs "will" and "shall" are most commonly used, but they are not indiscriminately applied to signify futurity. Each of these verbs is employed to signify the resolution of the speaker, or simple futurity, according to certain habits of collocation with certain nominatives. "Will" in the first person, and "shall" in the second and third, signify resolution. Simple futurity is expressed by "shall" in the first, and "will" in the two others. The simple future is as follows:

"I shall," "thou wilt," he will."
"We shall," "ye will," "they will."

The future of determination is,

"I will," thou shalt," "he shall."
"We will," "ye shall," they shall."

Rule on the use of *shall* and *will*.

The perplexities occurring in the use of these auxiliaries, in consequence of the tendencies of the Irish and Scotch being different from those of the English dialect, which is the acknowledged standard, may be avoided, if we always recollect that it is not the resolution of the *person spoken of* that they are at any time employed particularly to express, but of *the speaker*. "Will," therefore, is employed for simple futurity in the second and third persons, and is even appropriate where an event is mentioned that is opposite to the inclination of the person who is the subject of the assertion. We say, "If you become obnoxious to the criminal law, you *will* be punished." The word "will" does not here imply intention or even consent, yet it is appropriate, because "shall" would imply constraint or authority on the part of the speaker. It is also to be remembered that, in mentioning any thing future with respect to ourselves, although it should be the effect of our intention, this does not render it proper to use the auxiliary verb "will." "Will" in the first person always expresses emphatic resolution, implying the apprehension of difficulty or resistance from others. If another has said, "you shall not," a man replies, "I will;" but in expressing the common acts which are to fill up our future time, we say simply, "I shall go home," "I shall tell you the whole matter when we next meet."

Occasional uses of these auxiliaries.

But there are occasions, independently of provincial solecisms, in which "will" may be employed in the second and third person to express the resolution of the person spoken of, and "shall" in the first, the resolution of some other. Observing another person obstinate, we may say, "It seems you *will* do it, and cannot be prevented." If another person has said to us, "You do not admire my friend, but you *shall* treat him civilly," we may reply, "perhaps I may, but you are mistaken in telling me that *I shall*." These last modes of speaking, however, are awkward, and require an uncommon emphasis to be laid on the respective auxiliaries, in order to express the full meaning of the speaker. It is therefore more elegant to employ more explicit phrases, as, "it seems you *are resolved* and cannot be prevented." "Perhaps I may, but you are wrong in supposing that I *am to be forced*."

Other English expressions of futurity.

Our language, like every other, has various words and phrases which express futurity along with something more, as "I intend," "I am obliged," "I am likely." We have also a phrase for expressing simple futurity in the use of the substantive verb followed by an infinitive, as "I *am to* go," "he *is to* come in my stead." We have the phrase, "to be about," which literally means to be somewhere in the neighbourhood of an action, and is by conventional application appropriated to the expression of *near futurity*.

5. *The other Tenses.*

General character of the other tenses.

It is unnecessary to consider particularly the other modifications of tense, such as the *plu-perfect*, and the *paulo-post futurum*, or to enter on an analysis of the phrases formed by the combinations of the auxiliaries "have," "do," "shall," "will," "had," "did," "should," "would," "shall have," "will have," "should have," "would have," to which grammarians add "can" and "could," with their combinations. All these are conducted on the same principles with the combinations already explained.

Combinations of meaning which are expressed in our language by the junction of several words, are expressed in Greek and Latin by means of syllables added to the radical letters of each verb, and forming with them entire words; as *amarem*, "I should love," *amaverim*, "I could love," or "I would love," (translated in our grammars "I may have loved,") *amavissem*, "I should have loved."

Dr Smith's observations on the ancient and modern structure of the verb.

Dr Adam Smith, in the comparison which he makes betwixt the ancient and modern languages, considers the former as deriving, from the use of syllabic variations, a great simplicity compared with those which fulfil the same purpose by means of auxiliary verbs. He thinks it more natural, after men possess a word for representing an event, to express the modifications of that event, in respect to person, number, and time, by altering the word, or giving various terminations, than by inventing separate words for the modifications intended. He considers the formation of a separate word of this kind in the same light with the formation of the substantive verb, that is, as a great effort of abstraction, which could only be the result of refined metaphysical speculation. His observation, however, loses all force when we recollect that a termination is as really a sign as a word is; and that the general employment of a termination or any other modification, on a number of analogous occasions, is the same kind of mental exertion as the prefixing of a sign of this variation in the form of a distinct word. It is not necessary to suppose that a general word in the form of an auxiliary verb is first contrived and perfected in all its parts, and then applied to use. It may first be used in a single form suggested in a moment of need, while we are using the verb descriptive of the event. It may be afterwards readily transferred to an association with a different verb; and this facility of association is the same, whether it is a subjoined syllable or a separate word. The distinction betwixt syllables and separate words is probably not fully acknowledged till mankind commit language to writing. The fact however is, that verbs which previously existed as expressions for separate assertions, are afterwards adopted as auxiliaries; a circumstance which removes still farther the necessity of ascribing the invention of them to refined metaphysical speculation.

Dr Smith further considers this mode of expressing the modifications of the verb in the ancient languages as conferring on them a great advantage over the modern languages in respect of brevity and force. But this brevity is often a deception arising from the prejudices attached to the appearance of written language. That author adduces as an exemplification of his remark the Latin word *amavissem*, which expresses a modification of thought, which in English requires no fewer than four, being translated by the phrase, "I should have loved." The English phrase, however, is pronounced with equal facility and dispatch as the single word *amavissem*; it consists of the same number of syllables, and these have no greater character of perplexity or tardiness in the one case than in the other. The Latin syllables, in this instance, nearly correspond to the separate English words; *am*, signifies "love;" *av*, "have" with "ed;" *iss*, "should;" and *em*, "I."

G eral remark on assertion and indicative mood.

Hitherto we have been occupied with those parts of the verb which serve as the copula in the composition of a sentence, and which, in technical language, are called *indicatives*. This appellation, however, if it is not a name for a mere form, if it has any scientific meaning, must be extended to some forms which have usually been considered as belonging to the subjunctive mood, as they are not confined to the purpose of subjunction, but sometimes form the only verb in a sentence: as *Illi potius quam alteri* CREDEREM. MALUERIM *te quam ullum alium imitari. Si cum hoste dimicâsset* PERIISSET. The words here marked in capitals have the full force of the indicative; that is, they convey affirmations; they indicate new connections of ideas, intended to be impressed on the mind of the person spoken to. They are therefore improperly distinguished by the title of *subjunctives*, if this implies that they are fitted only to maintain a subordinate rank in the composition of a sentence. Some further observations will be made on them in the sequel.

Sect. IX. *The Subjunction of Sentences.*

Sentences be various degrees of importance.

Every improved language possesses various contrivances for the subjunction of certain sentences to others. In every continued discourse, some are distinguished as of greater importance, and holding a more eminent rank than the rest. These others may be equally necessary to the full elucidation of the subject; but their utility arises from their subserviency to the developement of the former. Some sentences are preparatory, and contain propositions which are said to be premised. Others are inserted as constituent parts of more prominent sentences. This last operation may be denominated *subjunction*.

Sentence may be used as noun.

A whole sentence is capable of being used as a noun, and applied to every species of syntax competent to the noun. Sometimes the sentence retains the same form as when it stands unconnected. It may, for example, be made the nominative to a verb. This use of sentences is of frequent recurrence in treating of the subject of language, as in treatises on universal grammar, in which sentences as such, are the subjects of discussion. We can make a sentence by conjoining the three words "this is right," and we can then make it a nominative to the verb "is" by saying, "*This is right* is a short sentence." We can also make it an accusative to the verb "think," or the verb "say:" "He thinks or he says *this is right*."

Expedients for including one sentence within another.

Sentences may also be rendered parts of other sentences, by means of slight changes on some of the words composing them, or by the interposition of other parts of speech, contrived either for simple annexation, or for pointing out at the same time the particular relation in which the subjoined sentence stands to the whole.

Subjunction is of two kinds; subjunction to nouns, and subjunction to sentences.

I. *Subjunction to Nouns.*

Nature of subjunction to the noun.

A sentence is subjoined to a noun when it is employed for the same purposes of amplification or qualification as the genitive case or the adjective. This is done by using, instead of the nominatives "he," "she," "it" or "they," the relatives "who," "which," or "that;" as in the sentences, "Men who speak little are esteemed prudent:" "A man who commits murder deserves death:" "Men who speak ill of their neighbours are dangerous:" "Men who are capable of hypocrisy are not to be trusted." Here each of the sentences introduced by the relative "who," limits the assertion to a definite part of the general class of beings represented by the nouns "men," or "man."

It may be objected that the words, "who speak little," do not of themselves form a significant sentence. If this is the case, however, it depends entirely on the nature of the nominative "who;" and it may be remarked, that this nominative has the full meaning of the pronoun "he;" "he speaks little" is a complete sentence, though, in order to be made intelligible, it requires some previous knowledge of the person referred to by the word "he;" but the case is the same with innumerable entire sentences in language. "Who" implies the meaning of "he," and something more; it implies a mark that the sentence of which it is the subject is subjoined to a noun, and is thus an entire sentence with something additional.

Analysis of the relative.

The author of the article Grammar in the *Encyclopædia Britannica*, ingeniously analyses the relative into the preposition "of" preceding the pronouns "he," "she," "it," or their plurals, or oblique cases. When thus analysed, this word "of" must govern not the pronouns separately, which in fact are sometimes nominatives, but the subjoined sentences to which they belong. He shews that Mr Harris was deceived in supposing that the relative might be resolved into the third personal pronoun preceded by the conjunction "and." The phrase "Men who speak little," may be resolved into "Men *of they* speak little." Readers who are not accustomed to such analyses, and who regard the present habitudes of language as exclusively significant, may imagine that this analysis renders the sentence u. meaning. But, if we could suppose that the preposition "of" were one of those which govern nouns and sentences indiscriminately, we should find that the uncouthness of this paraphrase does not render it unintelligible. To these the words "before and after" belong. We can either say "before his dinner," or "before he had dined." It is sufficiently supposable that our language might have been so constructed as to put it in our power to say, not only "the time of dinner" but "the time of he dines;" and to say not only "men of few words," but "men *of* *they* speak little." In this paraphrase we shall have an intelligent analysis of the relative.

Varieties in the application of the relative.

In sentences thus subjoined, the relative may sometimes be the nominative, as in the examples which we have given; or it may be the accusative; or it may be subjected to any other regimen competent to the noun. We may say, "A man *whom* the world admires. "A man *whose* veracity is unimpeached," or "A man *of whom* all are forced to speak well."

It is also to be remarked, that the noun to which such sentences or clauses are subjoined, may occupy any place in the larger sentence that is competent to a noun; it may form either part of the subject, or of the predicate. We may either say, "The man *who* loves his country deserves honour," or "the world respects Cato as a man *who* loved his country."

Query on the nature of assertions.

When we attempt to reduce sentences to a precise and uniform theory, the following question will arise. Is the verb when thus subjoined by means of the relative, actually used for assertion? or is it deprived of this power by the relative? and ought the indicative of the verb to be on that account considered as applicable to other purposes besides assertion? It seems unscientific to maintain that the verb, separately considered, performs in this instance a different office, since the whole change of application is produced by the power of the relative. It would be most advantageous to consider the office performed by it in real assertions and in subjunctions of this kind as possessing some character in common, and to consider the modifications to which it is liable as consisting in the differences of the nominatives. If to any of our readers there should seem to be a gap in this part of our theory, we should be happy to have the means of supplying it pointed out. But to us there appears to be no impropriety in calling this general character by the name of *assertion*. An assertion may be first made, and may afterwards be mentioned for the sake of reference. An assertion may be used as the definition of an object. Of this object we may speak either by a single name, or by using the terms of the definition introduced by the relative "which." It seems rather incongruous to maintain that the definition in that case loses its character of assertion. The most that can be said is, that its office has been previously performed, and that it is now in this respect dormant. Its adaptation to that original application, even in the present connection, is certainly still apparent.

All uses of the indicative may be denominated assertion.

Substitutes for a sentence as introduced by the relative.

It is worthy of remark, that the place of a sentence thus subjoined to a noun often admits of being supplied by a noun in the genitive, or by an adjective. The meaning expressed by the phrase, "A man who is capable of hypocrisy," may be expressed by the phrase, "A hypocritical man;" therefore a new theoretic question arises, does the adjective "hypocritical" imply the copula used in assertion? Nay, the whole meaning may be condensed into a single noun. Instead of either of the preceding phrases, we may say, "A *hypocrite* is not to be trusted." Does the noun "hypocrite" imply an assertion? Then it will follow, that the office of assertion is not peculiar to the verb, but is included in the noun itself. This is so far true, that every noun is susceptible of a definition containing the indicative or asserting form of the verb. A noun signifying a compound idea may be defined by an enumeration of the parts of which that idea consists. A noun signifying a simple idea may be defined by pointing out the relation of that idea to various others, whether by resemblance, connection, or contrast.

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In the progress of human knowledge, combinations and distinctions of ideas are created, which are at first expressed in propositions and afterwards by single words; and these words are not understood till the processes of thought which gave origin to them, and which were first expressed by asserting propositions, are comprehended. Condensed signs, however, are not attached to all the results of these mental processes. This is only done when they are to be frequently referred to or treated as the chief subjects of discourse. When only occasionally mentioned, they are expressed in a more circuitous manner. Instead of a single word, we on some occasions use a noun with an adjective, as "an honest man," "a faithful servant;" or a noun governing another in the genitive, as "a man of consequence," "a man of probity," "a member of parliament." Sometimes these modes of annexation are accumulated, as, "a wealthy citizen of London," "a man of the highest reputation." On other occasions, when the combination of ideas is less familiar, we describe an object by attaching to a noun a regular sentence by means of the relative, thus; "a man *who* has, in a certain circle, the highest character for understanding."

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Sometimes the relative is employed to introduce a sentence which is not intended to form a descriptive definition of any object, but part of a narrative conveying new information; as, "Peter, *who* had all the time *listened* to my words, now presented himself before me." This has the same meaning with two sentences connected by the conjunction "and," viz. "Peter had all the time listened to my words, and now presented himself before me." The obliquity which this use of the relative produces is but slight, and promotes an elegant variety of diction.

2. The Participle.

The pa ciple u for sub tion.

In the use of the participle we have a method of subjoining a descriptive sentence to the noun, which, with respect to briefness and extent of regimen, is intermediate betwixt the use of the adjective, or of the genitive case, and that of the relative. It resembles the adjective in the manner in which it is introduced, but always follows the particular verb to which it belongs in the regimen which it possesses as introductory to other words. Hence it is capable of annexing a train of ideas to the noun. We say "a case *bearing* an analogy to the preceding;" "a man possessed of fine sensibility;" and, in a mathematical theorem, "the square of the side of a right angled triangle *subtending* the right angle is equal to the sum of the squares of the other two."

Analy a the pa ciple.

After the remarks which we have made on the possibility of resolving the meaning of any noun into a a definition, we can have little difficulty with the participle. It is obviously resolvable into an indicative sentence introduced by the relative: "A man walking" is resolvable into "a man who walks."

A designation formed by the annexation of the participle to a noun, differs from the use of a noun which contains the whole meaning, by approaching nearer to the form of assertion. It prominently exhibits the analysis of that meaning which in the corresponding noun is more condensed, and, like the relative with the indicative mood, it enables us to extend considerably our specifications.

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The participle may, like the relative and the indicative of the verb, be used for immediate assertion, as

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well as for definition. Thus Hume says of Charles V. "At last the emperor, *dreading* a general combination against him, was willing to abate somewhat of his rigour."

We formerly observed that the indicative mood of a verb might be resolved into the participle with the copula: that "he walks" might be resolved into "he is walking." And we have now remarked that the participle may be resolved into the indicative mood introduced by the relative; that "a man walking" might be resolved into "a man who walks." The indicative is of earlier origin, and therefore less complex than the participle. The participle is an ulterior accommodation in language, though, when once contrived, it has in some respects no greater complexity than an adjective, or the genitive case of a noun.

Tenses and voices in participles.

Participles are varied in their form and meaning, as they often express something more than the subjunction of the general meaning of a verb to that of a noun. They are employed to express time, and also to give either an active or passive character to the object expressed by the noun.

There are in most languages two participles, one of which has been called the present participle active, and the other the perfect participle passive. The former is distinguished in English by the termination "ing:" the latter, sometimes by a change in the vowel of the verb, but most frequently by the termination "ed."

English participles in ing not always present,

The participle in "ing," however, is often used without any implication of tense, and therefore may be applied to the past or the future, as well as the present. When we say "Yesterday, the public attention was excited by an aeronaut ascending;" if the word "ascending" were necessarily present, it would contradict the expression of past time contained in the verb "was." Grammarians avoid that absurdity by observing that the act was present at the time expressed by the verb, and therefore may be mentioned in the present tense, as the principal verb of the sentence gives its own tense to all the subordinate words. But this statement will not apply, otherwise we might as well use the expression, "The public attention was excited by an aeronaut who *ascends*," or "who *is ascending*." And we might say, "I thought that he *ascends* in a beautiful style." These phrases would be condemned as not only chargeable with bad grammar, but with incongruity and absurdity. It is therefore necessary to allow that the participle in "ing" is not restricted to any tense.

nor always active.

This participle, though generally active, is not confined to that voice. It is passive in such phrases as the following. "The house is *building*." "I saw a man *carrying* to prison." "I heard of a plan *forming* for his rescue." "A large sum of money is *owing*." The French sometimes use the passive participle *du* on the same occasions on which the English use the word "owing."

Participle in ed always preterite and not always passive.

The participle in "ed," and others called perfect participles, belong essentially to the preterite tense. But with respect to voice they are not exclusively passive. The words "gone," "landed," "departed," "strayed," "decayed," "well behaved," "drunk," "mistaken," are active participles. The participle in *us* corresponding to it in Latin, is also sometimes active; as in *tacitus* "silent." Although these words may appear to express quiescent qualities, they are such qualities as the action produces in the agent and not in an object acted on.

3. *Subjunction to Verbs or to Sentences.*

Subjunction to verbs by conjunction.

An assertion is sometimes employed for the purpose of being subjoined to a verb. This is for the most part effected by the interposition of the parts of speech commonly called conjunctions, and which are to be considered in the sequel under the name of sentential prepositions.

Meaning of the general conjunction "that."

Some assertions introduced in this manner are subjoined to the verb by a regimen bearing an exact resemblance to that of a noun governed in the accusative. The conjunction "that" is indeed interposed; a word not expressive of any particular relation, but merely a general sign of subjunction. Its sole office in this application is to shew that the sentence which it introduces is subjoined. It is ingeniously and justly considered by Mr Tooke as the same word with the *pronoun* or *adjective* "that." Their identity of form is not the effect of accident, which sometimes produces an ambiguous coincidence in signs which are of different origin and intended to perform totally different offices. This is merely an instance of a word single in its origin and meaning, and applied on different occasions. It is in fact an adjective, agreeing with the sentence as a whole. In the sentence "I believe that he is come," we take the subjoined part "he is come" as an object, and say with respect to it "I believe that." Hence it is in Latin *quod*, which is also the relative; or *uti*, or *ut*, which Mr Tooke with great probability derives from the Greek word ὅτι. This last is closely connected in its etymology with the article ὁ, ἡ, το, and the relative ὅς, ἥ, ὅ, and is in reality the neuter gender of ὅτις. The circumstance of being made introductory to a sentence is a variety of application. Hence it is on some occasions of this sort subjected to a variation in its form. When placed before a sentence, it is commonly called a *conjunction*, and thus is ranked along with some other words which have a similar destination. This form of subjunction is extremely familiar in all sorts of language, colloquial, historical, and poetical. "I hope *that* you are well." "The general saw *that* the enemy was too powerful for an attack in the open field, and concluded *that* it would be more prudent to harass him by the well-timed operations of partisans." In our language the conjunction is sometimes dispensed with: as, "I hope you are well." All these instances, whether introduced by the word "that" or not, as well as the corresponding ones in Latin and Greek, are placed in the same situation with a noun in the accusative. Thus in the following Latin phrases, the verbs *dicit*, *vult*, and *timet*, have the same regimen. *Quid dicit? Dicitne nihil? Dicit quod sapis. Quid vult? Vult ut huc venias.—Quid timet? Timet ne discedas.*

Subjunction by the infinitive.

This mode of subjunction is sometimes performed by the infinitive of the verb. "I suppose him to be sincere" is equally good English with "I suppose that he is sincere." In Latin it is far more common. *Dicit te sapere* is more agreeable to common use than *Dicit quod tu sapis*. This interchange of phraseology will be more particularly illustrated under the head of the infinitive mood, which will be delayed till we have finished the consideration of some other parts of speech subservient to the same end.

Sentences are also subjoined to verbs by the medium of conjunctions signifying particular relations. Some of them express hypothetical representation, as "if," "suppose," "provided;" others causation, as "be-

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By particular conjunctions.

cause," since;" others concession, as "though," "granting;" others time, as "while," "when," "after," "before;" others alternation, as "whether," and "or," (not the same application of the word "or" which is made of *vel* in Latin, but one corresponding to the Latin *an.*) These words, like the preposition, are interposed betwixt the verb and the words standing for the governed object, and they express a specific relation of the one idea to the other. They bring along with them various modifications of the form of the verb which they introduce. These will come into view under the next head, the Subjunctive Mood, which has received its name from the frequency with which it is thus applied. We shall naturally be led to inquire into its various forms and uses as compared with those of the indicative, and thus trace the comparative adaptation of both to the purposes of subjunction.

4. *The Subjunctive Mood, and other Forms of the Verb allied to it.*

The subjunctive mood varied in its meaning.

The moods of the verb are different in different languages. Sometimes a mood in one language comprehends two or more of those in another. One of the most frequent is the subjunctive, such as it exists in the Greek, Latin, and French languages. In the English it is sometimes expressed as the indicative, sometimes by means of auxiliaries. The various applications of it, and the variety of translations which its parts receive into English, as adapted to the occasions on which it is used, render it a matter of some interest to discover what properties are common to it on all occasions. It so happens that we have exactly that number of varieties of it in Latin which corresponds to the number of the tenses in the indicative, and hence they have been distributed into tenses under the same names; the present, the preter imperfect, the preter perfect, the pluperfect, and the future.

The indicative may be used subjunctively.

This mood has been called subjunctive from the circumstance of its being used in assertions which are subjoined by the relative and by various conjunctions. But this office is not peculiar to this mood. It is sometimes performed by the indicative preceded by the relative or by some of the conjunctions, such as "before," "after," "when," "where," "while," "if," and the words by which these are translated into other languages. On some occasions of subjunction the two moods are used indiscriminately; *Si hic adest*, and *Si hic adsit*, are equivalent. We also say, *Qui vinum amant*, or, *Qui vinum ament.*

And the subjunctive indicatively.

It is equally true that the subjunctive mood is not restricted to this office, but may with equal propriety be on certain occasions used indicatively, that is, for expressing the leading assertion in a sentence; as, *Si cum hoste dimicasset*, PERIISSET In this instance, the subjunctive mood in Latin when used subjunctively is translated into the English indicative, "if he *had* fought with the enemy," whereas that which conveys the assertion which is the ultimate object of the sentence, receives a peculiar translation by means of the auxiliaries "would have:" *periisset* "he would have perished." This is remarkable in most instances, though not in all, of the translations of Latin subjunctives into English. When used subjunctively, they are translated by the English indicative; when used indicatively, they are translated by a peculiar phraseology.

Peculiarity in the English language.

Real subjunctives translated indicatively.

They are translated indicatively, when introduced by the words, *qui, quoniam, cum, quanquam, si, etsi, quasi.* This takes place in all the tenses: *si venias* "if you come;" *si venires* "if you came;" *si veneris* "if you have come;" *si venisses*, "if you had come;" *si veneris* "if you shall come."

Sometimes by auxiliaries.

On some occasions they are translated into English by peculiar auxiliaries. *Uti* or *ut*, and *ne*, are the words which chiefly give rise to a translation different from the indicative in the subjunctive mood which they introduce, and this takes place only in the present and preter imperfect: *ut eas* "that you may go;" *ut ires* "that you might go." Yet *uti* appears to have originally been equally extensive in its meaning with the word "that," by which it is translated. It is not merely applied to denote the *purpose* of an asserted event, but to intimate other forms of subjunction: as *odisti ut amas*, "you hate as you love;" *ut veniebat* "as he came," or "when he came." *Ut* with the present and preter imperfect subjunctive, (as *ut amet* and *ut amaret,*) may be supposed to have been originally fitted for any general subjunction, and afterwards applied to express the subjunction of a purpose; or, *ut* may have been adopted for variety as a synonymous word with *quod*, in order to introduce a more special phraseology by performing a certain department of the same office. *Ut venias* may originally signify "that you come," and may be used as a noun in the ablative. *Quâ causâ hoc mihi dixisti? Hâc causâ, ut iterum venias.* In English, the same word "that" by which *quod* is translated is on such occasions used for translating *ut*, but the verbal expression is then varied by the introduction of the auxiliary "may." The production of the effect is expressed by the production of the *power*. This is sufficiently natural, as the effect implies the power. It is an accidental pleonastic idiom, probably adopted for the sake of distinguishing this form of subjunction from the form of it expressed by the particle "that" with the simple indicative.

The same observations apply to the introduction of the imperfect subjunctive in Latin, by means of the word *ut*. It gives the verb the same relation to the past which the former gives it to the present. It expresses the purpose, and it is to be remarked that in both instances it renders the verb in the subjoined phrase significant of something subsequent in order and in time. The tense called the present subjunctive when introduced by *ut* is future, and the imperfect expresses something subsequent to a past event.

Latin subjunctives used imperatively.

The present and the future subjunctive are sometimes used imperatively: as, *audiant meum sermonem*, "let them hear my discourse;" *doceas filios sapientiam*, "teach your sons wisdom." These have every appearance of being instances of ellipsis, in which *obsecro* or *precor te ut* is understood. The Italians often use the *infinitive* imperatively; as *non stringere la mia mano cosi*, "not to grasp (that is, "do not grasp") my hand so tight." This part of the verb expresses the simple act, or a connection which may be subjoined to another part of speech; and custom assigns to it the additional circumstances conveyed, as suited to the different occasions on which it is introduced.

The future subjunctive is applied imperatively, most probably on the same principles as the future indicative, and it is often translated by that part of the English verb; as *ne occideris*, "thou shalt not kill." The Latin phrase has however the additional advantage of being originally subjunctive, and thus possessing the same fitness to be used imperatively by ellipsis as the present tense of the same mood.

Indicative use of the subjunctive.

All these tenses are also occasionally used indicatively, and the application of them is so contrived that they express some modification of the simple assertion.

This more rarely happens with the present than with the others. Yet we have instances of such an application. Thus, in the ninth book of the Æneid, Nisus says to Euryalus,

Si quis in adversum rapiat casusve Deusve
Te superess VELIM.

"If chance or Providence should render the enterprise unfortunate, I wish (or I should wish) you to survive."

In like manner, in the 7th book, Juno dismissing Alecto from the superior regions, says,

Te super æthereas errare licentius auras
Haud pater ipse VELIT *summi regnator Olympi.*

This part of the subjunctive, when thus employed, is translated by the auxiliaries, "can," "may," "should," and "would," and generally refers to future events.

The preter-imperfect subjunctive, when used indicatively, is translated by "should" or "would." *Illam si amaret, in matrimonium* DUCERET, "If he loved her, he would marry her." The preterperfect is used on similar occasions, and translated in the same manner. *MALUERIM illum quam ullum alium imitari,* "I would rather imitate him than any other man." It is a remarkable circumstance, that these three subjunctive forms, called the present, the preter-imperfect, and the preter-perfect, when used indicatively, are often applied to the future. This cannot be considered as accidental; for, when translated into the English language, which adheres to no form of expression as an appropriate version of the Latin word, but varies it as occasion seems to require, they retain the form of the past tense "would" and "should," even when the event spoken of can apply only to the future. It might therefore seem interesting to inquire what peculiarity the meanings of these expressions have which should render them analogous to the past tense. We clearly see that there is a foundation for such an inquiry, when we advert to the import of some English phrases. "I may go," and "I might go," are radically future in their application. "I should go," is equally future with "I shall go," though not otherwise synonymous. "I can go," and "I could go," are also future as applied to the verb "go." The analysis of these phrases is comparatively easy, as they consist of auxiliaries. We at once recollect that the future of a verb may be expressed by the present of a verb preceding it signifying preparation for futurity; and, as the present is only one instant, and therefore has been said by some metaphysicians to have no existence, we consider it as including some adjoining portion of time, (most generally a part of the past,) at least as great a range as gives us scope for that short exercise of memory which we confound with consciousness, and which is necessary for reviewing any event and enabling us to describe it. There seems to be no impropriety in describing by a past tense a present action at least that is to be discontinued. If the present may be thus delineated, it follows that the verb preparatory for the future may also be used in the preterite tense. "I might go," is future as applied to the verb "go," though the preterite of the verb "may." For the purpose of tracing the source of this phraseology, it is of importance to observe that "may" and "might," which are different in their own tense, impress different characters on the future event which they are employed to introduce. Both of them express an uncertain or conditional futurity. But "may" signifies a state of greater preparation, and expresses a belief in the probability of the condition being obtained, and the consequent contingency taking place. "I may if you will," expresses greater readiness than "I might if you would." The latter phrase is either a hesitating way of intimating that we are partially prepared, on which account it would on some occasions be reckoned less polite; or, signifies a hesitation originating in our modified hopes respecting the condition, and then it is a more diffident manner of making a proposal. But the question recurs, why should the past tense be preferred for this uncertain mode of speaking of futurity? We should be happy to present a satisfactory solution of that problem. Although we had none to offer, we should have thought it unfair to decline stating the query. Perhaps this form of expression is used, because these uncertain expectations consist of images which possess the same sort of dimness with any object which retires to a distance in time or place, and consequently with an event which fades from the view by taking its place among ideas of distant recollection. Or, if this explanation is objected to as a refinement too subtile to have given origin to expressions so common, perhaps the choice of the past tense of the auxiliary on such occasions has proceeded from its signifying that the state of things preparatory for the future is discontinued: this want of extension to the present may conventionally be held equivalent to a less confident mode of representing a contingent futurity. But, though this explanation of the English phraseology now under review should be thought in some degree plausible, it might still be asked, How are such principles to be applied to the Latin subjunctive tenses? Do these tenses imply in their etymological structure all the force of the English auxiliaries? Did they possess that force in the intentions of the persons by whom they were first employed? Or are they mere general modes of stating a connection of ideas applicable to conditions and other subjunctions, as well as to conditional assertions? The difference betwixt these two methods of explaining them is perhaps merely verbal. If the subjunctive is an instrument intended to be applied indiscriminately to all connections of ideas whether actual or hypothetical, the purpose fulfilled by it is the same, whether it consists in the want of some character belonging to the indicative, or in the possession of a superadded character, including the meaning of an additional sign. Even if it were acknowledged to be of subsequent invention, and on the whole more complicated in its form than the indicative; this is to be accounted for, not by its expressing more ideas, but by its later use as applied to the purposes of human language. The English auxiliaries express something indefinite with regard to the events described; and the same thing is done by the subjunctive form of the Latin verb. But the variety of the English auxiliaries, as applied to translate the same Latin word, leads us to regard the Latin subjunctives as of less special meaning, and therefore partaking more of the character of general marks of annexation, which admit of being applied to a variety of purposes, the particulars of which are left to be inferred from the tenor of the discourse. If we knew the etymology of the ancient subjunctive forms, some light would be thrown on their history, but very little on their intrinsic nature. Words derived from the names of particular kinds of objects often become much more general; and, though they receive subsequent limited applications which render them again particular, they do not denote the same kinds of objects by which they were

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first suggested. The expedients adopted for varying general signs, and fitting them for expressing different particular meanings with precision, are entirely arbitrary, and often consist in an advantage taken of accidental original synonymes. This last stage of variation is that which has given the Latin language the form in which it is found in the writings of the classics. The varieties of phrase are not in general founded on corresponding differences in the direct etymological origin of the words. The indicative uses of the subjunctive mood therefore may on the whole be considered as elliptical.

Indicative use of the pluperfect.

The pluperfect subjunctive, when used indicatively, expresses a conditional assertion concerning the past. This is the meaning of it in the example already mentioned, *periisset*, "he would have perished." Sometimes it may be translated by "ought to have." Thus in the fourth book of the Æneid, after Dido's voluntary death, her sister says, *eadem me ad fata* VOCASSES, "You *ought to have* invited me to share your fate." This is a conditional preterite, and may be considered as implying, "If this had been the character of past events, all would have been well." The past is subjoined to an implied regret, and resembles such an ellipsis as the following English phrase. "If I had but seen him before he died!"

The future.

The future subjunctive is justly considered as differing slightly in tense from the future indicative, by expressing the "future completion of an event." But it is not on that account deprived of the peculiar character of the subjunctive mood; nor can we think, with some, that it differs from the future indicative in tense alone. It is not used, in general, for the simple and unconditional assertion of this species of futurity. It is not probable, for instance, that it would be used for expressing the assertion in the following sentence: "As soon as you have finished your letter, I *shall have* finished mine." That the tense in this sentence may be literally expressed in Latin, the passive voice is preferred, as it supplies an indicative tense of this sort by the combination of the future indicative of the substantive verb with the past participle. *Quum literas tuas scripseris, meæ etiam* FINITÆ ERUNT. This combination is denominated in our grammars a future *subjunctive* of the passive voice. The cause of this denomination is, that it is similar in tense. It unquestionably belongs to the indicative mood, while the others coupled with it in our grammars are subjunctive. The future of the subjunctive is indeed like its other tenses used indicatively; but like these others it is limited to uncertain and hypothetical assertions.

The subjunctive mood of the verb is on the whole a generic form applied chiefly to two less general uses, viz. subjunction, and the assertion of uncertain or conditional connections betwixt different objects. The property which these two uses of the verb have in common is uncertainty. There is one use of this mood which we have not hitherto mentioned, as it did not require to be separately illustrated, to wit, interrogation; as in this phrase, *An sit quies scelerato?* This will be considered as an instance of subjunction by those who allow, what we shall afterwards more fully state, that an interrogative sentence implies the imperative of the verb "to tell." *Quis est* signifies *Dic mihi quis est*. From this it follows, as well as from the obvious nature of a question, that uncertainty is also involved in that application of the subjunctive. Its imperative application has been already stated to be an instance of subjunction by ellipsis.

Use of the subjunctive in interrogation.

Theory of Dr Gregory.

In Dr Gregory's memoir *On the Theory of the Moods of Verbs*, contained in the 2d vol. of the Edinburgh Philosophical Transactions, there are some apposite observations on the application of the subjunctive mood to a great variety of phrases mutually analogous, which had occasioned some difficulty. That author considers the moods of the verb as formed for giving a direct representation of the feelings, intentions, or present actions of the speaker, and resolves them into a variety of affirmations in the first person singular. *Oro* or *jubeo* is, according to this theory, implied in the imperative; *dico*, in the indicative; *opto*, in the expression of wishes, and a variety of others on different occasions as suited to the various applications of the subjunctive. From the great diversity of feelings and purposes which may actuate a speaker, he infers that the real moods are too numerous to be expressed by separate modifications of the verb without rendering language cumbersome and complicated; but that those which are most common are expressed in this manner, for the sake of giving a condensed force to the utterance of human thought.

General observations on argument.

The view which we have given of the moods of verbs, and of language in general, differs from the principles now mentioned. We have considered language as not originally directed to the object of expressing spontaneously and naturally our own thoughts. It executes our purposes, by arranging the signs of thought in that order which is in our opinion best fitted to influence another person; an object which may be sometimes most successfully accomplished by concealing our own sentiments. To express our mode of thinking is indeed a very frequent object of language, and naturally has certain contrivances adapted to it; but to tell that we are speaking or asserting, seems to constitute no part of its object in addition to the use of the signs fitted for performing that office. The author, therefore, acknowledges that his principles have not so full an application to the indicative as to the other moods.

With whatever degree of vehemence or of delicacy men wish to express their feelings, they are provided with means adapted to their object. Significant gestures and tones independent of language may be employed. When it is thought proper to exhibit the same animation in the form of written language, syllabic imitations of involuntary exclamations are committed to writing, and are afterwards employed by rule. We sometimes execute the same purpose by placing our communicable ideas in such a point of view as tends to produce in others the feelings which occupy our own minds, sometimes by describing in more deliberate and explicit language the manner in which we are affected. Language is on other occasions fitted for expressing the feelings of the speaker by elliptical turns of phrase, in which more is at first meant than is verbally stated. These phrases are afterwards appropriated to the expression of specific feelings. Moods of the verb which were originally of a more general meaning may, by transpositions of words, or by an abruptness in the manner of their introduction, be subjected to such diversities as to become characteristic of the most vehement, the most rapid, or the most subtile modifications of sentiment. For example, instead of telling that we wish for the occurrence of a particular event, we may express the ardour of our wishes by the exclamation "oh." "Oh that he would return!" Or, without such an exclamation, we may say, "That he would return!" or, "That he would but return!" The Romans may be supposed to have at one time been in the habit of using the word *uti* in this manner, *Uti rediret!* But, as this might have been ambiguous from being too general, and might be supposed by the hearer to signify some purpose entertained in the performance of another act, as, *uti rediret, veniam ei polliciti sunt*, another particle *nam* is introduced to indicate that this kind of

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event is abruptly mentioned as an object of the wishes of the speaker. It may not be easy to shew why a particle equivalent to the English word "for" was preferred to any other; but, when habitually used in this connection, it becomes appropriate. It is thus that *utinam* becomes equivalent to "oh that," or "I wish that."

The optative mood.

The Greeks have an optative mood adapted to the expression of wishes, though it appears not to be applied exclusively to that object.

Various expedients for giving brevity and force to language.

The brevity and force thus created by means of the moods of verbs are effects of the contrivances of language which abound in all the different parts of speech. When a combination of ideas or an assemblage of thoughts or feelings becomes habitual, it receives an appropriate condensed expression. We complain of tediousness when an idea which might have been expressed by a single word or a short phrase is slowly brought out by means of a long series of words or of sentences. But when we have an unusual assemblage of ideas to express, no circumlocution is to be spared which may be necessary to give our language perspicuity, and the beauty of felicitous contrivance is often conspicuous in the invention of means for exhibiting thoughts which servile imitators would either not have conceived, or not have attempted to express. Language is happily used, where those phrases and words which are rendered intelligible and appropriate by established usage are employed judiciously for expressing complicated ideas. They may be placed in a connection with each other fitted to create combinations which are still more complicated, and possess a character of novelty which is rendered necessary by the purpose of our discourse. In fine, the skill of a writer may occasionally be discovered by the use of simple signs, in such a fortunate succession as to express, apparently by accident, some novel but well defined state of feeling and of thought. The expedients suited to these purposes are therefore not confined to the use of particular moods of the verb, and the act is not characteristic of their nature.

5. *The Infinitive Mood.*

We had occasion, in describing other parts of speech, to mention the *Infinitive* of the verb. We observed, that it is not an original word, nor the earliest form of the verb, but consists of the imperative in composition with a sign derived from some different source. In explaining the uses of the subjunctive mood, we observed that in the Latin language that mood with the introductory particle *ut* may have its place supplied by the infinitive. *Volebat ire* is equivalent to *volebat ut iret*. We shall now inquire more particularly into its nature and uses.

General character of the infinitive mood.

Both its etymology and application shew that it expresses merely the specific idea conveyed by the particular verb to which it belongs, in such a way that it can be used as a noun by becoming the subject or predicate of a sentence, or part of either. It does not, like the indicative, appear to contain the copula, except when substituted for that mood by ellipsis, as it frequently is by Sallust and other authors in depicting scenes of bustling activity or striking interest. Hence it has by some been denied the properties of the verb, and considered as in all respects nothing more than an abstract noun. It is formed in Latin by adding to the radical letters of the verb, as existing in the imperative, the termination *re*. From *ama* we have *ama-re*; and from *doce*, *doce-re*.

Its etymology.

This termination, being identical with the radical letters of *res* "a thing," seems to be exactly the same original sign, and in this application it retains the same meaning. *Ama* signifies "love;" *ama-re*, "love-thing," i. e. "love" considered as "a thing," or object of thought. In English the infinitive consists of the radical letters of the verb preceded by the word "to;" as "*to* love" and "*to* teach." Mr Tooke considers the infinitive as possessing the character proper to the verb, though he does not tell us in what this consists. He describes the word "to" as having the power to confer the verbal character on a noun. At the same time he considers it as originally the same with the verb "do," and as meaning "act," "effect," or "consummation." These suggestions are extremely obscure. It is not easy to conceive what influence the additional idea of "effect" or "consummation" could have to impress the character of a verb on a word which is otherwise a noun. We must therefore leave the opinions of that author in the same ambiguous state in which we find them. On some occasions in the English language this prefixed word is dispensed with. As "we saw him *go* away," and "we bid him *write* to us when he arrived at the end of his journey." In whatever light the infinitive mood of the verb may be considered, we find that this form of it, as existing in the English language, has the same meaning and uses with the words formed by such terminations as the Latin *re*, and receiving the same appellation in other languages.

Is it a noun or a verb?

The following is the question which claims our present attention. Is the infinitive mood of the verb properly and in all respects a noun? Is *amare* "to love," for example, a word of the same signification and uses with *amor amoris* "love?"

We shall obtain the most advantageous view of the nature of this part of speech, by taking in detail a survey of the circumstances in which it resembles the noun, and those in which it deviates from it.

It coincides with the noun in some uses;

It resembles the noun in being used as a nominative to a verb; as in the following Latin sentence from Cicero, as well as in the translation of it into English: *Loquor de docto homine et erudito cui* VIVERE *est* COGITARE. "I speak of a man of learning and erudition for whom *to live* is *to think*." It is also, like the noun, capable of being governed by an active verb; as *Oblitus est* SCRIBERE, "He has forgot *to write*." On some rare occasions in the Latin language, an adjective is employed to agree with it as with a noun. Thus Cicero says, *Cum* VIVERE *ipsum turpe sit nobis*; also, *Totum hoc displicet* PHILOSOPHARI. Persius says, VELLE *suum cuique est*. Petronius, *Meum* INTELLIGERE *nullâ pecuniâ vendo*. In these instances *vivere* is used in the same manner as *vita*; *velle* as *voluntas*; *philosophari* as *philosophatio*, if such a noun existed; and *intelligere* is used as *intellectum*, the accusative of the noun *intellectus*. Sometimes it is employed as the genitive of a noun; thus Cicero says, *Tempus est* ABIRE, à phrase equivalent to *tempus est abeundi*. Sometimes as an ablative. Thus in Plautus, *Ego sum defessus* REPERIRE, *vos defessi* QUÆRERE.

But differs from it in others.

In other respects, however, it differs from the noun. The concordance of an adjective with it in the manner now mentioned is a rare occurrence even in the Latin language, and does not take place in the English and others. The additional idea which the adjective would express is connected with the infinitive by a different sort of syntax. In Latin, *meum intellectum*, or *meam intelligentiam* is more consonant to general usage than *meum intelligere*. We should not in that language say *bonum intelligere*. If *bonus* were employed, it would be along with *intellectus* or some other noun; and, if the infinitive *intelligere* were employed, the additional idea would be conjoined by means of a part of speech which we have not yet considered, the adverb; in this instance, *benè intelligere*. In English we should not say, "my to understand," but "my understanding;"

nor "a good to understand," but "a good understanding," or "to understand well."

Peculiarities of the infinitive.

When an agent is mentioned along with an action in the infinitive, it is not in the form of a noun in the genitive, as it would be if the act were expressed by a noun. We do not say *illius amare* as we should say *illius amor*. Nor is it put in the nominative. Though we say *ille amat* we do not say *ille amare*. The syntax of the infinitive is in this instance peculiar; the agent is put in the accusative: *Illum amare*. This arrangement does not arise from the regimen of a preceding word expressed or understood governing the noun in the accusative. The combination of the noun in this form with the infinitive sometimes constitutes a phrase which is used as a nominative to a verb. In the Greek language this combination is sometimes even used as a noun in different oblique cases in which it has an adjective agreeing with it. Thus Anacreon says,

Σὺν ΤΩ, δὲ ΠΙΝΕΙΝ ἩΜΑΣ,
Εὕδουσιν αἱ μέριμναι.

The accusative here only intimates that the noun and the infinitive occupy the place of a subjoined sentence. In English, when the phrase is to be employed as a nominative to a verb, we use the noun preceded by the particle "for," which may be reckoned equivalent to an oblique case in Latin. We say, "*for a man to tell a lie* is a sign of cowardice." We sometimes find this differently expressed in low and provincial dialects. "To," for example, is employed instead of "for;" as, "*To you* to deceive me was unbecoming." At other times the noun in the objective case is used without any preposition, as, "But *him* to think that he was entitled to any credit was ridiculous."

Its coincidence with the verb.

When an *object acted on* is mentioned in connection with an act expressed by the infinitive, or when the name of an object referred to, and usually governed by a verb in some oblique case, is introduced, it is not put in the genitive as when it follows a noun signifying the same action. In this respect the infinitive retains the regimen of the verb to which it belongs. We say *amor uxoris*, for "the love of one's wife," or, if the person entertaining this affection is already mentioned in the genitive, the object of it is introduced by a preposition in such a phrase as *amor illius erga uxorem*. But when the infinitive *amare* is used, it governs *uxorem* in the accusative. We say, *Illum amare uxorem*, "for him to love his wife." Sometimes an ambiguity might thus be created, because both the agent and the object are mentioned in the same case, and, on account of the common practice of inversion in the Latin language, the order in which the words are placed does not strictly follow that of their syntax. Hence the ambiguity of the famous response of the Pythian oracle to Pyrrhus, *Aio te Romanos vincere posse*, which admits of being translated, "I say that you can overcome the Romans," or "I say that the Romans can overcome you." In general, however, the connection renders the meaning of such sentences evident, and their perspicuity is assisted by the name of the agent being placed before the infinitive, or nearest to it, while the accusative signifying the object acted on either comes after, or is at a greater distance before it. The same thing takes place in the English language, although in it the infinitive differs a little in its mode of formation, as it consists of the prefixing of a separate word. When we use the noun "desire," we say, "the desire *of food*," "*of money*," or "*of fame*." But "*to* desire *food, money*, or *fame*." The production of this mode of transition seems to us to be the great power conferred on a noun by the word "to" prefixed as the sign of the infinitive. In this therefore, according to Mr Tooke, the nature of a verb should consist. It might appear, however, that this is not common to all verbs, and therefore is not the characteristic circumstance which, when added to a noun, makes it a verb. In neuter and intransitive verbs it scarcely appears. Yet it is not always lost even in these. Every verb admits of a transition of discourse to some other ideas expressed by nouns, if not by direct regimen, yet through the medium of prepositions, and this is generally more or less altered when a word from being a noun receives either the form of assertion so as to become a verb, or is transformed into that part of speech called the infinitive of the verb. Let us take, for example, the word "struggle," which is used both as a noun and as a verb. We say, "his struggles were strenuous and incessant." When we use it as a verb, we say, "he struggled with a powerful antagonist." We often also use such expressions as, "His struggles with his antagonist were obstinate." But in this last phrase we are conscious of a slight defect; and, although the brevity and manifest meaning of it may in general enable it to pass without censure, an accurate writer will prefer the introduction of a verb for the purpose of completing the series of words demanded by the syntax. It will be felt more strictly agreeable to the import of the different materials of language to say, "the struggles *which he maintained* with his antagonist were obstinate." It is also to be remembered, that even the least transitive verbs differ from nouns by having all qualifying ideas conjoined with them not by adjectives but by adverbs, and that in this particular the infinitive mood follows the law of the verb; we say, "a *violent* struggle," but "to struggle *violently*." It is only in these peculiarities of transition, and in receiving adverbs instead of adjectives, that we can perceive any difference betwixt the infinitive of a verb and the corresponding noun. The former of these differences depends, in a great measure, on the character of particular verbs, and both of them seem too slight to confer on the infinitive the same rank with the asserting verb, and to divest it of the character of a noun. This is more especially the case when we consider that it is often used without an adverb, and without any such transition as has now been described, but is never independent of some character of syntax which is common to it with the noun. With this statement of the facts, we leave the argument to the consideration of our readers. We deprecate, in the mean time, any premature attempt to improve, in this or any other instance, the nomenclature of grammar.

Use of … infinit… subjun… tion.

The infinitive mood, in consequence of resembling in some particulars the noun, and in others the verb, is rendered fit for performing, in a manner peculiar to itself, the office of the subjunction of sentences to verbs. It may be made a question whether connections of words formed by means of it ought to be called sentences; but they certainly contain the meaning of sentences. We have already remarked that every noun may be resolved into a sentence, by means of a definition. But by the use of the infinitive, we have the parts of the sentence in a more distinct state than if they were all implied in a noun, though not so explicitly as in a definition, or even in a sentence formed by the subjunctive mood. It has thus a character intermediate betwixt the noun, with its regimen of genitives or the accompaniment of adjectives, and such subjoined sentences as have been already described. The same connection of ideas may be expressed by any one of the three following modes of diction:

Subju… tion t… tence… three … feren… mode… compared.

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1. By nouns alone, as in this sentence, "he wishes his son's *departure*."

2. By the infinitive mood, as when we say, "he wishes his son *to depart*."

3. Or by a sentence subjoined in the subjunctive, thus, "he wishes *that* his son *would depart*."

Here the verb "to wish" is that to which the other ideas are subjoined; and the verb "to depart" is that which is variously implied in the subjoined series of words.

The preference of one of these to another will sometimes be dictated by convenience, according as the intention of a writer is to study brevity, or to indulge in minuteness of detail; and sometimes there will be so little foundation for any particular preference, that the choice will be left to fancy, to habit, or to the love of variety. Sometimes a sentiment expressed in one of these modes in one language requires a different one when translated into another. *Credo te sapere* may be translated "I believe you to be wise;" but *dixi te sapere* cannot be translated "I said you to be wise;" the infinitive is here to be laid aside, and instead of it, a sentence must be subjoined by means of the word "that." "I said that you were wise."

We generally find it more eligible to use an infinitive than a noun, when we have occasion to connect with the meaning of the word any considerable variety of circumstances. We say "murder is a heinous crime;" but when we mention the agent and the object, we prefer using the infinitive mood, we say, "for a son *to murder* a parent is a heinous crime." This is a more complete expression than "the murder of a parent by a son." Indeed this last phrase evidently requires a verb or a participle to make it complete; thus, "the murder of a parent *committed* by a son, is a heinous crime;" and, as this makes the phrase verbose and tedious, it is better to say, "for a son to murder a parent is a heinous crime." In the Latin language, this idea would be most conveniently expressed by the subjunctive mood preceded by the particle *ut*. *Ut filius parentem interficiat nefas est.* It is but seldom that the mention of the agent is combined with the use of the infinitive, when the combined phrase is to be made the nominative to a verb. Such expressions as *filium interficere parentem nefas est*, are sometimes used, but they are inconvenient and ungraceful, and therefore not common.

Tenses of the infinitive.

The infinitive mood is varied in respect of tense. That form which is called the present infinitive is in reality of no tense. It is pure, absolute, and aoristic. It may be employed without the implication of time, and it admits of being applied equally to past, present, and future transactions. The remarks which we have made on that part of the *indicative* mood called its present tense, will suggest sufficient proofs of this fact; and the subjects are so nearly analogous, that it is unnecessary to bring forward particular illustrations of this point.

The general infinitive.

The preterite.

The infinitive in the past tense is, in the Latin language, fully expressed by the termination *isse*, which is nearly allied to the pluperfect subjunctive, a circumstance probably arising from the coincidence of their use as consisting in a subserviency to subjunction.

The future.

The future infinitive, both in Latin and in English, is formed by circumlocution. In Latin the general infinitive of the substantive verb is, for this purpose, conjoined with the future participle. *Iturum*, or *iturus esse*. In English it is constructed on similar principles. We say "to be about to go." We sometimes merely use the general aoristic infinitive after a verb which implies a reference to futurity, as "I expect him to go." In expressing such ideas, however, we frequently reject the infinitive as not well fitted for our purpose, and in its stead employ a sentence in the future indicative, subjoined by the word "that;" as "I expect that he will go."

Similar principles are discovered in the formation of the tenses of the infinitive in the passive voice.

6. *The Gerund and Supine.*

The gerund nearer to the noun than the infinitive mood.

The *Gerund* is a part of speech nearly resembling the infinitive, but tending more strongly to the noun, both in form and syntax. Like the noun, it is governed by prepositions, which the infinitive, at least in the Latin and English languages, is not. We say, "much harm is done to the constitution *by drinking*." In Latin this idea is expressed by the ablative of the gerund (*potando*.) The infinitive is sometimes thus used without a preposition, as in a passage already quoted from Plautus, *Ego sum defessus reperire, vos defessi quærere*; but the gerund is, in almost every instance, better adapted to such purposes. Such passages contribute to show to what extent the infinitive may be used as a noun; but the infrequency of that mode of employing it, and the frequent use of the gerund, prove to us that differences in the forms of words, or parts of speech, often consist in a different extent of adaptation to particular purposes, and that the characters of some pass almost insensibly into those of others.

The gerund differs from the infinitive in not admitting the mention of the agent in equally close syntax. It does not even, like the noun, admit of the annexation of this or any other idea by a genitive or an adjective, nor has it any power analogous to that which the infinitive has of taking an accusative before it, to signify the agent. The gerund therefore is employed only when no mention of the agent is required, or when this is done by connecting it with some other word in the sentence, as when we say "*men* hurt themselves *by drinking*."

Yet differs from the noun.

The gerund takes the regimen of the verb with respect to the nouns which it introduces. In Latin we say *potando vinum*; and in English, "by drinking wine." The same word may however be also used as a noun, and then it may take an adjective and govern the genitive; as "by *the* drinking *of* wine." The difference betwixt the word in "ing," in these two modes of employing it, is analogous to the difference betwixt the Latin gerund in *dum*, and the noun in *tas*, or in *atio* or *itio*, formed from the verb. Instead of the preceding phrase, we may employ *potu*, or *potatione vini*. The Latin word called the gerund also admits of being used as a noun; we can say *potando vini*, as well as *potando vinum*.

The preterite gerund.

The gerunds now mentioned have no accident of tense conjoined with them. We formerly observed, however, that the preterite form of the English verb, as used after the auxiliary "to have," has the nature of a preterite gerund. "Gone" is the name of an act completed. In the phrase "I have gone," it occupies the place of a noun governed in the accusative. In verbs of the transitive kind, while it is thus governed, it governs in its turn another noun, in the same manner as the other parts of the verb to which it belongs. We say "I have *given* them my promise." This is the nature of the word separately considered; but it is never used as a gerund in any other connection, and therefore grammarians have neglected to ascertain its proper character.

The supine.

The word called a *supine* in the Latin language is, in structure and use, similar to the gerund, though not possessing all its inflections, and more limited in its application.

Sect. XII. *Interrogation.*

Interrogation is a part of the object of language, performed by means of the verb, which remains to be considered. We have mentioned it (at p. 397.) in enumerating the forms of imperative influence which mankind, by means of language, exert on one another. Its peculiar object is, to obtain information from the person addressed. Mr Harris considers it as a modification of the use of the verb, and constituting a distinct mood, although the verb when thus applied should not possess a distinct form. It is a direct request, and therefore implies the imperative in a very prominent degree. "What is your name?" is another mode of saying "tell me your name." Interrogative words and interrogative arrangements of words are abbreviations implying the subaudition of the imperative of the verb "to tell." "Who is there?" means "tell me the person who is there."

The interrogative mood of Mr Harris.

Analysis of interrogative forms.

Selective questions.

Interrogative words implying a request for the particular mention of one circumstance that must be *selected* as true, from many others that are imaginable, have a close etymological connection with the relative, and sometimes consist of it unaltered. *Quis* in Latin is different from *qui*, but is evidently derived from it, and the variation which it receives is intended to intimate that the imperative of the verb "to tell" is understood; or rather it is so altered as to express this imperative distinctly and fully. In the Italian language, we have an instance of the employment of a different sort of word; "what do you want?" is expressed by *cosa volete*? which literally translated is, "thing you want." But on most other occasions, in every language the interrogative words are more or less allied to the relative. From *qui* in Latin, we have *quis? qualis? quando? quo? quorsum?* and from "who," and "which," in English, the words "when?" "where?" and "whence?" are evidently derived.

Alternative questions.

There are other questions which may be denominated *alternative* in their nature, because the speaker supposes two opposite statements, one of which must be true and the other false. A subject and a predicate are connected in a question, and the only reply that it admits of is, either an assertion of a connection betwixt the subject and this predicate, or betwixt it and a predicate which is completely the reverse. This may be also done by single words of affirmation or negation, rendered completely significant by their reference to the question. Interrogations of all kinds, however, imply the meaning of the imperative of the verb "to tell." The words of which they consist are a sort of subjoined sentences to this imperative, and are in some degree elliptical in their first creation, though generally rendered precise by receiving a peculiar form.

CHAP. VII.

Of Adverbs.

Want of precision in the description of the adverb.

The term *Adverb* is considered by Mr Tooke as expressive of no character by which a part of speech can be distinguished. He considers the adoption of it as an artifice by means of which, under the colour of scientific order, grammarians have brought together a variety of words, originating in abbreviations and corruptions, and possessing in no other respect any common property. In this opinion we cannot acquiesce, although we are sensible that some confusion has arisen from the unskilfulness of grammarians in ranking among adverbs some words which ought to have been included under a different head.

Its gene characte

Adverbs are words expressly formed for the purpose of subjoining an idea to that which is contained in an adjective or a verb. They are all capable of being annexed to verbs, and some of them to no other part of speech. From this circumstance the whole class has derived its designation. They never express an idea in so close subjunction as a noun governed by a verb in the accusative; they rather resemble nouns which are governed in the ablative, or phrases consisting of a noun with a governing preposition. They sometimes are employed to qualify the character of an idea expressed by an adjective or a verb. At other times they superadd some circumstance of relationship to objects which are capable of being separately conceived.

It does owe its gin to c ruption

We cannot concur with those recent grammarians, who consider as instances of corruption the formation of adverbs by means of alterations made in the forms of words belonging to different parts of speech. They are words skilfully devised for fulfilling a definite object. They do not, as has been supposed, always arise from abbreviation. Although they are capable of being expressed by a plurality of words, this property is common to them with all parts of speech. Some of them are evidently abbreviations, while others have marks of being used as single words previously to any phrases into which they can be resolved. We have not even any demonstrative evidence that all of them are derivatives, and that none are original words.

Distrib tion of verbs.

Adverbs are divided into different species. Some express intensity, remission, or other modifications of attributes expressed by adjectives and verbs. Such are the adverbs "very" and "much;" as "very good" "much better," "much obliged;" also their comparative and superlative forms, as "more" and "most." The words "slightly," "little," "less," and "least," are of a similar nature. Some have considered the comparative and superlative degrees of nouns as condensed combinations of adjectives in their positive state with the adverbs "more" and "most," because they can be resolved into phrases thus constructed. "Richer" and "richest," are "more rich" and "most rich." But these adverbs may in their turn be resolved into other phrases containing adjectives. "More" is "in a greater degree," and "most" "in the greatest degree;" and, from the first consonant being common to them with the positive adjectives *magnus*, *multus*, "many" and "much," and their terminations being characterised by the consonants *r* and *st*, it appears evident that "more" and "most" are derivatives. The Latin word *maximè* is evidently derived from *maximus*, in the same manner as a great variety of adverbs is derived from adjectives.

Advert intensit

Adverl of manne

Adverbs expressing modifications of qualities are generally derived from adjectives. Such are adverbs in *è* and *ĭter* in Latin, as *longè, ingenuè, breviter, feliciter*. In English they are formed by the addition of the termination "ly," as in "shortly," "considerably," "wonderfully." This termination seems, as Mr Tooke remarks, to owe its origin to the word "like," of which it is an alteration, or, as he terms it, a corruption. It is sometimes used as an adjective termination in composition with a substantive, as in "princely," "kingly," which mean "prince-like" and "king-like." The adoption of it for distinguishing the adverb is entirely conventional, and the most profound investigation of its meaning will not lead us to a satisfactory conclusion on the nature of this part of speech. Yet the use made of this termination, and the

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nature of the adverb, are sufficiently apparent. They imply a notification that the idea expressed by the compound word is to be annexed in syntax, not to a substantive noun, but to an adjective or a verb. They are also capable of being attached to other adverbs; as "very nobly," "surprisingly well," "too uniformly."

The adverbs just mentioned are called *adverbs of manner*. Some of them merely express a general reference, and have the same relation to the words called demonstrative pronouns which others have to different adjectives. Such are the adverbs "thus," "so," and "as." In Lancashire, instead of "thus" and "so," it is common to say "i' this'n," and "i' that'n."

Numeral adverbs.

There are numeral adverbs as well as adjectives. Such are "once," "twice," and "thrice." These belong to the cardinal numbers, as expressing repetition. There are also adverbs which signify a mere reference to repetition, such as "first," "secondly," and "thirdly," and belong to the ordinal.

Adverbs of place.

There are adverbs of local situation, as "here," "there;" and of local aspect, as "hence," "thence," "hither," "thither," "upward," "forward."

Of time.

Adverbs of time, as "now," "formerly," "soon," "afterwards," "immediately."

It is unnecessary to enlarge on the nature of these words, or to point out the phrases into which they are resolvable, and of which they often are abbreviations.

Of affirmation and negation.

The adverbs of *Affirmation* and *Negation* have been reckoned different in their nature from all the others. When the subject, the predicate, and the copula are arranged in the order of assertion, no separate word is necessary to affirmation; but sometimes an adverb is conjoined to call the attention of the mind with greater emphasis to the truth of the assertion. Such are the adverbs "indeed," "truly," and "certainly." If a question is asked which admits of an answer by the simple affirmation or negation, the answers in the affirmative may be given in English by such adverbs as "certainly," "even so;" or in Latin by *etiam*, *imo* or *utique*. Sometimes a peculiar word, and one which is never used as an adverb in a sentence, is applied to this object. The English word "yes," is of this kind. "Yes," is considered by Mr Tooke as derived from *ay-es* "have" or "enjoy," and meaning "have or entertain that belief." The English "yea," the German *ja*, and the corresponding words in the northern languages, are derived from a similar source. It is therefore to be considered not as an adverb, but as an abbreviation for a sentence. The adverb "certainly," and others equivalent to it, become by ellipsis contractions for the same sentence. If we keep out of view the etymological origin of the words used on such occasions, and consider them all as containing an equally full expression of the meaning of the speaker, we must reckon them abbreviations for sentences; but wherever they are introduced into the body of a sentence, they are adverbs possessing the same properties as other words of that class. They signify that the assertions to which they are applied are not hypothetical, but in conformity to the nature of things.

The negative adverb expresses the absence of this conformity. The same word is in some languages either used singly as an answer to a question, or annexed to a verb in the formation of a sentence. The Latin words *minimè*, *nequaquam*, and *non* are used in both of these ways. But in English the word is on these occasions subjected to a slight change. The adverb is "not." The negative answer is "no." This last is said to be of prior date, and derived from a verb signifying "I deny," or "I am averse;" but, whatever its etymological origin may be, it is, like the word "yes," a contraction for a sentence, with this difference, that the sentence for which it stands implies the force of the adverb "not," and thus reverses the meaning. "Not" has the same general character with the other adverbs: it modifies the verb, and thus forms part of the predicate.

Remarks on negative sentences.

A negative sentence is the reverse of the corresponding affirmation. Yet there is no general difference of character betwixt affirmations and negations. Affirmations are often as directly opposite to each other as to negations. "He is without," and "he is within," are directly contrary. Many assertions can be made equally well in the negative and in the affirmative form. "He is at home" is an affirmative sentence, and the same idea is expressed by these negations, "He is not from home," and "He is no where but at home."

CHAP. VIII.

Of Prepositions.

Difficulties in defining prepositions.

Differences of opinion have been entertained on the nature of *Prepositions*. It is easy to give a character which will apply to them all; but it has been found difficult to give one which will apply to them exclusively. Mr Tooke has been considered by some as solving every difficulty, by pronouncing them abbreviations of nouns or verbs. This author shews that many of them are of the same nature with some of those words which are called conjunctions, and considers that circumstance as proving the inaccuracy of this instance of grammatical distinction. In so far as *the idea expressed* has been represented as a ground of distinction, this author is correct. But when we abandon that system, and take the circumstances of syntax as the foundation of our classifications of words, we shall find that some distinctions which were formerly improperly accounted for are referable to satisfactory data.

Extension of the term.

The classification of the short words called particles appears to us defective, and we shall in the present instance introduce a slight variation from the common usages of grammarians. We shall apply the term preposition to a more extensive genus than our predecessors have done, by including under it some words hitherto called conjunctions. Those words which are usually called prepositions, we distinguish by the appellation of *Nominal prepositions*, because they are introductory to nouns; and the others by that of *Sentential prepositions*, because they are introductory to sentences.

Distribution of them into two species.

Sect. I. *Nominal Prepositions.*

Character of the nominal preposition.

Nominal prepositions have been described by many grammarians as "words which signify the mutual relations of objects." But these relations are equally expressed by every part of speech. Mr Ruddiman with greater propriety describes the preposition as "An indeclinable part of speech signifying the relation of one *substantive* to another." We prefer saying that it signifies "a relation subsisting betwixt the idea expressed by one substantive noun and that expressed by another." It is to be observed that, with the exception of the preposition "of" in English, and some rare expressions already alluded to under the head of the genitive case, a verb, adjective, or participle is interposed between the first of the nouns and the preposition. The preposition "of" is as frequently employed immediately after a noun in English as the genitive case is in Latin; but such phrases as "Newcastle-*on*-Tyne," and "Ashton-*under*-line," are in very small number. The prepositions "on," "under," and all the others except "of," subjoin a noun to an adjective, a participle, or a verb; as "fit *for* use," "good *at* singing," "depending *on* his fidelity," "connected *with* the government." "He has gone *from* home, *along* the road, *to* a distant place."

Mr Tooke's etymologies.

Mr Tooke has shewn great learning and ingenuity in proving that the prepositions, both in ancient and modern languages, are derived from nouns or verbs. *Chez* he derives from *casa*, "a house." *Avec* from *avez que*, "you have that:" *Sens* in French, and *senza* in Italian, from *assenza* "absence:" The Latin *sine* from *sit ne*, i. e. *ne sit* "let it not be:" The Italian *fuori*, the Spanish *afuera*, the French *hors*, (formerly *fors*,) from the Latin *foris*; and this from the Greek word θυρα, in the Doric dialect φορα, "a door or gate." "Through" is derived from a Teutonic word *thuruh*, signifying "a door or passage." *Ad* he derives from the past participle of the verb *agere*, by these steps of transmutation, *agitum, agtum, agd, ad*. He considers the English "to" as the same word with the verb "do;" and "till" as derived from "to while." "For" comes from a Gothic word signifying "a cause;" "of" from *afora*, "progeny;" "by" from *be-on*, "to be;" "with" from *withan*, "to join;" "betwixt" from the imperative "be," and *twos*, the Gothic word for "two." "Before," "behind," "besides," are from the same imperative conjoined with nouns which are either still separately used, or have left familiar traces in different forms. "Beneath" is from an old word *neath*, signifying "bottom; "under" from *on* and *neder*; "beyond" from *geond*, which has the same meaning with "gone" or "past." The termination "ward," which is used both in forming adverbs and prepositions, is from the Saxon verb *weardian*, "to look at," which also gives origin to the word "regard." "Athwart" comes from *thweorian*, "to wrest or twist;" "among" is from *gemengan*, "to mix;" "along" means "on long," i. e. "on length;" "round" and "around" come from a word signifying "a circle;" "near" from *neahg*, "neighbouring;" "instead" is "in station," or "in place;" "down" is from *dufen*, "to dive or dip;" "up," "upon," "over," "above," he derives from *ufa*, "high." The same sort of investigation has been with considerable success applied to the Greek prepositions by Mr Bonar, in the 5th volume of the Transactions of the Royal Society of Edinburgh, and by Professor Dunbar in a separate work on the subject.

The grammatical system founded on these etymologies is in a great measure the contrivance of Mr Tooke. Some of his etymologies have been called in question by Mr Bonar and others. The author of the article Grammar in Dr Rees's *Cyclopædia* attempts to controvert the greater part of them in support of a different system in which he traces the modern languages of Europe to an Oriental origin. Some of Mr Tooke's etymologies however are unquestionable; and it is of great importance to observe, that the author has shewn that all prepositions are resolvable, *with regard to their meaning*, into nouns or verbs. The same ideas may be expressed by all these parts of speech. This property is independent of any opinion that may be formed regarding their particular etymology. "From," for example, may have its place supplied by the noun "beginning." "The figs came from Turkey," means "The figs came *beginning* Turkey." "The lamp fell from the ceiling," "The lamp fell *beginning* the ceiling." "The lamp hangs from the ceiling," "The lamp hangs *beginning* the ceiling."

Prepositions resolvable into nouns.

Do they represent real objc?

Mr Tooke's opinion was, that prepositions represent objects in the same manner as nouns. This is denied by other authors, who proceed on the presumption that nouns are the names of *things*, but prepositions the names of the *relations* of things. And some have derided the absurdity of pronouncing things and their relations to be the same. It might however be maintained that, as variety is essential to the existence of human knowledge, its objects wholly consist in relations. If there should be any difficulty in conceding that point, it ought to be remembered, even in a grammatical view, that the relations of things may be expressed by nouns as well as by prepositions, and that therefore no distinction betwixt these two parts of speech can be founded on such data. Mr Tooke, however, is not content with observing this coincidence betwixt nouns and prepositions. He considers prepositions as invariably derived from *concrete* nouns, or verbs containing these, and insists that they are the names of substantial material objects. The preposition "through," for example, being according to him derived from a word signifying "a door," carries along with it the full meaning of that concrete noun. This statement has been supposed to favour the system of materialism, and perhaps it was so intended; but it is in itself too inaccurate, or at least imperfect, to lead to any general conclusion. If the whole meaning of the concrete noun is retained in the prepositions thus derived, it is only in the form of allusion. A language is not pure and perfect till the allusion itself disappears, and till the word is employed to express an appropriate and well-defined degree of generality, independently of the concomitant ideas contained in the subject from the name of which it has been borrowed. "Through" expresses only one property of a door, and a property in which it resembles many other objects which have different names. This preposition is indeed equivalent to a noun, but it is to a more general one than that which suggested the term. The noun to which it is nearly equivalent is "passage" or "medium."

Proper[ty] of the [pre]position [in] syntax

It is from its properties in syntax that the preposition must take its rank among the parts of speech. In this respect it deviates from the noun. When, instead of the preposition, we employ simply a substantive noun, as in the examples formerly mentioned, in which the noun "beginning" was substituted for the preposition "from," the sentence labours under an awkward chasm. The meaning may be fully understood, but it appears to be imperfectly expressed. There seems to be as great a deficiency as if in an affirmative sentence we should omit the copula, saying, like a lisping child, or an unpractised foreigner, "That man good," instead of "that man is good." In order to complete the syntax, we must either use an additional word along with the noun thus substituted, or supply its place by a different part of speech. The force of those Latin prepositions which govern the accusative, is on the whole more completely expressed by a word which has the regimen of an active verb. This character will apply to all the prepositions of the English language, as they all govern the noun in the same form. Those Latin prepositions which govern the ablative must be considered as less transitive in their regimen. (See our observations on the Ablative Case, at p. 414.)

It ha[s the] regim[en] of a ver[b].

Some[times] resem[bl]es the a[...] geru[nd]

The part of speech to which the preposition is most nearly allied in the mode in which it is introduced, will differ according to the sort of words to which it is immediately subjoined. When it is subjoined to a verb, the verb will govern it nearly in the same manner as it governs the gerund of another verb in the ablative. *Trans* will be represented by *transeundo*; *per* by *perforando*, or *permeando*. The English preposition "from" might be represented by the Latin gerund *linquendo*; the Latin *a*, *ab*, or *abs*, by *abeundo*. The prepositions imply no such specification as is signified by any of the verbs with which, for the sake of pointing out the properties of their syntax, we have here combined them. It was necessary to make gerunds by combining them with verbs, and thus appearing to add to the ideas which they express rather than to explain them, because we have no verb exactly corresponding to the simple preposition. The preposition itself is the gerund, though indeclinable.

Sometimes a participle.

If the preposition is introduced by the substantive verb alone as the first word of the predicate, it will possess the syntax of a participle agreeing with the nominative which precedes. *Sub* will have the regimen of *subjacens* or *subjunctus*. *In* will approach to the participle *habitans* or *inclusus*, though more general in the idea which it conveys. "Out of," when used in such a sentence as "He is out of town," will also have the power of a participle, though we cannot name any word in that form to which, with respect to generality, it makes any approach. This cannot always be expected. If the office of a preposition were to be performed with equal advantage by the gerund or participle of a verb in present use, there would be in some respects no occasion for the prepositions themselves.

The peculiarities of the preposition.

Here we trace the peculiarities of this part of speech. It is usually more general than any other to which it is allied. It is marked by a peculiar brevity, and by the absence of inflexion. Without the formality of significant terminations, prepositions possess all their force. They thus correspond to the rapidity of human thought, and to the subordinate rank of the ideas which they convey. They have been called the pegs and nails of language. This account of them is severely censured by Mr Tooke, and is inaccurate when intended to intimate that they differ from other words in not expressing ideas. Yet it is certainly true that the ideas which they express might often be left to be inferred from the other words of the sentence. They are not the central ideas in discourse. The preposition *secundum*, "according to," implies all the ideas expressed by the noun "harmony" or "agreement;" the word "from" those expressed by the noun "beginning;" "above" those of the noun "top;" "below" those of the noun "bottom." But such ideas are never interesting on account of any general properties of their own. We never have occasion to write dissertations on "tops," "mediums," "beginnings," "endings," "outsides," or "insides." Yet the frequent recurrence and consequent familiarity of these ideas, together with their subordinate character, render it desirable for us to express them with rapidity, by endowing them with all possible brevity of form. Words possessing this character render language copious and minute without incumbrance. They are the Επεα πτεροεντα, the winged words, of discourse. Whether we consider them as always derived from other parts of speech of greater length, which a large proportion of them undoubtedly is, or suppose it possible that they have occasionally consisted of syllables thrown in at random, and afterwards adhered to as significant, in the same manner as almost all original words must have been produced, we see, in their general form and application, their excellent adaptation to the completion of language.

Sect. II. *Sentential Prepositions.*

Nature of the sentential preposition.

The *Sentential Preposition* is a sort of words generally numbered among conjunctions, and forming in elementary grammars more than one half of that list. But the conjunctions, as thus classified, are not susceptible of any common definition; and this proceeds not merely from their coincidence in use with words of a different kind, but from their dissimilarity to one another. That this disadvantage may be diminished, if not entirely remedied, we here give a separate consideration to those words which have the power of introducing subjoined sentences in the same manner as the words called prepositions have with respect to nouns. We denominate them *sentential prepositions*, in contradistinction to the others, to which we have given the designation of *nominal*. In some instances the same word serves for a preposition of both kinds. "After" is a nominal preposition in the phrase "after dinner," and a sentential preposition in the phrase "after we have dined." In other instances the word employed as a nominal preposition undergoes some slight alteration, or receives some addition, to distinguish its application as a sentential preposition. The Latin *cum*, ("with,") sometimes retains the same form when used for subjoining a sentence, and sometimes is transformed into *quum*. *Ante* and *post* are converted into *antequam* and *postquam*.

The general kinds of it.

The nature of the general sentential preposition "that" in English, and *quod* and *ut* in Latin, has been already discussed. *Quam* is another, like these, of very general meaning. It is sometimes translated "as," sometimes "than." It then performs the part of a relative, and has the same relation to an antecedent adverb which the relative noun has to the noun antecedent. *Quam* has the same relation to *tam* as *qui* has to *ille*. *Tanquam*, from *tam* and *quam*, may be called a sentential preposition, but it differs from *quam* in being more particular, as including the antecedent adverb. Of this last kind are also the sentential prepositions *antequam* and *postquam*. *Ante* and *post* are used adverbially, and the Roman authors often disjoin them from the subsequent *quam*: as, *Ante autem huc venerat* QUAM *sperâssem*. It might appear that *quam* should be considered as giving the subjoined sentence the character of a noun, and the word *ante* or *post* as a preposition governing or introducing it in that state. It is however more agreeable to the analogy of language to consider *ante* and *post* as adverbs, and the compound words *antequam* and *postquam* as synonymous with *anteaquam* and *posteaquam*, formed from the adverbs *antea* and *postea*. Adverbs in general might be resolved into nouns in the ablative case; and a special sentential preposition, or one which implies the meaning of an antecedent adverb, would, on this principle, be resolved into the ablative of an antecedent noun and that of the relative. *Antequam* is equivalent to *tempore* ANTERIORE *illi tempori* QUO. *Ut* is also used as a relative; *sic* is often its antecedent when it introduces the indicative mood, and *ita* when it introduces the subjunctive. *Ut* has sometimes in itself the force of *sicut* or of *ita ut*, and, when no antecedent adverb is expressed, may always be considered as implying by ellipsis the meaning of one. The sentential prepositions *dum* and *quum* have the same relation to *tum*; "when," "while," and "where," to the adverbs "then" and "there." The resemblance and near relation subsisting betwixt "when," and the adverb "then," have led many grammarians to give to both the common designation of adverbs. *Postquam*, *antequam*, and other ana-

Their affinity to the relative.

Special words of this class have a compound form.

Or a compound signification by ellipsis.

Universal Grammar.

logous words, have also been denominated adverbs; and thus the whole of this part of grammar has been involved in confusion: but we shall see the difference clearly if we recollect that the words now mentioned are not attached to verbs to modify their meaning, or exhibit in themselves any concomitant circumstance, but to introduce a subjoined sentence. The word "as" is used both for an antecedent adverb, and a sentential preposition. It is an adverb in the phrases "*as* good," "*as* soon," and a sentential preposition after the adverb "so," "He did not come so soon *as* I expected." All special sentential prepositions might be resolved by an analysis similar to that which we have given of *ut* and *antequam*. We have not antecedents in the form of adverbs for them all, but we may express them by ablatives of nouns or of gerunds. *Si*, "if," implies the meaning of *ea conditione, eo casu*, or *supponendo. Quanquam, etiamsi, etsi*, "though," "although," (words of nearly the same meaning with *si*, and differing slightly in the occasions of their application,) imply the force of *concesso* or *concedendo*.

Always distinguishable from adverbs.

Mode of analysing them.

Station of the sentences subjoined by special sentential prepositions.

It is in fine to be observed, that the special sentential preposition and the sentence subjoined by it, taken as a whole, occupy the place of an adverb, or of a noun in the ablative case. In some instances we find single words in this form equivalent to such sentences. *Citò* is equivalent to *priusquam multum temporis preterierit*. In the following sentence, "He was appointed to the office *till the propriety of the continuance of that measure should be ascertained*;" the whole subjoined ideas marked in italics may be fully expressed by the single adverb "provisionally." When *ita* is used without any subjoined regimen, it is an adverb implying a reference to some assertion previously made, or some connection of ideas exhibited at the instant of speaking: When it is employed as the antecedent to *ut* with a subjoined sentence, the whole sentence along with the *ita* and *ut* occupy the place of an adverb or the ablative of a noun.

Mr Tooke's etymologies.

The following is Mr Tooke's account of the etymology of some English words belonging to this part of speech. "If" is from *Gif* the imperative of *Gifan* "to give." The old synonyme "an," from *Anan* "to grant." "Unless," from *Onlesan* "to dismiss." "Though," from *Thafigan* or *thafian*, to "allow." "Without," from *Wyrthanutan*, to "be out." "Lest," from *Lesan*, "to dismiss." "Since," from the participle *Seon*, "to see." "As" is *es*, a German word for "it," "that," or "which."

Some words are used as sentential prepositions which still retain the form of gerunds or participles; as "supposing," "provided," "providing that," "granting that." "Seeing," was formerly used in the same manner.

CHAP. IX.

Of Conjunctions and Miscellaneous Particles.

Conjunctions connect words or sentences on equal terms, without regimen or subjunction. They continue the syntax of the introducing word to that which they introduce. General words of this description are not numerous, as the purposes to which they are applied do not admit of great variety. One kind of them may be termed *Conjunctions of union*, as they unite the meanings of the words which they connect. Such are the English word "and" and the Latin *et, ac, atque*. Another kind may be termed *Conjunctions of alternation*, as *aut* and *vel* in Latin, and "or" in English. The negative "nor" is a conjunction combined with a negation. It might appear in its etymology the reverse of "or," but in meaning it is the reverse of "and." It is equivalent to "and not." In Latin this is also its etymology. It is not *non vel* or *ne vel*, but *nec* from *ne ac*, and *neque* from *ne* and *que*.

General conjunctions.

Conjunctions of union.

Of alternation.

Words announcing conjunctions.

Sometimes the first of the nouns or verbs connected by conjunctions is preceded by a peculiar word. "Both" is used to precede words connected by "and;" "either" those connected by "or;" and "neither" those connected by "nor." It is natural to ask to what head "both," "either," and "neither" are to be referred. In the English language, their etymology might strongly lead a grammarian to refer them to the class of adjectives when they precede nouns, and thus make them equivalent to *ambo, uter*, and *neuter*. When they precede verbs, they might be reckoned adverbs, and in English would be equivalent to adverbs formed by adding the termination "ly" to the adjective, as if we said "bothly," "eitherly," "neitherly." They perform the office of an adverb referring to concomitance. In Latin the same word is used both as the preceding and the conjoining word. *Et ille et alter; Et venit et vidit.* It will be found, on the whole, that conjunctions are near akin to adjectives and adverbs. They are necessarily frequent in the use of language, and therefore have received an abbreviated form.

Conjunctions resemble adjectives, and adverbs.

Special conjunctions.

Some miscellaneous particles may be called *special conjunctions*, as including a more particular character of mutual relation betwixt the ideas contained in the words or sentences which they connect. Such are the words "also," "farther," "moreover," "but," "likewise," "yet," "notwithstanding," "however."

CHAP. X.

Of Interjections.

Nature of interjections.

The term *Interjection* is applied to those words which express by short exclamation certain overpowering emotions of mind. Such as 'Αι αι! *Heu! Atat! Proh!* "Ah!" "Oh!" "Alas!"

This part of speech is treated by Mr Tooke with great contempt, as a brutish inarticulate sound which has as little to do with speech as the neighing of a horse, the barking of a dog, coughing, groaning, shrieking, or any other involuntary convulsion with oral sound. These words, however, though at first involuntary, are afterwards uttered from design. A man desirous of impressing another with a particular passion, first contrives to excite it in his own mind, and then utters the sound by which it is expressed. Hence corresponding syllables are committed to writing in works which depict human passions and manners. They belong to language, as language must include every sound addressed by one man to another, from the highest to the lowest state of mental cultivation. Interjections may be considered as a mixture of involuntary expression with social discourse. In the use of this part of speech, man is seen to rise from the character of an animal impelled by passion to that of a reflecting being, who displays intelligence and address in influencing his fellow creatures.

Either voluntary or voluntary sounds.

Not to refuse place in language.

Special interjections.

Sometimes words belonging to other parts of speech, and expressing definite ideas, are introduced abruptly to express emotion, and numbered among interjections; as "Amazing!" "Wonderful!" "Prodigious!" "Shocking!" "Horrible!" "Mercy!" "Pitiful!" "Woe's me!" Whether we call such exclamations as these interjections, or abbreviations by ellipsis, is of little importance. Their meaning is never ambiguous.

In the introductory part of this article we described language as essentially imperative; and the slightest reflection will shew that interjections, in so far as they partake of the nature of social discourse, possess an imperative character.

Books of merit on universal grammar are but few. But numerous observations on the subject are to be found in all good and complete grammars of particular languages, and in the larger Dictionaries. Some parts of it are also occasionally discussed in books of metaphysics. The principal English and French works on this subject are the following: Monboddo's *Treatise on the Origin and Progress of Language;* Harris's *Hermes;* Beauzée's *Grammaire Générale; Grammaire Générale et Raisonnée,* par M. M. de Port Royal; Condillac's *Grammaire* in his *Cours d'etudes;* Tooke's *Diversions of Purley;* Beddoes *on the Nature of Demonstrative Evidence;* Pickbourne's *Dissertation on the English Verb;* Mr Dunbar's *Analysis of the Greek Verb;* Dr Gregory *on the Theory of the Moods of Verbs in the* 2d vol. of the *Transactions of the Royal Society of Edinburgh;* Mr Bonar's *Essay on the Greek Prepositions,* in the 5th Vol. of the same work; Dr Jamieson's *Hermes Scythicus;* Beattie's *Essay on the Theory of Language;* Hutton's *Dissertation on the Theory of Language;* Dr Adam Smith's *Essay on Language,* (published with his *Theory of Moral Sentiments*); Mr Stewart's *Philosophical Essays,* Part I. Essay 5th; and the article *Grammar* in the *Encyclopædia Britannica,* and that of Dr Rees. *

GRANADA, a celebrated city in Spain, and capital of the province of that name, is pleasantly situated on two small hills, at the extremity of a beautiful and extensive plain. It was built by the Moors in the tenth century, and was finally reduced by the Spanish armies in 1492, after a siege of more than twelve months. At that period it is said to have covered a space three leagues in circumference, and to have contained 400,000 inhabitants, a statement unquestionably far above the truth. Its walls were defended by more than a thousand towers; and it was farther protected by two fortresses, on the summits of the two adjoining hills, each of which was capable of containing 40,000 men. These fortresses still remain, but the walls and gates of the city are demolished, and many of its finest structures in a state of decay. It nevertheless exhibits evident proofs of its former magnificence; and its appearance from a distance is described as peculiarly majestic. The plain before it is above 30 leagues in circumference, and about 1200 miles above the level of the sea, but so completely inclosed by mountains of stupendous height, as to have all the appearance of a delicious valley. It is watered by five rivers, and intersected by numerous rivulets and canals; covered with the richest meadows, forests of oak, plantations of orange trees, and sugar cane, fields of corn and flax, orchards of fruit-trees, and all kinds of vegetables; bounded on the north by the lofty Sierra Nevada, with the mountains of Elvira, and on the other sides by successive amphitheatres of hills; agreeably planted with vines, olive, mulberry, lemon, and orange trees. It contains within its circuit not less than 52 towns; and in its centre appears the Soto de Roma, which is a beautiful wood of elms, white poplars, and ash trees, full of game, especially pheasants, more than a league in length, and half a league in breadth, and formerly the retreat of the Moorish kings. At the termination of this fertile plain, the city of Granada is perceived from a considerable distance, extending in the form of a half moon from the river, along the gradual ascent of a hill, its streets rising above each other, exhibiting a profusion of turrets and gilded cupolas; the summit of the whole crowned by the palace of the Alhambra, and the back ground composed of the majestic Sierra Nevada, covered with snow. But the splendid illusions, created by this distant view, are sadly dissipated by a nearer inspection of its fallen grandeur. It was formerly divided into four quarters, which may still be considered as distinctly marked, namely, the quarter of Alhambra, which principally contains that immense citadel on the mountain of the sun, and where the splendid palace of the Moorish kings is still in existence, and in a state of sufficient repair to impress the spectator with the most lively idea of its original beauties; the quarter of Albayzin, a kind of suburb on the rising ground, separated from the town by a rampart, and containing about 4000 houses; the quarter of Antiquerula, which has the appearance of another suburb built upon the plain, was peopled by settlers from Antequera, and is principally occupied by dyers and silk-weavers; and the quarter of Granada which covers the commencement of the plain, and a part of the valley between the two mountains, and is the best built and best inhabited part of the town. The river Darro runs through the middle of the city, and empties itself into the Xenil, which passes near the walls. The extent of the whole town is much the same as it was in the time of the Moors, but it is thinly inhabited in proportion to its buildings; and the present population is only about 60,000. The streets are generally narrow, and the houses very inferior in their appearance to those of many other cities in Spain. Even those which surround the market-place are very despicable, few of the upper apartments having glass in the windows, and the shops below being very indifferently supplied with goods. But there are many fine buildings, handsome squares, extensive gardens, and beautiful fountains in different parts of the city. The El Campo is a large square at the entrance of the town, on the road from Antequera, and is partly occupied by an hospital, which is a large and handsome building. The Plaza Mayor in the middle of the town is very spacious; and is used for public shows, particularly the bull-fights. The Biva Rambla, a handsome area, 400 feet by 200, is embellished by an elegant jasper fountain, and has on one side the Alcaxeria, and on the other the Chancery; the latter of which has a very handsome front, ornamented with alabaster columns, and a range of windows with gilt balconies; and the former, an immense edifice without ornament, formerly the bazar of the Moors, still contains about 200 shops: these shops are so very small, that the owner, sitting in the centre, is able to reach whatever his customers may require, without rising from his seat. The cathedral is a very splendid but irregular building. It has a handsome dome resting on twelve arches, supported by twelve pilasters; and against these columns are placed the statues of the twelve apostles in gilt bronze, as large as life. The vault is full of paintings, and two rows of

* The Editor is indebted for this valuable article on GRAMMAR to Henry Dewar, M.D. F.R.S.E.

Granada, Province.

gilded balconies run round it above the arcades. In this church are some of the best pictures and statues by the celebrated Spanish artist Alonzo Cano, and his pupil Pedro de Mena. The palace of the archbishop stands close to the cathedral, and is a very extensive mansion, and of a handsome appearance. But the most interesting and splendid object in Granada is the Alhambra, the ancient fortress or palace of the Moorish kings, described in a former article: (See ALHAMBRA.) Though this noble structure is fast hastening to decay, and likely to become in a few years a heap of ruins, it is still viewed by travellers with the strongest sensations of wonder and delight. In a higher situation on an opposite hill, is another palace, called the Generaliffe, which was used as a retreat in the intense heats of summer. The rooms are floored with marble, and have streams of the clearest water rushing through them. It is surrounded by gardens, groves, and orchards, planted with orange, lemon, and cypress trees, and provided with a multiplicity of transparent pools and crystal fountains. Most of the houses have fountains and baths in their courts, which, besides supplying water for domestic uses, moderate by their coolness the extreme heat of the climate in the summer season. In imitation of the Moors, the present inhabitants spread an awning over these courts to keep off the sun, and live there all the summer, eating their meals and receiving their visitors amidst its refreshing coolness. The environs of the city are delightful, and the shady walks on the banks of the Xenil, with others more wild and romantic on the Darro, afford the most refreshing and pleasing retreats. The sides of the hills around the city abound with caves resembling the troglodyte habitations in Abyssinia. They were originally employed as granaries for corn, but are now inhabited by gipsies, who are very numerous in the south of Spain, and are said to bear a great resemblance to the same class of people in England. Granada contains an university, and an academy for mathematics, but they have no library, few masters, and scarcely any students. There is a royal manufactory for saltpetre and gun-powder; and several for woollen cloths and serges, which are said to employ about 7000 persons, and to consume 460,000 pounds of wool annually. Silk stuffs, such as velvets, sattins, and taffetas of a very durable quality, are made in the city, and a considerable quantity of ribbons, in the manufacture of which the spring shuttle used at Coventry is generally adopted, the only kind of machinery observed in the manufactories of the place. See Jacob's *Travels in Spain;* Townsend's *Travels in Spain;* Laborde's *View of Spain;* and Murphy's splendid work, entitled, the *Arabian Antiquities of Spain*, Lond. 1815. (*q*)

GRANADA, a province of Spain, sometimes called Upper Andalusia, is bounded on the east and south by Murcia and the Mediterranean, and on the west and north by Andalusia. It is situated between 36° 20′ and 38° North Latitude, and between 5° 5′ and 1° 30′ West Longitude from Greenwich. It is of a very irregular figure, approaching to the shape of a pyramid, with its base to the east on the kingdom of Murcia, and its apex to the south-west, towards the straits of Gibraltar. It is 58 leagues in length from the east to the south-east; and in breadth, in some places 8, in others 18, and at its base 28. The principal towns are Granada, the capital, already described, Malaga, Almeria, and Amunecar, three sea-ports on the Mediterranean; Guadix, Motrel, Morbella, Velez-Malaga, Baza, Vera, Ronda, Loxa, Santa-Fé, Huesca, Antequera, and Alhama. Its rivers are the Verde, Xenil, Las Feguas, Guadalentia, Guadavar, Guadalmeja, Rio de Almeria, Rio Frio, Guadalmerina, Darro, Guadix, Bravata, Marchan, &c.

Extent and boundaries.

History.

The Moors having acquired possession of Spain after the bloody battle of Xeres in 711, in which Roderigo, the last of the Gothic princes, was slain, Granada became a part of their empire in the south of the peninsula; and, in 1013, was chosen by Almanzor as the royal residence, instead of Cordova. In 1051, the family of Almanzor were deprived of the sovereignty by Joseph ben Taschphen, King of Morocco, who filled the throne with dignity and splendour. After his death, the kingdom was divided among a number of pretenders; but, in 1146, was again united under a prince of the family of the Almohades. Mahomed the First, one of the greatest of the Moorish princes, laid the foundation of a new dynasty in 1232, and raised the kingdom of Granada to its greatest degree of prosperity. While he kept on foot a powerful army for the defence of his dominions, he was equally attentive to promote the welfare of his subjects by the arts of peace. He regulated the revenues, administered justice, cultivated science, endowed hospitals, and laid the foundation of the Alhambra, the glory of Mahommedan Spain. Mahomed the Second succeeded his father, and was distinguished, above all the monarchs of his race, as the protector of science, and the patron of arts and commerce. His court was the resort of astronomers, physicians, philosophers, orators, and poets; and his own compositions in verse are celebrated by Arabian writers for their epigrammatic humour. He was succeeded in 1302, by his son of the same name, who resembled him in his love of literature, and his patronage of the fine arts; but, while he was engaged in war with the King of Arragon, an insurrection in his capital transferred the crown to his brother Almasser, a young prince of 25 years of age, celebrated for his progress in mathematical and astronomical learning; but who, yielding to the turbulent dispositions of his subjects, was in his turn supplanted, in 1314, by Ismael, Prince of Malaga.

State of the Moors in Granada.

The kingdom of Granada, hard pressed by the Christian states in the north of Spain, and thus torn by a succession of intestine commotions, was fast approaching to its fall. Its sovereign Albohassen, availing himself of the discontents created in Castile by the accession of Ferdinand and Isabella, marched a hostile army into their dominions in 1482. Ferdinand, having procured a truce of three years, and quieted his rebellious subjects, became the aggressor in his turn; and, aided by the dissensions among the Moorish chiefs, pushed his conquests with such rapid success, that in the course of two years, he had reduced the power of Abo Abdeli, the eldest son of Albohassen, within the city and plain of Granada. Having occupied the surrounding country with his troops, and built the city of Santa-Fé, he was preparing to invest the Moorish capital, when the besieged prince, more afraid of his subjects than of the enemy, proposed to capitulate, and submitted to the power of Ferdinand. In defiance of the terms expressly stipulated for the protection and toleration of the vanquished, the Moors were finally banished to the sterile regions of their ancestors; and their empire in Spain completely terminated in the year 1492. But for a considerable period after the conquest of Granada, a few scattered bands, who had taken refuge in the mountains, maintained an unavailing struggle with their conquerors, displaying the most heroic spirit in their sufferings, and unshaken constancy to their chiefs. Under the sway of the Mahommedan princes, which comprehends a period of nearly eight centuries, the kingdom of Granada was the seat of opulence, arts, and

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learning, while the other states of Europe, under the spiritual domination of Rome, were sunk in the deepest mental barbarism. The Omniades in Spain, following the example of Almamon, the seventh caliph of the Abassides, exerted themselves so sedulously in the advancement of knowledge, that they are said to have collected 600,000 volumes, and to have established 70 public libraries in the cities under their dominion. The Arabian writers enumerate, in 1126, 150 authors natives of Cordova, 52 of Almeria, 76 of Murcia, and 53 of Malaga, besides those of Seville, Valencia, and Granada, where the spirit of literature was preserved in full vigour nearly four centuries. In this last mentioned city, where it principally flourished, there were at that time two universities, two royal colleges, and a public library, stored with the productions of the best Greek and Arabic writers. The love of learning was so general in Granada, that, in spite of the prohibitions of Mahomed, it extended to the female sex; and we find recorded the names of the poetess Naschina, the historian Mosada, and the mathematician Leila. Their physicians, though imperfectly acquainted with anatomy, as their religion prohibited all dissections of the human frame, acquired great celebrity. Botany was one of their favourite studies; and they made some progress in the operations of chemistry. They chiefly excelled in the various branches of mathematics, namely astronomy, arithmetic, geometry, trigonometry, and optics; but they were little acquainted with physics, and, though they were instrumental in preserving many Greek authors, they were as little acquainted as the nations of Christendom at that period, with the classical authors of Greece and Rome. Among the Arabians, in short, in the south of Spain, human genius is said to have produced more prodigies in a few centuries, than it has done in the history of ages in all the rest of the world. All the great modern discoveries, paper, printing, the mariner's compass, glass, gunpowder, &c. are affirmed to have been there anticipated and again forgotten; and in the exercise of fancy and invention, they are considered as having far surpassed all former and succeeding ages. Agriculture formed the principal occupation of the Saracens in Granada; and, while it was stimulated by the demands of an extensive population, it was improved by the aids of science. They were particularly attentive to the application of manure, which they preserved in pits, that none of the salts might be lost; and they carried the practice of irrigation to a very great extent. But, as their bigotry forbade the sale of their superfluous grain to the neighbouring nations, they pursued its cultivation no farther than was requisite for their own subsistence; and directed much of their attention to the culture of fruits, which generally formed their principal aliment. To them Spain is indebted for the introduction of an infinite variety of fruits, and of its best horticultural productions, for the sugar-cane also, and the cotton-tree. Their commerce was not less extensive, and the luxuries of India were brought from Alexandria to Malaga at an early period. The silks of India, and the porcelains of China, were soon imitated, and even excelled by the Moors. They were skilled in the manufacture of woollen, cotton, and flax, but, above all, in the art of dyeing of leather. They made some progress in working mines, especially of lead and iron; and their articles of steel, particularly the swords of Granada, were preferred to all others in Spain. In their architectural plans and ornaments, they were deficient in taste; but their joiners and inlayers of wood worked with the utmost nicety; and they painted and gilded their stucco work with singular skill. Upon the banishment of this ingenious people, the arts and sciences departed with them; the magnificence, commerce, and manufactures of Granada rapidly decayed; and the indolence, poverty, and barbarism, which succeeded in their place, continue, in no small degree, to overspread the face of the most highly gifted region in the world.

Mountains.

Granada is beautifully diversified with majestic mountains, extensive plains, and delightful vallies. A chain of mountains, named the Alpuxarras, extends through the province from west to east. The loftiest points of the whole range are those of the Sierra Nevada, near the city of Granada, one of which, called Mulhacen, is 12,762 feet above the level of the sea; and all above 9915 feet are covered with perpetual snow. The mountains towards the south gradually decline in height, till at the Sierra de Gador, near Almeria, where they rise to the elevation of 7800 feet. At this extremity near Macael is the celebrated rock called Filabres, which is four miles in circumference, two thousand feet in height, and which consists of one entire and solid piece of white marble. The secondary mountains are of various kinds; but many are composed of marble of different colours, black, white, red, and flesh colour. About two leagues from Granada, on the banks of the Xenil, is a quarry of green serpentine beautifully veined, and capable of receiving a fine polish. There are many sorts of alabaster in the mountains which environ the city, some of which are as brilliant and transparent as oriental cornelians. There are also quarries of jasper, and a variety of precious stones. In the mountains of this province are several mines of silver, copper, and lead, some of which were formerly worked by the Moors. Gold is found in the sands of the river Darro; but of late the quantity has been small. Mineral waters, both cold and hot springs, are very abundant in the province; but few of them have been analysed: They are chiefly chalybeates, and sulphureous. But one of the most remarkable circumstances in the mountains of Granada is the quantity of bones, of men and other animals, found on their summits, especially at Concud, where there is a hill entirely composed of them, lying under a stratum of limestone.

Climate.

The climate of Granada is cold in the mountainous districts; extremely hot and sultry in the vallies; but it is tempered in the plains by the coolness of the waters, which are conveyed in all directions. The country is exposed to a number of winds, particularly on the coast; one of which especially, called Solano, is attended with the most pernicious effects. It is a hot wind, which blows from Africa, dries up the plants as soon as it touches them, affects the body with the feelings of strong fever, and throws the mind into a state little better than madness. Murders and assassinations are observed to be most frequent during its prevalence.

Soil and produce.

In this province agriculture is in a more flourishing state than in any other district in the south of Spain; and the Vega of Granada, already described, is the finest and richest plain in the kingdom. The principal mode employed for aiding the crops is the irrigation of the soil. Streams are conveyed along the upper side of every field by means of embankments, in which sluices are cut, which convey the water into small gutters; and these are allowed to run at short intervals, so as to flood the whole field with ease in the hot season. Great attention is paid to the preservation of manure, which, according to the old Moorish practice,

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is collected in large pits, well rammed, to prevent leaking; and, when once well rotted, is distributed over the land, in a state almost liquid. It is not applied, however, to the production of corn, but is used in the gardens, the melon grounds, and the mulberry plantations. Yet, without any manure, and by the mere assistance of irrigation, the most abundant crops of grain are raised, especially of wheat, barley, and maize. On land capable of being properly watered, the annual produce of wheat is said to be fifty bushels per acre. Great quantities of rice are cultivated in the lower grounds near the rivers, and subject to floods; and frequently a crop of hemp, or flax, is taken from the land before the rice is sown. But the Spanish farmers pay more attention to the breeding and fattening of cattle, than to the cultivation of grain or fruits. They make no hay; but the grass grows most abundantly in winter, when the cattle are fed in the uplands; and after harvest, which is generally in June, the stubble fields furnish subsistence to the flocks and herds. The flax and hemp are very cheap; and the latter, having a remarkably strong fibre, is thought to make the best sail cloth. There are very extensive plantations of mulberry trees, which are cultivated solely for the sake of the leaves, as the food of the silk worm. The white mulberry, grafted on the wild stock, is considered as the best for that purpose, and as making the worms yield a finer silk than the red or black species: The tops are cut off to increase the quantity of leaves. As much silk is annually raised in the plain of Granada as furnishes employment to 1500 persons. The manufactures in the city alone are calculated to require a supply of 100,000lbs. It is estimated, that 1500 worms produce about one pound of silk; and it is found, that a mulberry tree, of ten years of age, will scarcely supply food for as many of these insects as yield seven pounds. The mountains round the city of Granada are well calculated for vines, but so little attention is paid to their cultivation, that the wine produced from them is of a very inferior kind, and generally acquires a disagreeable taste from the sheep skins with tarred seams in which it is brought from the vineyards; but, in other parts of the province, excellent wines are made, especially the Tierno, Moscatel, and Malaga. The grapes often grow in bunches of eight, ten, and even fourteen pounds weight, and great quantities are dried in the sun for exportation. Olive trees are numerous; but oil is not produced in sufficient quantity for the consumption of the inhabitants. Sugar canes are cultivated in many parts, but especially around Malaga; and are as large and juicy as those of the West Indies.

Commerce.

The commerce of Granada with the other provinces, consists chiefly in exchanging corn, wine, and dried fruits, for oil and silk. Its trade with foreign countries is carried on from the ports of Almeria and Malaga, (see Almeria and Malaga,) and consists in exports of wine, dried fruits, oil, anchovies, lemons, almonds, lead, kali, sumach; and in imports of cloths, ironware, mercery, lace, &c.

Inhabitants.

The inhabitants of this province, like the Andalusians in general, are considered as the Gascons of Spain, vain, talkative, boastful and licentious. The women are represented as sufficiently seducing, handsome in their figure, and peculiarly attractive as dancers. The language is mixed with so many Arabic words, and the pronunciation so guttural and vitiated, that a Castilian often finds it difficult to understand the speech of an Andalusian. See the works referred to under the preceding article. (*q*)

Granada, New.

GRANADA, New, a division of Spanish America, lying between 2° and 8° of North Latitude; is bounded on the north and east by Caraccas and Cumana, on the west by Popayan, and on the south by Peru. It extends in length about 300 miles, and nearly as much in breadth. It is so far elevated above the level of the sea, that, though approaching almost to the equator, its climate is remarkably temperate. Its vales and level districts are not inferior in fertility to the richest spots of America. Its mountainous tracts abound in mines of gold, silver, lead, copper, and in precious stones of various kinds. Its forests afford a variety of excellent timber, adapted particularly for ship-building. Its principal towns are Bogota, or Santa Fé de Bogota, the seat of government, and the see of an archbishop, situated nearly in 4° North Latitude, and containing 40,000 inhabitants; Flonda, a pleasant little town on the river Magdalena, about 60 miles north-west of the capital, the principal port for the commerce of the interior provinces, and containing about 10,000 inhabitants; Merida, a considerable manufacturing town in 8° 11′ North Latitude, situated in a well-watered valley, about 20 leagues south of Lake Maracaiba, and containing 11,000 inhabitants; Neyva, 107 miles south-west of the capital; Maraquita, 59 miles north-west; St Miguel, 94 miles north-east; Caguan, south of Neyva and Tunia in 5½° North Latitude; all small settlements, rather in a declining state. There are likewise several missionary stations, especially towards the south of the province, called Los Llanos, and several villages of the Indians. Antioquia, perhaps rather a separate province, is also generally comprehended in that of New Granada. It is situated towards the west, bounded by Carthagena on the north, by Popayan on the south, and on the west by Choca. It is mountainous, and abounding in mines; temperate, well watered, and rich in pastures. Its capital, of the same name, in the valley of Nori, is situated in 7° 14′ North Latitude.

A few manufactures of cotton cloths, carpets, counterpanes, and woollens, chiefly for the purposes of internal consumption, are carried on in the province. Several of its native productions, especially chocolate, tobacco, and cotton, all of excellent quality, might be collected in great abundance for exportation; and the river Magdalena, which runs through the province into the Atlantic, and is navigable as far as Florida, 160 leagues from its mouth, affords a commodious outlet to the European markets. But agriculture and trade are said to have greatly declined of late years in the province; and its present unsettled state, struggling for independence of the mother country, though likely to issue at length in its prosperity, must obviously be extremely unfavourable to every kind of cultivation or commerce. Its chief support is derived from the produce of its gold mines. These indeed can scarcely be called mines, as the metal is not generally procured by digging into the earth, but is mingled with the soil near the surface, from which it is separated by repeated washings. This work is commonly performed by Negro slaves, who cannot bear the chill air of the mines, but are more able than the Indians to support the labours of the field. In some districts, the metal is found in large grains; and on some spots, particularly near Pamplona, single labourers have collected in one day a quantity equivalent to 1000 pesos. One of the governors of Santa Fé procured a mass of pure gold estimated to be worth £740, which was deposited in the royal cabinet of Madrid as the finest and largest specimen ever found in the New World.

Granada, or Santa Fé as it is sometimes called, gives name to an extensive viceroyalty, which is sometimes confounded with the province, properly so denominated. This kingdom of New Granada was originally established in 1547, and was governed by a royal audience, with a captain-general as president. In 1718, it was formed into a viceroyalty, which was suppressed in 1724, and finally restored in 1740. It comprises the provinces of Carthagena, Panama, Santa Martha, Maracaibo, Porto Bello, Antiognia, Choca, Granada Proper, Veragua, Mariquita, Rio de la Hacha, Giron, Neyva, and the Llanos, which form the northern division, under the jurisdiction of the royal audience at Santa Fé; and the southern districts, Jaen de Bracamoros, Loja, Cuenza, Macas, Riobamba, Popayan, Quito, Guaynquil, &c. which are under the jurisdiction of a governor and royal audience at Quito, who are subordinate to the viceroy of New Granada. This extensive territory, when first subjected to Spain in 1536, was more populous, and its inhabitants more civilized, than any other portion of America; but the amount of its whole population is now calculated by M. Humboldt only at 1,800,000. Nothing is wanting for its prosperity, but the revival of industry and commerce; and nothing prevents it from enjoying these benefits, but the impolitic restrictions and oppressive system of its European rulers. See Robertson's *History of America*, vol. iii.; Playfair's *Geography*, vol. vi.; Pinkerton's *Geography*, vol. iii.; and Humboldt's *Account of New Spain*. (*q*)

GRANGE, Joseph-Louis la,* a celebrated mathematician and natural philosopher, was born at Turin, on the 25th of November, 1736. He was the son of Joseph-Louis la Grange, treasurer of war, and of Marie-Therese Gros, only daughter of a rich physician of Cambiano.

His father was rich, and had made an advantageous marriage; but was ruined by hazardous undertakings. Let us not, however, lament the situation of M. la Grange. He himself viewed it as the first cause of all the good fortune that afterwards befel him. "Had I been in possession of a fortune," said he, "I should not probably have studied mathematics." In what other situation would he have found advantages that could enter into comparison with those of a tranquil and studious life, with that splendid series of discoveries in a branch of science considered as the most difficult, and with that personal respectability which was continually increasing to the very last period of his life?

His taste for mathematics did not appear at first. He was passionately devoted to Cicero and Virgil, before he could read Archimedes and Newton. He then became an enthusiastic admirer of the geometry of the ancients, which he preferred to the modern analysis. A memoir which the celebrated Halley had composed long before, to demonstrate the superiority of the analytic method, had the glory of converting him, and of teaching him his true destiny. He devoted himself to this new study with the same success that he had in the synthesis, and which was so decided, that at the age of 16 he was professor of mathematics in the Royal Military School. The extreme youth of a professor is a great advantage to him when he has shown extraordinary abilities, and when his pupils are no longer children. All the pupils of M. la Grange were older than himself, and were not the less attentive to his lectures on that account. He distinguished some of them, whom he made his friends.

From this association sprung the academy of Turin, which in 1759 published a first volume entitled Acts of a private Society. We see there the young La Grange directing the philosophical researches of the physician Cigna, and the labours of the Chevalier de Saluces. He furnished to Foncenex the analytical part of his memoirs, leaving to him the task of developing the reasoning upon which the formulæ depended. In these memoirs, which do not bear his name, we observe that purely analytical method, which afterwards characterised his great productions. He had discovered a new theory of the lever. It constitutes the third part of a memoir, which was very successful. Foncenex, in recompense, was placed at the head of the Marine, which the king of Sardinia formed at that time. The two first parts have the same style, and seem written by the same person. Do they likewise belong to La Grange? He never expressly laid claim to them; but what may throw some light on the real author is, that Foncenex soon ceased to enrich the volumes of the new academy, and that Montucla, ignorant of what La Grange revealed to us during the latter part of his life, is astonished that Foncenex interrupted those researches which might have given him a great reputation.

M. la Grange, while he abandoned to his friend insulated theorems, published at the same time, under his own name, theories which he promised to develope further. Thus after having given new formulæ of the *maximum* and *minimum* in all cases, after having shown the insufficiency of the known methods, he announces that he will treat this subject, which he considered as important, in a work which he was preparing, in which, would be deduced from the same principles all the mechanical properties of bodies, whether solid or fluid. Thus at the age of 23 he had laid the foundation of the great works, which have commanded the admiration of philosophers.

In the same volume he reduces under the differential calculus the theory of recurrent series and the doctrine of chances; which before that time had only been treated by indirect methods. He established them upon more natural and general principles.

Newton had undertaken to submit the motions of fluids to calculation. He had made researches on the propagation of sound; but his principles were insufficient, and his suppositions inconsistent with each other. La Grange demonstrates this. He founds his new researches on the known laws of dynamics, and, by considering only in the air the particles which are in a straight line, he reduces the problem to that of vibrating cords, respecting which the greatest mathematicians differed in opinion. He shows that their calculations are insufficient to decide the question. He undertakes a general solution by an analysis equally new and interesting, which enables him to resolve at once an indefinite number of equations, and which embraces even discontinued functions. He establishes on more solid grounds the theory of the mixture of simple and regular vibrations of Daniel Bernoulli. He shows the limits within which this theory is exact, and beyond which it becomes faulty. Then he comes to the

* This excellent life of La Grange is taken, with a few slight abridgments, from the eloge of the Chevalier Delambre, with whose kind permission it is here published. As we have not been able to get a copy of the original eloge, we have been obliged to make use of the translation in Dr Thomson's *Annals of Philosophy*, vol. iii. Ed.

construction given by Euler, a construction true in itself, although its first author had arrived at it by calculations which were not quite rigorous. He answers the objections of D'Alembert. He demonstrates that whatever figure is given to the cord, the duration of the oscillations is always the same: a truth derived from experiment, which D'Alembert considered as very difficult, if not impossible, to demonstrate. He passes to the propagation of sound, treats of simple and compound echos, of the mixture of sounds, of the possibility of their spreading in the same space without interfering with each other. He demonstrates rigorously the generation of harmonious sounds. Finally, he announces that his intention is to destroy the prejudices of those who still doubt whether the mathematics can ever throw a real light upon physics.

We have given this long account of that memoir, because it is the first by which M. la Grange became known. If the analytical reasoning in it be of the most transcendent kind, the object at least has something sensible. He recals names and facts which are well known to most people. What is surprising is, that such a first essay should be the production of a young man, who took possession of a subject treated by Newton, Taylor, Bernoulli, D'Alembert, and Euler. He appears all at once in the midst of these great mathematicians as their equal, as a judge, who, in order to put an end to a difficult dispute, points out how far each of them is in the right, and how far they have deceived themselves; determines the dispute between them, corrects their errors, and gives them the true solution, which they had perceived without knowing it to be so.

Euler saw the merit of the new method, and took it for the object of his profoundest meditations. D'Alembert did not yield the point in dispute. In his private letters, as well as in his printed memoirs, he proposed numerous objections, to which La Grange afterwards answered. But these objections may give rise to this question: How comes it that, in a science in which every one admits the merit of exactness, geniuses of the first order take different sides, and continue to dispute for a long time? The reason is, that in problems of this kind, the solutions of which cannot be subjected to the proof of experiment, besides the part of the calculation which is subjected to rigorous laws, and respecting which it is not possible to entertain two opinions, there is always a metaphysical part which leaves doubt and obscurity. It is because in the calculations themselves, mathematicians are often content with pointing out the way in which the demonstration may be made; they suppress the developements, which are not always so superfluous as they think. The care of filling up these blanks would require a labour which the author alone would have the courage to accomplish. Even he himself, drawn on by his subject and by the habits which he has acquired, allows himself to leap over the intermediate ideas. He defines his definitive equation, instead of arriving at it step by step with an attention that would prevent every mistake. Hence it happens that more timid calculators sometimes point out mistakes in the calculations of an Euler, a D'Alembert, a La Grange. Hence it happens that men of very great genius do not at first agree, from not having studied each other with sufficient attention to understand each other's meaning.

The first answer of Euler was to make La Grange an associate of the Berlin academy. When he announced to him this nomination on the 20th of October, 1759, he said, "Your solution of the problem of isoperimeters leaves nothing to desire; and I am happy that this subject, with which I was almost alone occupied since the first attempts, has been carried by you to the highest degree of perfection. The importance of the matter has induced me to draw up, with your assistance, an analytical solution of it. But I shall not publish it till you yourself have published the sequel of your researches, that I may not deprive you of any part of the glory which is your due."

If these delicate proceedings, and the testimonies of the highest esteem, were very flattering to a young man of 24 years of age, they do no less honour to the great man, who at that time swayed the sceptre of mathematics, and who thus accurately estimated the merit of a work that announced to him a successor.

But these praises are to be found in a letter. It may be supposed that the great and good Euler has indulged in some of those exaggerations which the epistolary style permits. Let us see then how he has expressed himself in the dissertation which his letter announced. It begins as follows:

"After having fatigued myself for a long time and to no purpose, in endeavouring to find this integral, what was my astonishment when I learnt that in the Turin Memoirs the problem was resolved with as much facility as felicity! This fine discovery produced in me so much the more admiration, as it is very different from the methods which I had given, and far surpasses them all in simplicity."

It is thus that Euler begins the memoir, in which he explains with his usual clearness the foundation of the method of his young rival, and the theory of the new calculus, which he called the *calculus of variations*.

To make the motives of this admiration which Euler bestowed with so much frankness better understood, it will not be useless to go back to the origin of the researches of La Grange, such as he stated them himself two days before his death.

The first attempts to determine the *maximum* and *minimum* in all indefinite integral formulæ, were made upon the occasion of the curve of swiftest descent, and the isoperimeters of Bernoulli. Euler had brought them to a general method, in an original work, in which the profoundest knowledge of the calculus is conspicuous. But however ingenious his method was, it had not all the simplicity which one would wish to see in a work of pure analysis. The author admitted this himself. He allowed the necessity of a demonstration independent of geometry. He appeared to doubt the resources of analysis, and terminated his work by saying, "If my principle be not sufficiently demonstrated, yet as it is conformable to truth, I have no doubt that, by means of a rigid metaphysical explanation, it may be put in the clearest light, and I leave that task to the metaphysicians."

This appeal, to which the metaphysicians paid no attention, was listened to by La Grange, and excited his emulation. In a short time the young man found the solution of which Euler had despaired. *He found it by analysis.* And in giving an account of the way in which he had been led to that discovery, he said expressly, and as it were in answer to Euler's doubt, that he regarded it not as a metaphysical principle, but as a necessary result of the laws of mechanics, as a simple corollary from a more general law, which he afterwards made the foundation of his *Mechanique Analytique.* (See that work, page 189 of the first edition.)

This noble emulation, which excited him to triumph over difficulties considered as insurmountable, and to rectify or complete theories remaining imperfect, appears to have always directed M. la Grange in the choice of his subjects.

D'Alembert had considered it as impossible to subject to calculation the motions of a fluid inclosed in a vessel, unless this vessel had a certain figure. La Grange demonstrates the contrary; except in the case when the fluid divides itself into different masses. But even then we may determine the places where the fluid divides itself into different portions, and ascertain the motion of each as if it were alone.

D'Alembert had thought that in a fluid mass, such as the earth may have been at its origin, it was not necessary for the different beds to be on a level. La Grange shows that the equations of D'Alembert are themselves equations of beds on a level.

In combating D'Alembert with all the delicacy due to a mathematician of his rank, he often employs very beautiful theorems, for which he was indebted to his adversary. D'Alembert on his side added to the researches of La Grange. " Your problem appeared to me so beautiful," says he in a letter to La Grange, " that I have sought for another solution of it. I have found a simpler method of arriving at your elegant formula." These examples, which it would be easy to multiply, prove with what politeness these celebrated rivals corresponded, who, opposing each other without intermission, whether conquerors or conquered, constantly found in their discussion reasons for esteeming each other more, and furnished to their antagonist occasions which might lead them to new triumphs.

The academy of sciences of Paris had proposed, as the subject of a prize, the theory of the libration of the moon. That is to say, they demanded the cause why the moon, in revolving round the earth, always turns the same face to it, some variations excepted, observed by astronomers, and of which Cassini had first explained the phenomena. The point was to calculate all the phenomena, and to deduce them from the principle of universal gravitation. Such a subject was an appeal to the genius of La Grange, an opportunity furnished to apply his analytical principles and discoveries. The attempt of D'Alembert was not disappointed. The memoir of La Grange is one of his finest pieces. We see in it the first developement of his ideas, and the germ of his *Mecanique Analytique*. D'Alembert wrote to him: " I have read with as much pleasure as advantage your excellent paper on the Libration, so worthy of the prize which it obtained."

This success encouraged the academy to propose, as a prize, the theory of the satellites of Jupiter. Euler, Clairaut, and D'Alembert had employed themselves about the problem of three bodies, as connected with the lunar motions. Bailly then applied the theory of Clairaut to the problem of the satellites, and it had led him to very interesting results. But this theory was insufficient. The earth has only one moon while Jupiter has four, which ought continually to act upon each other, and alter their positions in their revolutions. The problem was that of six bodies. La Grange attacked the difficulty and overcame it, demonstrated the cause of the inequalities observed by astronomers, and pointed out some others too feeble to be ascertained by observations. The shortness of the time allowed, and the immensity of the calculations, both analytical and numerical, did not permit him to exhaust the subject entirely in a first memoir. He was sensible of this himself, and promised further results, which his other labours always prevented him from giving. Twenty-four years after, M. La Place took up that difficult theory, and made important discoveries in it, which completed it, and put it in the power of astronomers to banish empiricism from their tables.

About the same time a problem of quite a different kind attracted the attention of M. la Grange. Fermat, one of the greatest mathematicians of his time, had left very remarkable theorems respecting the properties of numbers, which he probably discovered by induction. He had promised the demonstrations of them; but at his death no trace of them could be found. Whether he had suppressed them as insufficient, or from some other cause, cannot now be ascertained. These theorems perhaps may appear more curious than useful. But it is well known that difficulty constitutes a strong attraction for all men, especially for mathematicians. Without such a motive would they have attached so much importance to the problems of the brachystrochonon, of the isoperimeters, and of the orthogonal trajectories? Certainly not. They wished to create the science of calculation, and to perfect methods which could not fail some day of finding useful applications. With this view, they attached themselves to the first question which required new resources. The system of the world discovered by Newton was a most fortunate event for them. Never could the transcendant calculus find a subject more worthy or more rich. Whatever progress is made in it, the first discoverer will always retain his rank. Accordingly, M. la Grange, who cites him often as the greatest genius that ever existed, adds also, " and the most fortunate. We do not find every day a system of the world to establish." It has required 100 years of labours and discoveries to raise the edifice of which Newton laid the foundation. But every thing is ascribed to him, and we suppose him to have traversed the whole country upon which he merely entered.

Many mathematicians doubtless employed themselves on the theorems of Fermat; but none had been successful. Euler alone had penetrated into that difficult road in which M. Legendre and M. Gauss afterwards signalized themselves. M. la Grange, in demonstrating or rectifying some opinions of Euler, resolved a problem which appears to be the key of all the others; and from which he deduced a useful result; namely, the complete resolution of equations of the second degree, with two indeterminates, which must be whole numbers.

This memoir, printed like the preceding, among those of the Turin Academy, is notwithstanding dated Berlin, the 20th September 1768. This date points out to us one of the few events which render the life of La Grange, not entirely a detail of his writings.

His stay at Turin was not agreeable to him. He saw no person there who cultivated the mathematics with success. He was impatient to see the philosophers of Paris, with whom he corresponded. M. de Caraccioli, with whom he lived in the greatest intimacy, was appointed ambassador to London, and was to pass through Paris on his way, where he intended to spend some time. He proposed this journey to M. la Grange, who consented to it with joy, and who was received as he had a right to expect by D'Alembert, Clairaut, Condorcet, Fontaine, Nollet, Marie, and the other philosophers. Falling dangerously ill after a dinner in the Italian style given him by Nollet, he was not able to accompany his friend to London, who had received sudden orders to repair to his post, and who was obliged to leave him in a furnished lodging, under the care of a confidential person charged to provide every thing.

This incident changed his projects. He thought only of returning to Turin. He devoted himself to the mathematics with new ardour, when he understood that the Academy of Berlin was threatened with the loss of Euler, who thought of returning to Petersburgh. D'Alembert speaks of this project of Euler, in a letter to Voltaire, dated the 3d March 1766: "I shall be sorry for it," says he; "he is a man by no means amusing, but a very great mathematician." It was of little consequence to D'Alembert, whether this man, *by no means amusing*, went seven degrees nearer the pole. He could read the works of the great mathematician as well in the Petersburgh Memoirs as in those of Berlin. What troubled D'Alembert was the fear of seeing himself called upon to fill his place, and the difficulty of giving an answer to offers which he was determined not to accept. Frederick in fact offered him again the place of president of his Academy, which he had kept in reserve for him ever since the death of Maupertuis. D'Alembert suggested the idea of putting La Grange in the place of Euler; and, if we believe the author of the *Secret History of the Court of Berlin*, (vol. ii. p. 414,) Euler had already pointed out La Grange as the only man capable of filling his place. In fact, it was natural that Euler, who wished to obtain permission to leave Berlin, and D'Alembert, who wanted a pretext not to go there, should both of them, without any communication, have cast their eyes on the man who was best fitted to maintain the eclat which the labours of Euler had thrown round the Berlin Academy.

La Grange was pitched upon. He received a pension of 1500 Prussian crowns, about £250, with the title of Director of the Academy for the Physico-mathematical Sciences. We may be surprised that Euler and La Grange, put successively in the place of Maupertuis, received only the half of his salary, which the king offered entire to D'Alembert. The reason is, that this prince, who at his leisure hours cultivated poetry and the arts, had no idea of the sciences, though he considered himself obliged to protect them as a king. He had very little respect for the mathematics, against which he wrote three pages in verse, and sent them to D'Alembert himself, who deferred writing an answer till the termination of the siege of Schweidnitz; because he thought it would be too much to have both Austria and the mathematics on his hands at once. Notwithstanding the prodigious reputation of Euler, we see, from the king's correspondence with Voltaire, that he gave him no other appellation than his *narrow-minded geometer, whose ears were not capable of feeling the delicacy of poetry.* To which Voltaire replies: *We are a small number of adepts who know one another: the rest are profane.* We see that Voltaire, who had written so well in praise of Newton, endeavours in this place to flatter Frederick. He enters out of complaisance into the ideas of this prince, who wished to put at the head of his academy a man who had at least some pretensions to literature. Fearing that a mathematician would not take sufficient interest in the direction of literary labours, and that a man of literature would have been still worse placed at the head of a society composed in part of philosophers, of whose language he was ignorant; on that account he divided the situation, and put two persons in it, that it might be completely filled.

M. la Grange took possession of his situation on the 6th of November 1766. He was well received by the king; but soon perceived that the Germans do not like to see foreigners occupy situations in their country. He applied to the study of their language. He devoted himself entirely to mathematics, and did not find himself in the way of any person, because he demanded nothing; and he soon obliged the Germans to give him their esteem. "The king," said he himself, "treated me well; I thought that he preferred me to Euler, who was something of a devotee, while I took no part in the disputes about worship, and did not contradict the opinion of any one." This prudent reserve, if it deprived him of the advantages of an honourable familiarity, which would have been attended with some inconveniences, left him the whole of his time for mathematical labours, which hitherto had brought him nothing but compliments the most flattering and the most unanimous. This concert of praises was only once interrupted during the whole of his life.

A French mathematician, who to much sagacity united a still greater degree of selfishness, and scarcely gave himself the trouble to study the works of others, accused M. la Grange of *having gone astray in the new route that he had traced, from not having well understood the theory of it.* He reproached him with *having deceived himself in his assertions and calculations.* La Grange in reply expresses some astonishment at these harsh expressions, to which he was so little accustomed. He expected at least to have seen them founded on some reasons either good or bad; but he discovered nothing of the kind. He shews that the solution proposed by Fontaine was incomplete and illusory in certain respects. Fontaine had boasted that he had taught mathematicians the conditions which render possible the integration of differential equations with three variables. La Grange showed him, by several citations, that these conditions were known to mathematicians long before Fontaine was capable of teaching them. He does not deny that Fontaine discovered these theorems himself; "at least I am persuaded," says he, "that he was as capable of finding them as any person whatever."

It was with this delicacy and moderation that he answered the aggressor. Condorcet, in his *eloge* of Fontaine, is obliged to avow that, on this occasion, his friend deviated from that politeness which ought never to be dispensed with, but which perhaps he thought less necessary with illustrious adversaries, whose glory did not stand in need of these little delicacies. Every one can estimate the value of that apology, especially when applied to a man who, by his own acknowledgment, studied the vanity of others, that he might have an opportunity of wounding it. We must at least acknowledge, that he, who saw himself attacked in that manner when he was in the right, and who knew how to maintain politeness with an adversary who had himself dispensed with it, acquired a double advantage over him, besides victoriously repelling his imprudent attack.

It will not be expected that we should follow M. la Grange in the important researches with which he filled the Berlin Memoirs; and even some volumes of the Memoirs of the Turin Academy, which was indebted to him for its existence. All the space that can be devoted to this biographical account would not be sufficient even to convey an imperfect idea of the immense series of his labours, which have given so much value to the Memoirs of the Berlin Academy, while it had the inestimable advantage of being directed by M. la Grange. Some of these Memoirs are of such extent and importance, that they might pass for a great separate work, yet they constitute a part only of what these twenty years enabled him to produce. He had composed his *Mecanique Analytique*, but he wanted to have it printed at Paris, where he expected that his formulæ would be given with more care and fidelity. On the other hand, it was running too great a risk to intrust the manuscript into the hands of a traveller, who might not be aware of the whole of its value. M. la Grange made a copy of it, which M. Duchatelet undertook to deliver to the Abbé Marie, with whom he was intimately connected. Marie fulfilled with honour the confidence placed in him. His first care was to find a bookseller who would undertake to publish it; and, what it will be difficult to believe at this time, he could not find one. The newer the methods in it were, and the more sublime the theory, the fewer readers would be found capable of appreciating it; hence, without entertaining any doubts of the merit of the work, the booksellers were excusable in hesitating to print a book, the sale of which would probably be confined to a small number of mathematicians, disseminated through Europe. Desain, who was the most enterprising of all those to whom application was made, would not undertake to publish it, till Marie entered into a formal engagement to take all the copies of the edition which were not sold by a given time. To this first service, Marie added another, of which M. la Grange was not less sensible; he procured him an editor worthy of superintending the publication of such a work. M. Legendre devoted the whole of his time to the troublesome task of correcting the press, and was repaid by the sentiment of veneration for the author with which he was penetrated; and by the thanks which he received from him in a letter which I have had in my possession, and which M. la Grange had filled with expressions of his esteem and his gratitude.

The book was not yet published when the author came to settle in Paris. Several causes determined him to take this step; but we must not give credit to all that have been stated. The death of Frederick had occasioned great changes in Prussia, and still greater were to be apprehended. Philosophers were no longer so much respected as formerly. It was natural for M. la Grange again to feel that desire which had formerly conducted him to Paris. These causes, together with the publication of the *Mecanique Analytique*, were sufficient. It is not necessary to add other causes, which several publications that made their appearance in Germany, and particularly the anonymous historian of the court of Berlin, have noticed. We never, during a residence of 25 years in France, heard M. la Grange prefer the slightest complaint against the minister, who is accused in that publication of having disgusted him by a treatment full of haughtiness and contempt, which, out of respect for himself, it was impossible for M. la Grange to overlook. We might suspect that M. la Grange had sufficient generosity to forget or pardon bad treatment, which he punished in the only way worthy of himself, by leaving the country where his merit was overlooked; but when he was directly questioned on that subject by a member of the Institute, (M. Burckhardt,) he only gave negative answers, and assigned no other motives than the misfortunes which it was thought were about to fall upon Prussia. M. de Hertzberg was dead, and M. de la Grange, a senator and count of the French empire, could have no interest in concealing the truth. Hence we must consider his own statement as affording the only true reasons.

The historian, therefore, whom we have quoted, has been ill informed. But the spirit of calumny and satire, which has so justly rendered his work suspected, ought not to prevent us from extracting from it the lines in which he explains, with that energy which is peculiarly his own, his opinion, which is that of all Europe, when he does justice to M. la Grange.

"I think," says he, (*Hist. Sec. de la Cour de Berlin*, 1789, tom. ii. page 173,) "that there is at this moment an acquisition worthy of the king of France, the illustrious La Grange, the greatest mathematician who has appeared since Newton, and who in every point of view is the man that has the most astonished me;—La Grange, the wisest, and perhaps the only practical philosopher that ever existed, meritorious by his undisturbable wisdom, his manners, his conduct; the object of the most tender respect of the small number of men with whom he associates:—La Grange is misunderstood; every thing leads him to leave a country where nothing can excuse the crime of being a foreigner, and where in fact he is merely tolerated. Prince Cardito de Laffredo, Neapolitan minister at Copenhagen, offered him the most flattering conditions on the part of his sovereign. The Grand Duke, the king of Sardinia, invited him eagerly; but all their proposals would be easily obliterated by ours. I am very eager to see this proposal made, because I consider it as noble, and because I tenderly love the man who is the object of it. I have induced M. la Grange not to accept immediately the proposals made to him, and to wait till he receives ours."

The author whom we quote appears to fear the opposition of M. Breteuil; but, according to M. la Grange himself, it was the Abbé Marie who proposed it to M. Breteuil, who on all occasions anticipated the desires of the Academy of Sciences, presented the demand to Louis XVI. and induced him to agree to it.

The successor of Frederick, although he did not much interest himself in the sciences, made some difficulty in allowing a philosopher to depart whom his predecessor had invited, and whom he honoured with his particular esteem. After some delay, M. la Grange obtained liberty to depart. It was stipulated that he should still give some memoirs to the Berlin Academy. The volumes of 1792, 1793, and 1803, show that he faithfully kept his promise.

It was in 1787, that M. la Grange came to Paris to take his seat in the Academy of Sciences, of which he had been a foreign member for fifteen years. To give him the right of voting in all their deliberations, this title was changed into that of *veteran pensionary*. His new associates shewed themselves happy and proud in possessing him. The queen treated him with regard, and considered him as a German. He had been recommended to her from Vienna. He obtained a lodging in the Louvre, where he lived happy till the Revolution.

The satisfaction which he enjoyed did not show itself outwardly. Always affable and kind when interrogated, he himself spoke but little, and appeared absent and melancholy. Often in companies which must have been suitable to his taste, among the most distinguished men of all countries who met at the house of the illustrious Lavoisier, I have seen him dreaming, as it were, with his head against a window, where however nothing attracted his attention. He remained a stranger to what was passing around him. He acknowledged himself that his enthusiasm was gone, that he had lost his taste for mathematics. When informed that a mathematician was employed at such a task, "so much the better," he would say; "I had begun it, now it will be unnecessary for me to finish it." But he merely chan-

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ged the object of his studies. Metaphysics, the history of human nature, that of different religions, the general theory of languages, medicine, botany, divided his leisure hours. When the conversation turned upon subjects with which it was supposed he was unacquainted, we were struck by an unexpected observation, a fine thought, a profound view, which excited long reflections. Surrounded by chemists who were reforming the theory and even the language of the science, he made himself acquainted with their discoveries, which gave to facts formerly isolated that connection which distinguishes the different parts of mathematics. He undertook to make himself acquainted with this branch of knowledge, which formerly appeared to him so obscure, but which he found on trial *as easy as algebra.* People have been surprised at this comparison, and have thought that it could come from no one else than La Grange. It appears to us as simple as just; but it must be taken in its true sense. Algebra, which presents so many insoluble problems, so many difficulties against which La Grange himself struggled in vain, could not in that sense appear to him an easy study. But he compares the new elements of chemistry with those of algebra. They constituted a body, they were intelligible, they offered more certainty; they resembled algebra, which in the part of it that is complete presents nothing difficult to conceive, no truth to which we may not arrive by the most palpable reasoning. The commencement of the science of chemistry appeared to him to offer the same advantages, perhaps with somewhat less stability and certainty; but, like algebra, it has no doubt also its difficulties, its paradoxes, which will require to explain them, much sagacity, reflection, and time. It has likewise its problems which never will be resolved.

In this philosophic repose he continued till the Revolution, without adding any thing to his mathematical discoveries, or even opening his *Mecanique Analytique,* which had been published for two years.

The Revolution gave philosophers an opportunity of making a great and difficult innovation; the establishment of a system of weights and measures founded on nature, and perfectly analogous to our scale of numbers. La Grange was one of the commissioners whom the Academy charged with that task. He was one of its keenest promoters. He wished to see the decimal system in all its purity. He was provoked at the complaisance of Borda, who got quarters of the *metre* made. He thought the objection of little importance which was drawn against the system from the small number of divisors that its base afforded. He regretted that it was not a prime number, as 11, which would have given the same denominator to all the fractions. This idea perhaps will be regarded as one of those exaggerations, which are hazarded by men of the best understandings, in the heat of dispute. But he mentioned the number 11 merely to get rid of the number 12, which more intrepid innovators would have wished to substitute in place of the number 10, that constitutes the base of the whole of our numeration.

When the Academy was suppressed, the commission charged with the establishment of the new system was retained for a time. Three months had scarcely elapsed when, in order to purify that commission, the names of Lavoisier, Borda, La Place, Coulomb, Brisson, and Delambre, were struck out. La Grange was retained. In quality of president, he informed me, in a long letter full of kindness, that I should receive official information of my removal. As soon as he saw me on my return to Paris, he expressed to me his regret at the dismissal of so many associates. "I do not know," said he, "why they have retained me." But unless the suppression had been total, it could scarcely have extended to him. The more losses the commission had sustained, of the more importance was it not to deprive it of the consideration attached to the name of La Grange. Besides, he was known to be wholly devoted to the sciences; he had no place either in the civil department or the administration. The moderation of his character had prevented him from expressing what he could not but think in secret; but I shall never forget the conversation which I had with him at that period. It was the day after the atrocious and absurd sentence, contrary to every thing like justice, had thrown all lovers of the sciences into mourning, by cutting off the most illustrious philosopher in Europe. "It has cost them but a moment," said he, "to cut off that head, and a hundred years perhaps will not be sufficient to produce another like it." Some months before we had had a similar conversation in the cabinet of Lavoisier, on account of the death of the unfortunate Bailly. We lamented together the dreadful consequences of the dangerous experiment which the French had attempted. All these chimerical projects of amelioration appeared to him very equivocal proofs of the greatness of the human mind. "If you wish to see it truly great," added he, "enter into the cabinet of Newton employed in decomposing light, or in explaining the system of the world."

Already for some time he had regretted not having listened to the advice of his friends, who at the commencement of our troubles had recommended him to seek an asylum, which it would have been so easy for him to find. As long as the revolution seemed only to threaten the pension which he enjoyed in France, he had neglected that consideration, out of curiosity to be upon the spot of one of those great convulsions which it is always more prudent to observe at a distance. "It was your own choice," said he several times to himself when he entrusted me with his regret. It was to no purpose that a special decree of the Constituent Assembly had ensured the payment of his pension. The decree was of no value, because the depreciation of the paper currency was sufficient to render it illusory. He had been named member of the *Board of Consultation,* appointed to examine and reward useful inventions. He had been appointed one of the administrators of the Mint. This commission offered him few objects to fix his attention, and could in no degree remove his apprehensions. It was again proposed to draw him to Berlin, and to restore him to his former situation. He had agreed to the proposal. Herault de Sechelles, to whom he had applied for a passport, offered him, for the greater security, a mission to Prussia. Madame La Grange would not consent to quit her country. This repugnance, which at that time he considered as a misfortune, was to him a source of fortune and of new glory.

The Normal School, of which he was named professor, but which had only an ephemeral existence, scarcely gave him time to explain his ideas respecting the foundation of arithmetic and algebra, and their application to geometry.

The Polytechnic School, the result of a happier idea, had likewise a more durable success: and among the best effects which it produced, we may place that of having restored La Grange to Analysis. It was there that he had an opportunity of developing those ideas, the germ of which was to be found in two memoirs that he had published in 1772, and the object of which was to explain the true metaphysics of the differential and integral calculus. To render these happy developements more easily understood, the professor associated himself with his pupils. It was then that he composed his Analytical Functions, and his Lectures on that Calculus, of which he published several editions.

It was then likewise that he published his treatise on the numerical solution of equations, with notes on several points of the theory of algebraic equations.

It is said that Archimedes, whose great reputation, at least with the historians, is founded upon the machines of all kinds, by means of which he retarded the taking of Syracuse, despised these mechanical inventions, on which he wrote nothing, and placed importance only in his works of pure theory. We may sometimes conceive, that the great mathematicians of our age entertained the same sentiments with Archimedes. They consider a problem as solved when it presents no analytical difficulty, when nothing remains to be done but differentiations, substitutions, and reductions, operations which require merely patience, and a certain dexterity derived from practice. Satisfied with having removed all the real difficulties, they concern themselves perhaps too little with the embarrassments which they leave to the calculator, and with the long labour necessary in order to make use of their formula, even after it has been suitably reduced. M. la Grange had more than once attempted to abridge the usual calculations.

The general resolution of algebraic equations is subject to difficulties which are considered as insurmountable; but in practice every determinate problem brings us to an equation, all the co-efficients of which are given in numbers. It would be sufficient, therefore, to have a sure method of finding all the roots of such an equation, which is called *numerical*. This was the object which M. la Grange proposed to himself. He analyses all the known methods, and shews their uncertainty and insufficiency. He reduces the problem to the determination of a quantity smaller than the smallest difference between the roots. This is something. We cannot too much admire the analytical skill displayed throughout the whole work. But notwithstanding all the resources of the genius of M. la Grange, we cannot conceal that the labour of his method is exceedingly great, and calculators will doubtless continue to prefer methods less direct indeed, but more expeditious. The author resumed this subject no less than four times. It is to be feared, that a commodious and general solution will never be discovered, or at least it must be sought for by other means. The author seems to have acknowledged this himself, as he recommends the method of M. Budan as the most convenient and elegant for resolving equations whose roots are all real.

The desire of multiplying useful applications induced him to undertake a new edition of the *Mecanique Analytique.* His project was to develope the most useful parts of it. He laboured at it with all the ardour and intellectual power which he could have applied at any period of his life. But this application occasioned a degree of fatigue, which threw him into a fainting fit. He was found in that state by Madame La Grange. His head in falling had struck against the corner of a table, and this shock had not restored him to his senses. This was a warning to take more care of himself. He thought so at first; but he was too anxious to finish his work. The first volume had appeared some time before his death. It had been followed by a new edition of his *Fonctions Analytiques.* So much labour exhausted him. Towards the end of March a fever came on, he lost his appetite, his sleep was uneasy, and his waking was accompanied by alarming swoonings. He perceived his danger; but, preserving his undisturbable serenity, he studied what passed within him, and, as if he were assisting at a great and uncommon experiment, he bestowed all his attention on it. His remarks have not been lost. Friendship conducted to his house on the 8th of April, in the morning, MM. Lacepede, Monge, and Chaptal, who took care to write down the principal points of a conversation which was his last. (We have scrupulously followed these notes, and the passages under inverted commas are faithfully copied from the manuscript of M. Chaptal.)

"He received them with tenderness and cordiality. I was very ill, my friends, (said he,) the day before yesterday; I perceived myself dying, my body became weaker, my moral and physical powers were gradually declining; I observed with pleasure the gradual diminution of my strength, and I arrived at the point without pain, without regret, and by a very gentle declivity. Death is not to be feared, and when it comes without violence, it is a last function, which is neither painful nor disagreeable." Then he explained to them his ideas respecting life, the seat of which he considered as spread over the whole body, in every organ and all parts of the machine, which in his case became equally feebler in every part by the same degrees. "A little longer, and there would have been no functions, death would have overspread the whole body, for death is merely the absolute repose of the body; I wished to die," added he with greater force, "I found a pleasure in it; but my wife did not wish it. I should have preferred at that time a wife less kind, less eager to restore my strength, and who would have allowed me gently to have finished my career. I have performed my task, I have acquired some celebrity in the mathematics, I have hated nobody, I have done no ill; it is now proper to finish."

As he was very animated, especially at these last words, his friends, notwithstanding the interest with which they listened to him, proposed to retire. He retained them, began to relate to them the history of his life, of his labours, of his success, of his residence at Berlin, where he had often told us what he had seen near a king; of his arrival at Paris, the tranquillity he had enjoyed at first, the anxiety occasioned to him by the Revolution, and how he had been finally rewarded by a powerful monarch, capable of appreciating his worth.

He had neither been ambitious of riches nor honour; but he had received both with respectful gratitude, and rejoiced at the acquisition for the advantage of the sciences.

La Grange had not lost all hope of cure; he believed only that his convalescence would be tedious. He offered, when he recovered his strength, to go and dine at M. Lacepede's country house with MM. Monge and Chaptal, and proposed to give them details respecting his life, which could be found nowhere else. These details are irretrievably lost. We do not even know to what he alluded, nor what he could have added to the second volume of the *Mecanique Analytique*, which was then in the press. We have just learned that the Countess la Grange has put into the hands of M. Prony the complete manuscript of the second volume, in which will be found important additions, and sections entirely written anew. By the care of an editor so skilful, and so devoted to the memory of the author, the philosophical world is sure of obtaining with the greatest ac-

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curacy and dispatch what is wanting to complete the work, and perhaps even memoirs entirely new.

"During this conversation, which lasted more than two hours, his memory often failed him; he made vain efforts to recover names and dates, but his discourse was always connected, full of strong thoughts and bold expressions." This exercise of his faculties wasted the whole remains of his strength. Scarcely had his friends left him, when he fell into a fainting fit, and he died two days after, on the 10th of April, 1813, at three quarters past nine o'clock in the morning.*

M. la Grange was of a delicate but good complexion. His tranquillity, his moderation, an austere and frugal regimen from which he rarely deviated, prolonged his life to the age of 77 years, two months, and ten days. He was twice married: first at Berlin, in order to be on a footing with the rest of the academicians, none of whom were bachelors. He brought from Turin one of his relations. He married her, and lost her after a long illness, during which he had bestowed on her the most tender and unremitted care. When he afterwards married, in France, Mademoiselle Lemonnier, daughter of the celebrated astronomer of that name, he said to us, "I had no children by my first marriage; I do not know if I shall have them by my second; but I scarcely desire them." What he principally wished was an amiable companion, whose society might afford him some amusement during the intervals of his studies, and in this respect he was very successful. Madame la Grange, daughter, grandaughter, and niece, of members of the Academy of Sciences, was deserving of the name which he gave her. This advantage in her eyes making up for the difference of their ages, she soon felt for him the tenderest regard. He was so grateful that he could scarcely bear to be separated from her, and it was on her account alone that he felt any regret at relinquishing this life; and he was often heard to say, that of all his good fortune, that which he prized the most was having obtained a companion so tender and attached to him. During the ten days that his illness lasted, she never quitted him for a moment, and was constantly employed in recruiting his strength and prolonging his existence.

He loved retirement; but did not insist upon his young wife following his example. On her account he went out more frequently, and indeed his high situations obliged him to show himself in the world. It was often apparent that he continued the meditations in public which he had begun in his cabinet. It has been said that he was not insensible to the charms of music. In fact, in a numerous company he was not displeased at a concert. On one of those occasions I asked him what he thought of the music: "I love it," says he, "because it leaves me to myself. I listen to it during the first three measures, but I hear no more of it; I give myself up to reflection, nothing interrupts me, and in this way I have solved many a difficult problem." Hence the finest music must have been that during which he was inspired with the finest of his thoughts.

Though he had a venerable figure, he would never allow his portrait to be drawn. More than once, by a very excusable piece of address, persons have been introduced during the meeting of the Institute, to take a sketch of him without his knowledge. An artist sent by the Academy of Turin drew in this manner the outline from which was constructed the bust that was exhibited for some months in the hall of the Institute, and is at present in the library. A cast was taken of him after his death; and some time before, while he slept, a picture of him was taken, which is said to resemble him very much.

Gentle and even timid in conversation, he took a pleasure in asking questions, either to draw out others, or to add their reflections to his own vast knowledge. When he spoke, it was always in a tone of doubt, and his first words usually were, *I do not know.* He respected the opinions of others, and was very far from laying down his own as a rule. Yet it was not easy to make him change them. Sometimes he even defended them with a degree of heat, which continued to increase till he was sensible of some alteration in himself; then he immediately resumed his usual tranquillity. One day, after a discussion of this kind, M. la Grange having left the room, Borda remaining alone with me, allowed these words to escape him: "I am sorry to say it of a man like M. la Grange, but I do not know a more obstinate person." If Borda had gone away first, La Grange might have said to me as much of our associate, who was a man of excellent sense and considerable wit; but who, like La Grange, did not easily abandon those opinions which he had adopted after a mature examination.

A gentle and good-natured irony was often remarkable in the tone of his voice; but I never saw any person hurt at it; because it was necessary to have well understood every thing that went before to perceive the true intention of it.

Among all the master-pieces which we owe to his genius, his *Mecanique* is certainly the most remarkable and the most important. The *Fonctions Analytiques* hold only the second place, notwithstanding the fruitfulness of the principal idea, and the beauty of the developements. A notation less commodious, and calculations more embarrassing, though more luminous, will prevent mathematicians from employing, except in certain difficult and doubtful cases, his symbols and names. It is sufficient that he has proved the legitimacy of the more expeditious processes of the differential and integral calculus. He has himself followed the ordinary notation in the second edition of his *Mecanique.*

This great work is entirely founded on the calculus of variations, of which he was the inventor. The whole flows from a single formula, and from a principle known before his time; but the whole utility of which was far from suspected. This sublime composition includes all his other preceding labours which could be connected with it. It is distinguished likewise by the philosophical spirit which reigns from one end of it to the other. It is likewise the best history of that part

* The body of La Grange was deposited in the Pantheon, beside those of a number of unknown senators. We copied the following inscription from his stone tomb.

Joseph Louis La Grange
Senateur, Comté de L'Empire
Grand Officier de la Legion d'Honneur,
Grand Croix de L'Ordre Imperial de la Reunion.
Membre de L'Institut, et de Bureau des Longitudes
Né à Turin Departement du Po, le xxv Janvier 1736,
Decedé a Paris le x Avril 1813. ED.

of the science,—a history which could only have been written by a man perfectly master of his subject, and superior to all his predecessors, whose works he analyses. It forms a most interesting piece of reading, even to him who is not capable of appreciating all the details. Such a reader will at least find the intimate connection of all the principles on which the greatest mathematicians have founded their researches into mechanics. He will there see the geometrical law of the celestial motions deduced from simple mechanical and analytical considerations. From these problems, which serve to calculate the true system of the world, the author passes to questions more difficult, more complicated, and which belong to another order of things. These researches are only objects of pure curiosity, as the author announces, but they show the extent of his resources. Finally, we see there his new theory of the variations of arbitrary constant quantities of the motion of the planets, which had appeared with so much eclat in the *Memoirs of the Institute*, where it had shown that the author, at the age of 75, had not sunk from the rank which he had filled for so long a time in the opinion of all mathematicians."

GRANGEMOUTH. See Borrowstoness and Stirlingshire.

GRANITE. See Mineralogy.

GRANSON, or Grandson, is the name of a small town in the canton of the Pays de Vaud. It is situated on the western bank of the lake of Neufchatel, about a mile from the foot of Mount Jura, which here bears the name of Thevenon. In approaching this town from Yverdun, it appears finely situated above the lake, and is particularly distinguished by its lofty chateau crowned with five or six towers. At the entrance to the town there is an old church, which does not appear to be used. The road passes through an arch surmounted with a tower and spire. The number of houses in 1814, when we passed through it, was 100. The opposite bank of the lake of Neufchatel is a lofty ridge finely wooded, with the grand range of the eastern Alps towering above it.

Granson is celebrated in the history of Switzerland, for the great battle which the Swiss gained over Charles the Bold, Duke of Burgundy, on the 3d of March 1476. The Duke's army, which was 6000 strong, occupied Granson, and the villages of Poissine, Corsalette, Giez, Vallieres, and Tuileries, and was defended on the right by the lake, and on the left by Mount Arnou, and on the east by the Thevenon, and by entrenchments on every other point. The battle began near Concise and the Chartreuse of Lalance, and terminated in the complete defeat of the Duke of Burgundy, who lost all his baggage and jewels. One of his diamonds, which was the largest then known, was found by a Swiss soldier, and sold for a florin to the curate of Montagny. This diamond was afterwards sold to Pope Julius II. for 20,000 ducats. Other two diamonds were found by the Swiss, one of which now forms part of the imperial treasury of Vienna, and the other belongs to the crown of France.

GRANTHAM, a town of England in Lincolnshire, is situated on the river Witham, near the ancient Roman road, called Ermine Street. The town, which is neat and clean, and contains many excellent houses, consists of four principal streets, called Westgate, Watergate, Castlegate, and Swinegate. The church, which is elegantly built of stone, consists of a nave, with spacious north and south aisles. It is lighted with handsome painted windows, and has been celebrated for the elegance of its spire, which consists of a quadrangular tower, containing three stories. At each angle of the parapet is an hexangular crocketted pinnacle, over which rises an octagonal spire, ornamented with crockets in the angles, and at these several distances encircled with windows having triangular heads. The height of the tower to the battlements is 135 feet, and from that to the top of the vane 138, making a total height of 273 feet. The nave, including the chancel and side aisles, is 116 feet long inside, and 80 feet broad. The church contains several handsome marble monuments. The front, which is octangular, is deemed a handsome specimen of ancient sculpture. The crypt under the aisle is used as a charnel-house, which contains great numbers of bleached sculls and bones. The vestry has been fitted up to receive the library of the Rev. Dr Newcome, a native of Grantham, who bequeathed it for the use of the town and neighbourhood.

The guildhall was rebuilt in 1787, and contains a large apartment for an assembly-room. The free-school was founded by Richard Fox, Bishop of Winchester, and in the present school-house Sir Isaac Newton studied the classics for several years. Without the Spittlegate is the Grantham Spa, a mild chalybeate, containing a small portion of aërated iron.

A canal has some time ago been cut from Grantham to the river Trent, a distance of 30 miles, with a fall of 148 feet to the river Trent. In 1798, £114,734 had been expended on the undertaking, and the tonnage then amounted to £4381. Corn and coals are the principal articles which it conveys. There is a race-course in the neighbourhood of Grantham, where races are held annually.

The following is the population of the borough and parish, according to the census of 1811.

Number of inhabited houses	673
Do. of families	776
Do. employed in agriculture	61
Do. in trade and manufactures	430
Males	1677
Females	1969
Total population	3646

See *Beauties of England aad Wales*, vol. ix. p. 766.

GRANTOWN. See Morayshire.

GRAPHOMETER, is a name sometimes given to instruments similar to goniometers, or to particular modifications of the theodolite. See Goniometer.

GRATZ, or Graz, is the name of an ancient town in the duchy of Styria, situated on the river Muehre. The town of Gratz is well built, the streets spacious and well laid out, and the houses, which are almost all of stone, are neat and commodious. The town, properly so called, is very small, and is surrounded with walls, ditches, and fortifications; but the suburbs are very large, and have lately increased with rapidity. The suburbs lie round the town like distinct villages, and are intermingled with gardens and vineyards. The citadel is situated within the town, on a very steep hill, about 600 or 700 feet above the level of the river, and has a well communicating with the Muehre. It was once a place of considerable strength; but it has been so much neglected, that in the year 1797, it offered no resistance upon the approach of the French. One of the principal objects of interest at Gratz is the imperial mausoleum of Ferdinand II. who was born in this town in 1578. The architecture is not in the best style; but its interior is richly ornamented with sculpture. The life of the Emperor Leopold is represented on the roof, in several emblematic paintings. On the top of the mausoleum is an observatory, which was once well furnished with astronomical instruments. The emperor's second son John Charles, and Mary Anne, Duchess of Bavaria, his consort, are buried along with Ferdinand in the circular chapel in the lower part of the mausoleum.

The assembly-room and the theatre, which are both under one roof, form a very extensive building. The arsenal, the house of the states, and the private residences of the Count Sauran, Loibel, and Wermbrand, are the other buildings deserving of notice. The castle, which was formerly the residence of the Dukes of Styria, is now the dwelling of the governors, and the seat of the regency. The house in which Bonaparte resided is very spacious, and is now shown as one of the curiosities of the town. Gratz is the see of a bishop, who generally resides at it about eight months in the year.

At no great distance from the town are several handsome villages, and the intermediate space between them and the suburbs is covered by country houses, large and small, farm houses, and detached cottages, so that the whole of this tract, when seen from the citadel, forms a rich and pleasing picture, and not only occupies a plain of above 18 square miles, but encroaches even upon the neighbouring hills. These hills are of a moderate height, and are partly covered with wood, and partly occupied with fields, vineyards, and meadows, up to their very summits. The population of Gratz has been stated in some statistical tables at 40,000; but it probably does not exceed 33,000. The population of the circle of Gratz, one of the five circles of Styria, is 296,424. East Longitude, according to accurate observations, 15° 27′ 15″, North Latitude 47° 4′ 9″. See STYRIA.

GRASSES. See AGRICULTURE *Index*.

GRAVE-HARMONICS, in Music. See HARMONICS, *Grave* and *Acute*.

GRAVE *Intervals*, according to Maxwell and Liston, are such as are lessened by the major comma; they are marked with the grave accent (\`), and are usually called by us, *Comma-deficient* intervals.

The GRAVE *Diesis* of Liston, $\mathcal{E}' = \mathcal{E} - c = 10\,\Sigma + m$, is the *Minor* COMMA, which see.

The GRAVE *Limma* of Liston, $\mathcal{S}' = \mathcal{S} - c, = 36\,\Sigma + f + 3\,m$, is the SEMITONE *Minor*, which see.

The GRAVE *Tone* of Liston, (p. 14.) $T' = T - c, = 93\,\Sigma + 2\,f + 8\,m$, is the TONE *Minor*, which see.

GRAVE *Fourth* of Holden, or bearing fourth, has the ratio $\frac{16}{21}$, $= 240.06077\,\Sigma + 5\,f + 20\,m$; and is the *Lesser false* FOURTH of the trumpet, which see.

GRAVE *Semitone* of Holden, or deficient semitone of the same author, (p. 341.) has the ratio $\frac{20}{21}$, $= 43.052904\Sigma + f + 4m$; its common log. $= .9788107,0093$; it is $+ 43.234017 \times \Sigma, = 3.92754 \times c, = .070389 \times$ VIII. M. Feyton mentions it as his *Semitone* E E※, and it is the *Semitone* of Ptolemy's Diatonicum molle.

GRAVEL. See MEDICINE.

GRAVER. See ENGRAVING.

GRAVESEND, is a town of England, in the county of Kent, built on a gentle declivity, on the banks of the Thames. It consists of several narrow streets, the best of which are the one on the great London road, and another at right angles to it, leading to the river. The church, which is dedicated to St George, was erected near the river between 1731 and 1733. It is built of brick, with stone quoins and cornices, and consists of a spacious nave and chancel, &c. The town-hall was erected in 1764, and has a poultry market below it. It is supported by six columns in front, and three arches behind. A neat little theatre, with a brick front and wooden sides, and a small projecting wooden portico, surmounted by a bust of Shakespeare, was built in 1808; and a handsome chapel in 1812, on the north side of the London road. A new wharf and crane were erected in 1767, and two batteries of 16 guns each have more recently been built, for the defence of the town. There is here a small manufactory for cables and ropes, and a yard for ship-building. Most of the outward bound ships are supplied with live and dead stock at Gravesend, and also with vegetables, for the cultivation of which about 80 acres of ground are appropriated. The town is often crowded with seamen and strangers, from the great quantity of shipping that usually lie at anchor in the channel near the town; and in summer many visitors are attracted by the accommodations of a new bathing-house, which was built by subscription in 1796. About 18 or 20 Gravesend smacks are employed in the cod and haddock fishing.

According to the population return for 1811, Gravesend parish contains

Number of inhabited houses . . .	525
Number of families	698
Do. employed in agriculture . . .	83
Do. in trade and manufactures . . .	457
Number of males	1505
Do. females	1614
Total population	3119

See *Beauties of England and Wales*, vol. vii. p. 577.

GRAVIMETER. See HYDROMETER.

GRAVITATION. See ASTRONOMY, p. 599; Chapters I. II. III. IV. V. of *Physical* ASTRONOMY; and also the articles ATTRACTION and NEWTON.

GRAVITY, SPECIFIC. See HYDRODYNAMICS and SPECIFIC *Gravity*.

GRAY, THOMAS, an eminent English poet, was born at Cornhill in London, on the 20th of December 1716. His father, Philip Gray, was a money scrivener of the city. His mother, whose maiden name was Dorothy Antrobus, was, owing to the bad usage of her husband, obliged to apply to an eminent civilian for his advice as to a separation from him. Our poet, their fifth child, owed his life to the affectionate courage of his mother, who, by opening a vein with her own hand, removed a paroxysm which attacked him in his childhood. To this parent's exertions he was also indebted for his education; so that, considering the unhappiness of her life, and the gratitude which her son owed her, we can easily conceive the truth of what Mason tells us, that Gray always mentioned his mother's name with a sigh. Gray was educated at Eton, under the protection of Mr Antrobus, his maternal uncle, who was a fellow of Peterhouse, Cambridge. At that university, Gray was admitted a pensioner in his 19th year. During his first four year's residence there, he seems to have withdrawn himself from the severity of mathematical studies, while his enquiries centered in classical and modern literature.*

In 1738, he removed to the Inner Temple; but laid aside his legal studies to accompany Horace Walpole on a tour through France and Italy. An unhappy difference, however, with the blame of which Walpole has

* His productions during that period, were some Latin verses, entitled *Luna Habitabilis*, inserted in the *Musæ Etonenses*; a poem on the marriage of the Prince of Wales; and a Sapphic Ode to his friend West, both in Latin. A Latin version of a passage the *Pastor Fido*, and Fragments of Translations from Italius and Tasso.

candidly charged himself, parted the travellers at Reggio, and their broken friendship, in spite of a formal reconciliation, seems never to have been entirely cemented. Gray returned to London in 1741, in the same year in which his father died. His mother, with a very small fortune, had retired to live with her sister at Stoke, near Windsor. Mr Gray, therefore, found his patrimony too small to enable him to prosecute the study of the law; and though his mother and aunt would undoubtedly have contributed all in their power to assist him, he could not brook the idea of becoming a burthen to them. Yet such was his delicacy, that he could not peremptorily declare to his relations his resolution of abandoning his profession: he therefore pretended only to change the line of it, and accordingly he went to Cambridge, where he took a bachelor's degree in civil law. In the same year in which he graduated, (1742,) he lost his friend West, with whom his friendship had commenced at Eton, and had continued with unabated warmth after they had gone to different universities. The sorrow which the death of this amiable young man left upon our poet's mind, and the tenderness with which he honoured his memory, form one of the most interesting traits of his character. *

On his second return to Cambridge, he applied himself for about six years with the most intense assiduity to the perusal of Greek authors, and made himself a consummate scholar and critic in that language. In 1747, he appeared for the first time as an author, by the publication of his Ode on the prospect of Eton College, of which it would seem that at first little notice was taken. His Ode to Spring had been already written at Cambridge; and soon after the publication just mentioned, he sent to Dr Wharton of Durham, his poem on the Alliance of Education and Government, which he never pursued much farther. In 1749, he finished his Elegy, which he had begun seven years before, and which when published obtained immediate popularity.

In 1754 and 1755, he appears to have written his beautiful lines on the Pleasures arising from Vicissitude, his Ode on the Progress of Poetry, the Bard, and probably some of those fragments with which he seems to have amused himself, without much design of completion. About this period, he complains of listlessness and depression of spirits, which prevented his application to poetry; and from this time we may trace the course of that hereditary disease in his constitution, which the temperance and regularity of a whole life could not subdue. Next year, he left Peterhouse at Cambridge, where he had resided above twenty years, on account of some incivilities which he met with, and which Mason thus mentions. Two or three young men of fortune, who lived on the same staircase, had for some time intentionally disturbed him with their riots, and carried their ill behaviour so far as to awaken him at midnight. After having borne a considerable time with their insults, Gray complained to the governing part of the Society, and not thinking that his remonstrance was sufficiently attended to, quitted the College. He now removed to Pembroke Hall, which he describes "as an era in a life so barren in events as his."

In the July of 1757, he took his Odes to London to be published. "I found Gray (says H. Walpole) in town last week. He brought his two Odes to be printed. I snatched them out of Dodsley's hands, and they are to be the first fruits of my press." Although the genius of Gray was now in its firm and mature age, and though his poetical reputation was deservedly high, it is plain that these Odes were not favourably received. "His friends (he says) write to him that they do not succeed." Yet there were some better judges who admired them. Garrick wrote lines in their praise; and Warburton, while he bestowed his honest applause on them, shewed his indignation at those who condemned without being able to understand them. In this year Cibber died, and the laureatship was offered by the Duke of Devonshire, then Lord Chamberlain, to Gray, with a remarkable and honourable privilege to hold it as a mere sinecure. This offer he respectfully declined; and in a letter to Mr Mason, he gives some of his reasons for declining it. "The office itself (he says) has always humbled the possessor hitherto:—if he were a poor writer, by making him more conspicuous; and if he were a good one, by setting him at war with the little fry of his own profession: for there are poets little enough even to envy a poet laureat." In 1758, Gray describes himself "as composing for his own amusement the little book, which he calls a Catalogue of the Antiquities, Houses, &c. in England and Wales." † About this time, the study of architecture seems to have employed much of his time, in which his proficiency (as in every branch of study which he pursued) was accurate and deep. Early in the next year the British Museum was opened to the public, and he went to London to read and transcribe the MSS. which were there collected from the Cottonian and Harleian libraries. A folio volume of his transcripts was left among his papers. No other remarkable date occurs in the peaceful tenor of our poet's days, till in 1762, the professorship of modern history being vacant, by the advice of his friends, he applied to Lord Bute for the place through the medium of Sir Henry Erskine. He was refused, and the professorship was given to another; and "so (says Gray) I have made my fortune like Sir Francis Wronghead."

In the summer of 1765, he took a journey into Scotland to improve his health, which was then weak, and to gratify his curiosity with the romantic scenery of the north. He went through Edinburgh and Perth to Glammis castle, the residence of Lord Strathmore, where he stayed some time. Thence he took a short excursion into the Highlands, crossing Perthshire by Loch Tay, and pursuing the road from Dunkeld to Inverness, as far as the pass of Killikrankie. Then returning to Dunkeld, he travelled on the Stirling road to Edinburgh. In Scotland, his general shyness to men of letters was felt and complained of; but he formed an acquaintance with Dr Beattie, which was kept up by subsequent correspondence. The university of Aberdeen was disposed to confer on him the degree of Doctor of Laws; but he refused it, lest it should seem a slight to his own university. At Dr Beattie's desire, a new edition of his poems was published by Foulis at Glasgow, whilst Dodsley at the same time was printing them in London. In both these editions the long story was omitted, and some Welch and Norwegian fragments inserted in their place. To his Odes, Gray now found it necessary to add some notes; "partly," he says, "from justice to acknowledge a debt when I had borrowed any thing; partly from ill temper, just to tell the gentle reader, that Edward I. was not Oliver Cromwell, nor Queen Elizabeth the witch of Endor."

* Richard West was the son of the Lord Chancellor of Ireland, and grandson by the mother's side of the famous Bishop Burnet.

† It was printed and distributed among his friends by Mr Mason after his death.

Gray.

In 1768, the professorship of modern history became again vacant, and the Duke of Grafton, then in power, at the request of Mr Stonehewer, bestowed it on Gray. Soon after the Duke of Grafton was elected to the chancellorship of the university, and Gray wrote the Ode, that was set to music, on the occasion of his installation. "He thought it better that gratitude should sing than expectation." When this ceremony was past, he went on a tour to the lakes of Westmorland and Cumberland, from which his letters are written in a style of the most picturesque description. "He that reads his epistolary narrative," says Dr Johnson, "wishes that to travel, and to tell his travels, had been more of his employment."

In the April of 1770, he complains much of a depression of spirits, and talks of an intended tour into Wales, which took place in autumn; but not a single letter is preserved in Mr Mason's book on this journey.

In May 1771, he wrote to his friend Dr Wharton, just sketching the outline of his tour in Wales, and some of the adjacent country. This is the last letter that remains in Mr Mason's collection. He there complains of an incurable cough, of spirits habitually low, and of the uneasiness which the thought of the duties of his profession gave him, which, Mr Mason says, he had now a determined resolution to resign.* He mentions also different plans of amusement and travel which he had projected, but which unfortunately were not to be accomplished. Within a few days after the date of this letter he removed to London, where his health more and more declined. His physician Dr Gisborne advised free air, and he went to Kensington. There he in some degree revived, and returned to Cambridge, intending to go from that place to Old Park, near Durham, the residence of his friend Dr Wharton. On the 24th of July, however, while at dinner in the college hall, he was seized with an attack of the gout in his stomach. The violence of the disease resisted all the powers of medicine. On the 29th he was seized with convulsions, which returned more violently on the 30th, and he expired on the evening of that day in the 55th year of his age, sensible almost to the last, aware of his danger, and expressing no visible concern at the thought of his approaching death. His friend Mr Mason was at that time absent; and the care of his funeral devolved on the other executor Dr Brown, the president of Pembroke Hall, who saw him buried as he desired, by the side of his mother, in the church-yard of Stoke.

Gray, independently of his poetical character, sustained that of a first-rate scholar. He was perhaps (says the Rev. Mr Temple in the summary of his character) the most learned man in Europe. He knew every branch of history, natural and civil; had read all the original historians of England, France, and Italy; and was a great antiquarian. His skill in zoology was accurate; and in an interleaved copy of Linnæus which he had left behind, he had not only concentrated what other writers had written, but had altered the style of the Swedish naturalist into classical Latin.† Botany, which he had studied in early life, was also an amusement of his later years. In architecture he was eminently skilled; and in heraldry a complete master. To these accomplishments must be added his exquisite and scientific taste in painting and music. Walpole, in his History of Painters; Bentham, in his History of Ely; Pennant, in his Antiquities of London; and Ross, in his edition of Cicero's Familiar Epistles, were all respectively indebted to the learning of Gray.

Grazing || Great Scale.

As a man, the only blemish in his fine character seems to have been an excessive and half-affected delicacy. His genius as a poet is not of the most extensive, but of the highest cast. He is the only English poet who has divested elegiac poetry of its tædium; placed its sombrous images in a light of picturesque fancy; and given a tone of stedfast though subdued romantic feeling to the plain reflections of truth. Respecting his lyric poetry, the suffrages of criticism are certainly more divided. While by some his Odes have been extolled as the model of lyric poetry, they are esteemed by another school of taste to abound in over-wrought refinements, and obscurity of language. Our limits preclude dissertation; yet whatever justice there may be in the charge of obscurity which attaches to his Odes, the grandeur of thought, and the harmony of versification which pervade them, will for ever support their general merit, and their rank in the first rate productions of our language, and the muse of England will be for ever acknowledged to have expressed

A Pindar's raptures in the lyre of Gray.

See Mason's *Life and Letters of Gray*; and Mitford's *Life*. (*n*)

GRAZING. See AGRICULTURE.

GREAT INTERVALS, in music, are the same with *major* or *greater* intervals, and are marked with the large Roman numerals; as I. II. III. IV. &c. See MAJOR *Intervals*. But Mr Holden has used this term in a different way. See his *Great* SIXTH, and *Great* THIRD. (ϱ)

GREAT OCTAVE of the German theoretical writers on music, is that octave (or septave rather) which begins with C on the second leger line below the bass stave, and ends with B on the second line of that stave, or the *mi* of Guido. To this septave they exclusively apply the capital letters C, D, E, F, G, A, B, in their tablature or literal notation; and in the next octave above, the letters c, d, e, f, g, a, b are used. See SMALL OCTAVE, ONCE-MARKED, TWICE-MARKED, &c. *Octaves*; and Dr Callcott's *Musical Grammar*, Art. 34. (ϱ)

GREAT SCALE of M. Overend, approved by Dr Boyce, is a musical curiosity preserved in the library of the Royal Institution in London, in the Overend Manuscripts, vol. ii. pp. 113—133, 143—149, &c. It contains 86 notes within the octave, and was thought by the indefatigable musicians above named, to be capable of unravelling all the mysteries of the various ancient Greek scales of music, as Dr Pepusch had explained them diatonically, or by the use of the prime integers 1, 2, 3, and 5 only, in their ratios; but to the various systems of those, who, according to Dr Wallis, used the higher primes 7, 11, 13, 17, 19, &c. in the ratios, and in consequence have *decimals* of schismas, or Σ's in our notation; or of those, who divided the major *tone*, or the minor *fourth*, into *aliquot parts*, for obtaining their intervals or degrees, this great scale has no near relation. See CHROMATICUM, DIATONICUM, GENERA, and GREEK *Music*. (ϱ)

* He had held his professorship of history nearly three years without having begun to execute the duties of it, which consist of two parts; one, the teaching of modern languages; the other, the reading of lectures on modern history. The former he was allowed to execute by deputies; but the latter he was to commence in person, by reading a public lecture in the schools once at least in every term. He was at liberty to chuse his language, and chose the Latin, which Mr Mason thought somewhat injudicious; and although we do not find that he proceeded farther than to draw up a part of his introductory lecture, he projected a plan of very great extent, which, from his indolence and ill health, he would not in all probability have been able to execute. His death, however, prevented the trial.

† It is a circumstance not generally known, that he translated the Linnæan genera, or characters of insects, into elegant Latin hexameters.

GREECE,

Greece. Extent and situation.

THE most celebrated country of antiquity, was of very inconsiderable extent, and scarcely equalled in size the half of England. It is comprehended between 36° and 41° of North Latitude; and is bounded on all sides by the sea, except on the north, where it borders upon Epirus and Macedonia. Thessaly, its most northern province, is an extensive and fertile vale completely surrounded by lofty mountains; by Olympus on the north; by Ossa on the east; by Pindus on the west; and on the south by Oeta, at the foot of which lies the famous pass of Thermopylæ. The tract extending from the borders of Thessaly and Epirus to the Corinthian isthmus, contains the provinces of Acarnania, on the east frontier of which runs the river Achelous; Ætolia, bounded on the south by the sea, but defended on every other side by mountains almost impassable; Doris, wholly a mountainous country; Locris and Phocis, both of small extent, but full of fertile plains; Bœotia, a well-watered vale, bounded, except on the north-east, by the mountains Parnassus, Helicon, Cithæron, and Parnes; and Attica, a rocky and barren country, producing little grain or pasture, but yielding a variety of fruits, particularly figs and olives. The isthmus of Corinth, a mountainous ridge, at one place only five miles in breadth, leads farther south to the peninsula of Peloponnesus, which contains Achaia, a narrow strip of country on the northern coast, bounded on its inland frontier by a ridge of mountains, running along its whole extent from Corinth to Dyme; Argolis, a remarkably fruitful valley, included between two mountainous branches, stretching from Cyllene, the most northern of the Arcadian summits, and terminating, the one in the gulf of Argos, and the other at the promontory of Scylla; Elis, or Eleia, watered by the rivers Peneus and Alpheus, and less mountainous than the other provinces in Peloponnesus; Arcadia, the central state, consisting of a cluster of lofty mountains, the principal of which are Taygetus and Zarex; Messenia, the most level district in the peninsula, the best adapted for tillage, and most fruitful in general produce; and Laconia, traversed by two branches of the Taygetus and Zarex, between which runs the river Eurotas, watering several very fertile but not extensive vales.

Aspect, climate, and ...

The general aspect of Greece is rugged, but its climate is highly propitious; and both the summer heat and winter cold are preserved by the surrounding seas in an equable state of temperature. Some of its mountains contain valuable metals; others are composed of the finest marble; and many are covered to a great extent with a variety of useful timber. Its central plains produce corn, oil, and wine; its valleys afford the richest pasturage; and its long winding coast abounds with excellent harbours. The great variety in its surface gives occasion to considerable diversity both of produce and of climate in every season of the year. It has been remarked, as a peculiar feature in the topography of the most ancient cities of Greece, that every metropolis possessed its citadel and its plain; the former as a place of refuge in war, and the latter as a source of agriculture in peace. The most remarkable of its towns were,—in THESSALY, Gomphi, Metropolis, and Scotussa, north of the river Peneus; Atrax, Larissa, the city of Achilles; Magnesia, and Aphetæ the port of the Argonauts; Heraclea, named from Hercules, who is said to have thrown himself into the pile on the summit of Oeta, in its vicinity; Lamea and Hypata, on the banks of the Spercheus; Thaumaci, Halos, and Pthia, the country of the Myrmidones, Demetrias, Pheræ, Pharsalia, on the banks of the river Enipeus.—In ACARNANIA, Amphilochicum, Stratus, and Actium, at the bottom of the Ambracian Gulf.—In ÆTOLIA, Chalydon, Chalcis, on the river Evenus; Thermæ, Lysmachia, Canope, Naupactus, Erythræ, and Antirrhium.—In DORIS, Cytinium, and three smaller towns of little note.—In LOCRIS, Amphissa, Opus, Cnemis, Narix, the native country of Ajax, Thronium, Nicæa.—In PHOCIS, Delphi, accounted the centre of Greece; Elatea, on the river Cephissus; Crissa, and Anticyra.—In BŒOTIA, Thebes, near the river Asopus; Platæa, Leuctra, Orchomenos, Haliartus, Coronea, Cheronea, Lebadia, Thespiæ; Ascra, the birth-place of Hesiod; Aulis, Delium, and Tanagra.—In ATTICA, Athens, with its harbour Piræus; Phalereus and Munichia, Marathon, Phylæ, and Decelia.—In MEGARIS, Megara, Eleusis, and Nycæa.—In ACHAIA, Corinth, Sicyon, Patræ, Ægium, Dyme, and Pallene.—In ARGOLIS, Argos, on the river Inachus; Mycenæ, the city of Agamemnon; Epidaurus, Nemea, and Tiryns.—In ELIS, Elis, on the river Peneus; Olympia, and Pisa.—In ARCADIA, Megolopolis, Tegea, Mantinea, and Pallantium.—In MESSENIA, Messene, Stenyclarus, and Pylos, the city of Nestor.—In LACONIA, Sparta, on the river Eurotas; Gythium, Selasia, Helos, Amyclæ.

Periods of Grecian history.

It has been customary with most writers on the subject of Greece, to distribute its history into distinct periods or epochs; but few authors happen to agree in fixing upon the same points of division. If we proceed upon the principle of marking the degree of credibility in its records, there will then be only two portions to be contrasted; the one the period of uncertain, and the other that of authentic history.

The *first*, " the period of uncertain history," extends from the earliest accounts of the country, to the commencement of the first war with Persia, in the year B. C. 490; a period very variously computed, but, according to the lowest estimate,* comprising a space of nearly 700 years. Of this large portion of time, there are no documents really deserving the name of history; and the accounts which have been given of its events, were drawn up by writers who lived long posterior to the transactions of which they treat, and were compiled from scattered records and fragments, of which there are no sufficient data to ascertain the authenticity. Of this period, however, there may be specified four distinct subdivisions, which are marked by some peculiar historical features. The first, reaching from the earliest accounts of Greece to the commencement of the Trojan war, B. C. 900; a period of 200 or 300 years, and which, without scruple, may be termed " the fabulous age." The second, reaching from the expedition against Troy to the death of Homer, B. C. about 800; a period of at least 100 years, generally called " the heroic age,"

* The Chronology of Sir Isaac Newton.

of which the only history is contained in the poems of the Iliad and Odyssey. The third, reaching from the death of Homer to the death of Lycurgus, B. C. about 700; a period of another 100 years, which may be denominated "the era of revolutions," and of which scarcely any species of history exists. The fourth, reaching from the time of Lycurgus to the first invasion of Greece by Persia, B. C. 490; a period of 210 years, which may be termed "the era of traditionary history," possessing a considerable degree of credibility.

The *second*, "the period of authentic history," extends from the first invasion of Greece by the Persians, B. C. 490, to its final subjugation by the Romans, B. C. 146; a period of 341 years, the history of which, luminous and connected beyond that of any other portion of Pagan antiquity, has been recorded by writers of the greatest ability, who were contemporary with the events which they relate, and in which many of them bore a distinguished part. These writers were all Greeks, and some degree of national partiality may be suspected to have guided their narrations; but their number, and their connection with different states, renders them in some measure checks upon one another. This period, also, may be subdivided into four portions, distinguished rather by political than historical characteristics. The first, reaching from the Persian invasion, B. C. 490, to the commencement of the Peloponnesian war, B. C. 430; a period of 60 years, the era of Grecian unanimity and triumphs. The second, reaching from the beginning of the Peloponnesian war, to the accession of Philip of Macedon, B. C. 360; a period of 70 years, the era of civil wars and intestine commotions among the states of Greece. The third, reaching from the accession of Philip to the death of Alexander the Great, B. C. 323; a period of 37 years, distinguished by the entire ascendancy of Greece over Persia, and its own partial subjection to the foreign dominion of Macedonia. The fourth reaching from the death of Alexander, to the final subjugation of the Grecian states by the Romans, B. C. 146; a period of 177 years, during the greater part of which the destinies of Greece were directed by foreign influence, and were placed successively under the protection of Macedonia, Egypt, and Rome.

First inhabitants of Greece.

The early history of Greece, like that of most other countries, is involved in obscurity and fable. Its original inhabitants, generally considered as the descendants of Javan, son of Japhet, appear to have led a migratory and savage life, sheltering themselves in caves and huts, feeding upon acorns, clothing themselves with skins, and gradually associating in small bodies for their mutual support against the wild beasts of the woods and mountains, by which they were everywhere surrounded. Many different wandering hordes, of whom the Greek writers give no satisfactory account, seem to have successively overrun the country; sometimes mixing with the ancient inhabitants, and sometimes driving them from their possessions. These, in their turn, expelled and plundered others; and a state of petty piratical warfare characterised the first ages of every Grecian settlement. These plundering excursions became so general, that all the shores, both of the continent and the islands, are said to have been deserted, and the lands cultivated only at a considerable distance from the sea. From this state of barbarism, the inhabitants

Visited and civilized by foreigners.

of Greece began to emerge at an earlier period than those of any other country in Europe; and this advantage they seem to have owed entirely to their communication with the civilized nations of the East. Its islands were visited by the Phenician navigators, who introduced the knowledge of the precious metals. A people, named Pelasgi, apparently from Asia, extended their dominion over all the northern parts of the country; and various contemporary colonies from Egypt, (of whose migration the cause is not known, but for which the supposition of some political revolution may easily account,) appear to have founded the principal Grecian states.

Crete.

The island of Crete, which seems to have been occupied, and its inhabitants enslaved by some of these adventurers, first attained a considerable degree of civilization under Minos, above 1000 years before the Christian era;* and became the general fountain of legislation and jurisprudence to the other settlements. Of these, Sicyon and Argos are considered as the most ancient, and as having been founded nearly at the same time, about 80 years before the reign of Minos, and 1080 before the Christian era.

Sicyon.

Sicyon, till a very late period, had little influence in the affairs of Greece; and its early history is as uninteresting as it is uncertain. Ægialeus is mentioned as its first king; but the list of his successors rests on no authority, and is not worthy of being transcribed. It seems to have been soon eclipsed by the neighbouring

Corinth.

state of Corinth, which was noted, even in the days of Homer, for its commercial wealth. Among its early princes are numbered Sisyphus, Glaucus, and Bellerophon, whose exploits present a subject for poetry rather than materials for history.

Argos.

But the city of Argos, if not actually the oldest in Greece, was the first that acquired political eminence; and was founded by Inachus, or by his son Phoroneus, who is considered as having been the contemporary and brother of Ægialeus, the first king of Sicyon. Io, the daughter of one of the Argive princes, having been carried away to Egypt, her descendant Danaus, afterwards arriving at Argos, claimed the sovereignty, and extending his power over the whole of Peloponnesus, the inhabitants (called Pelasgi before his arrival) received from him the name of Danai. Perseus, one of his descendants, and the first Grecian who is celebrated as a warrior, founded the city of Mycenæ, which became for some time the capital of Argolis; but soon afterwards lost its pre-eminence.

Mycenæ.

Contemporary with Perseus was Pelops, son of Tantalus, King of Phrygia, who, being driven from his native land by unsuccessful war, came with immense treasures into Greece; and, being accompanied by a band of Achaians from Thessaly, established himself in Laconia. Marrying Hippodameia, daughter of the chief of Pisa, he succeeded to the sovereignty of that territory; and, by his numerous family connections, as well as able conduct, acquired so much influence throughout the peninsula, that it derived from him the name of Peloponnesus. His daughter Astydameia was united in marriage with Sthenelus, the son of Perseus; and their son Eurystheus was the prince so often mentioned in Grecian fable as the rival and persecutor of his kinsman Hercules. Pursuing the children and adherents of that deceased hero into Attica, he was slain in battle, and succeeded in the sovereignty of Argos by his uncle Atreus, who, uniting in his person the claims of both the houses of Perseus and Pelops, extended his authority over all Peloponnesus, and transmitted the Argian sceptre in its greatest glory to his son or grandson Agamemnon.

Lacedemon.

Lacedemon, or Sparta, concerning the origin of which there is no certain memorial, had

* The chronology of Sir Isaac Newton is here followed.

Greece.

now become distinguished under its sovereign Tyndareus, whose sons Castor and Pollux died in the prime of life, and whose daughters, Clytemnestra and Helen, were given in marriage to Agamemnon and his brother Menelaus. Through these princesses, the domains of Tyndareus fell to the two sons of Atreus; and Menelaus was invested with the immediate command of the Lacedemonian territory.

Thessaly.

Of the provinces without the peninsula, Thessaly (next to Crete, the most ancient scene of Grecian story,) first became celebrated for the wisdom of its princes, who extended their sway at an early period as far as the Corinthian Isthmus. In that country, always famous for its horses, the Centaurs were first known, who are supposed to have been a band of foreign adventurers of superior attainments to the more southern Greeks of their time. From a port in Thessaly, sailed the expedition of the Argonauts under Jason, who may be considered as merely the leader of one of the most considerable piratical expeditions, which had hitherto been undertaken. Bœotia, though a country originally subject to earthquakes and inundations, yet, from its great fertility, attracted at an early period the attention of adventurers; and a Phenician colony under Cadmus is understood to have founded its principal city of Thebes. The numerous fabulous stories relating to its history, comprehending the adventures of Bacchus, Amphion, Amphitryon, Hercules, Laius, Œdipus, Eteocles, and Polynices, serve at least to prove that it must soon have become a flourishing and powerful state; and the war, which it sustained against seven united potentates, the subject of the *Thebaid* by Statius, presents the first instance of a political league, and a regular warfare, recorded in the annals of Greece. Ætolia, though not inferior to the adjoining countries in early civilization, and though sufficiently celebrated in the histories of its heroes Tydeus, Meleager, and others; yet, from the dangers of its seas, being much excluded from the intercourse of more civilized nations, made little comparative progress in political improvement, and, for several centuries even after the Trojan war, had little communication with the rest of Greece. Phocis, Doris, and Locris, also afford no materials for history at this early period; and the only remaining state, whose origin is worthy of being narrated from tradition, is that of Attica. The first king of this country is said by some to have been Ogyges, whose name, however, is not mentioned by the older Greek historians, and who is conjectured at the utmost to have been only the leader of a band of Bœotians; who, having been driven from their own country by an inundation, had taken refuge in the adjoining districts of Attica. The first, at least, who introduced regular government and the arts of civilization among the Athenians, was Cecrops, the leader of a colony from Egypt, who introduced the worship of the goddess Athena, or Minerva; and thus gave a name, if not also a beginning, to the city of Athens. He is considered as the founder of the celebrated court of Areopagus; and, in consequence of his wise institutions, aided by the natural security of the country from invasion, strangers were attracted, population increased, and civilization made more rapid progress than in any other province of Greece. Of his successors, little is recorded even by tradition, till the time of Ægeus, contemporary with Minos, King of Crete, and the father of the renowned Theseus, whose romantic history bears no inconsiderable resemblance to that of the Gothic knight-errants, and whose wise measures as king of Athens laid the foundation of its future greatness. By the united influence of persuasion and authority, he consolidated, in one well-regulated government, the independent districts in Attica, and endeavoured to secure the stability of his improvements, by procuring the approbation of the Delphic oracle. Though well entitled, by his political regulations, to be ranked among the most illustrious patriots of ancient times, he is nevertheless represented, in his future history, as having forfeited the esteem of his subjects, and having at last died in exile. After him, the sovereignty of Attica was held by Menestheus, a descendant of the royal family, and the leader of the Athenian troops in the Trojan war.

Council of the Amphictyons.

These petty states, each of which was governed by its respective sovereign, and all of them independent of one another, were continually at war among themselves, and exposed to the incursions of foreign barbarians. To obviate these evils, and to secure, as far as possible, the general tranquillity, an assembly was formed of deputies from the different countries of Greece, whose business it was to decide all disputes between the states of which the association was composed, and to concert measures of defence against their common enemies. This was called the council of the Amphictyons, from its supposed founder Amphictyon, one of the sons of Deucalion, and king of Attica; but its original constitution, and the period of its commencement, cannot be satisfactorily ascertained. It is supposed by Sir Isaac Newton to have commenced about a century before the Trojan war. Besides its primary object of establishing a kind of national law among the Greeks, its attention was principally occupied in managing the concerns of the Delphian oracle. But, though its decrees were respected, its power was not very efficacious. It contributed to restrain the violence of wars, but was not able to prevent their frequent occurrence. It derived its greatest consequence from the increasing fame of the oracle at Delphi; and the superintendence of the religious institutions of Greece became ultimately its principal office. It is not mentioned by Homer; but its existence seems to be implied in the ready union of the Grecian states against Troy. See Amphictyons, Cadmus, &c.

Origin of the Trojan war.

Frequent piratical excursions appear to have been carried on between the inhabitants of the eastern and western coasts of the Ægean Sea; and the rape of Helen by Paris the son of Priam may be considered, according to Herodotus, as an act of retaliation for some similar injury received from the Greeks by the Trojan people. An outrage, however, so nearly affecting one of the greatest princes of Greece, and aggravated by a breach of the rights of hospitality, was considered as demanding the united vengeance of the Grecian chiefs; and the hope of returning home enriched with the spoils of Asia, presented no small incentive to the expedition. The extensive influence also of Agamemnon king of Argos, and brother of the injured Menelaus, urged on the general confederacy; and, under his supreme command, the chosen warriors of every Grecian state, from the southern extremity of Peloponnesus to the northern regions of Thessaly, assembled at the port of Aulis in Bœotia. The fleet, consisting of 1200 open vessels, conveyed to the Trojan coast, an army of 100,000 men, who speedily compelled the enemy to take refuge within the walls of their city; but, unable to surmount its strong and well defended fortifications, they attempted its reduction by excluding every kind of succour and supplies. Obliged, however, to detach large bodies from their army to procure subsistence for themselves, they were unable to prevent the Trojans from again taking the field, and receiving every requisite relief to their wants. In this way, the siege was prolonged for the space of ten years: and even at the last, the house of Priam was not overthrown without the aid of stratagem and treachery.

Its disastrous effect

But, while the allied Greeks triumphed over Troy, it was to each of them a victory dearly purchased. Few of the princes, who witnessed the successful termination of their expedition, were permitted to enjoy in their native country the renown and repose, which their exertions had earned; but, having made no provision for the administration of their affairs during their absence, were either murdered at their return by some usurper of their power, or compelled to reimbark with their adherents, in quest of distant settlements.

Flourishing state of Athens.

The Athenian state, which seems to have made the nearest approach to a settled government, suffered least by the absence of the commander of their army; and regular magistrates supplied the place of their chief. In this city, Orestes, the son of Agamemnon, obtained an asylum; and, after remaining seven years in exile, found means to avenge his father's death, and to recover the throne of Argos, which he held with great power and reputation till his death. See ACHILLES, AGAMEMNON, AJAX, HOMER, TROY, &c.

Here terminates the history contained in the writings of Homer, who seems to indicate, that the concluding events which he records were within the reach of his own memory; and whose works, in fact, contain almost the only materials for an account of the heroic age. He affords at least the best and most authentic view of the political and domestic state of the Greek people, during the period which preceded his death; and to his poems we may refer for a description of the religion, government, arts, and manners of the early Greeks.

Customs and manners of the early Greeks.

The ancient Pelasgian inhabitants of Greece are said by Herodotus to have prayed and sacrificed to gods, to whom they gave no name or distinguishing appellation; and the works of Hesiod still more clearly prove that they drew their first notions on the subject of religion from Oriental traditions.

Religion.

Their future system of polytheism seems to have been imported by the Egyptian colonists; but to the principal divinities thus introduced, their own lively fancy soon added a multitude of other imaginary beings, presiding over every mountain and river, every season and production; and these were arranged by Hesiod and Homer into a kind of system of the most extravagant and inexplicable description. There is neither omnipotence nor omnipresence among the attributes which the last mentioned poet ascribes even to the father of the gods; neither perfect goodness nor perfect happiness in the heaven, which he assigns as their residence. An incomprehensible power, denominated Fate, is represented as directing all events; and it seems to have been the principal office of Jupiter to superintend the execution of its decrees. Idolatry, as denoting the worship of visible objects, was at this period unknown; and even temples appear to have been rare. Prayers were addressed as to invisible deities; and sacrifices, the only duty which they seem to have been considered as expecting from their worshippers, were offered upon altars erected in the open air. A few crimes are sometimes denounced as exposing to the vengeance of the gods, but morality in general finds very little support in the religion of this period. Soothsayers, who professed to foresee future events, were sufficiently numerous; but fixed oracles had not yet attained any extensive celebrity. The salutary doctrine of the immortality of the soul, and a future state of rewards and punishments, was taught in those days; but the ridiculous absurdities, with which it was clothed, tended, when men had learned to despise the fables, to throw contempt also upon the momentous truth which they had veiled.

Government.

The form of government was monarchical, and in some degree hereditary; but the authority of the kings was extremely limited, and always controuled by established customs. It was the universal prerogative of the prince to exercise the judicial power, to superintend the institutions of religion, to command the armies, and to direct the ordinary business of the community; but, in any extraordinary or very important measure, he was required to consult, not only a council of the principal men, but also an assembly of the people; and a high degree of personal strength and accomplishments seems to have been always necessary to maintain his authority.

Letters & writing

It is generally admitted that letters were introduced into Greece from Phœnicia by Cadmus the founder of Thebes, at the lowest calculation 1045 years before Christ; but it is equally ascertained, that the use of writing had not become common till more than 400 years after his time; and nothing, in the whole history of the ancient Greeks, is more difficult to be explained than the high state of excellence, which the language had attained in the days of Hesiod and Homer, while so little of it could have been reduced to writing.

Poetry

In the absence of letters, poetry seems to have been invented, or at least to have been originally employed for the assistance of memory. Laws, among the early Greeks, were always promulgated in verse, and frequently sung in public. Morality was taught, and history related in the same manner. All, who wished either to instruct or amuse their fellow-citizens, were thus necessarily poets; and they who possessed so important a talent, were considered as sacred characters, favoured and inspired by the gods.

Music

The first poetry of the Greeks was uniformly accompanied with music, and both stringed and wind instruments are mentioned by Homer. But, there are no means of ascertaining its peculiar features; and, however powerful may have been its effects, it appears to have been extremely simple and inartificial in its composition.

Agriculture

Their agriculture appears to have been carried on with considerable regularity; and the practice of manuring, as well as ploughing and sowing, is expressly mentioned by Homer. Wine was made from the vine, and oil from the olive; but the principal source of wealth was found in pasturage; and cattle were made, in place of coin, the usual measure of the value of commodities.

Commerce.

Commerce was chiefly carried on by an exchange of articles; and the foreign trade of the Grecian cities was principally in the hands of the Phenicians. There were Greeks, indeed, in the days of Homer, who pursued a kind of coasting traffic among themselves; but the profession of a merchant for gain was not held in much estimation, and was less respected than even that of pirate.

Navigation.

Their navigation was very imperfect; and they used oars more frequently than sails. Their ships had no decks; and the largest that went to Troy, contained only 120 men. Anchors were unknown; and the vessels, when in port, were either moored to large stones on the shore, or were actually drawn out of the water upon the beach. The early Greeks, in short, were rather boatmen than seamen; and, indeed, to this day, the skill of the navigator is of little avail in their narrow and tempestuous seas.

Science

They had little knowledge of astronomy; and marked the length of the year by 12 revolutions of the moon, reckoning the months to consist of 29 and 30 days alternately. But, in progress of time, they learned to fix the seasons more correctly by the rising and setting of the stars; and had arranged them in constellations, much in the same manner, and with the same names as at the present day. They considered internal diseases as inflicted by the immediate hand of the Deity, and as therefore beyond the reach of human skill. Their medical art was thus restricted to the practice of surgery, which was held in high esteem; but which seems to have extended no farther than the extraction of a weapon, or any other extraneous body from a wound, and the application of a few simples to stop a hæmorrhage, or to assuage inflammation. Their architecture was more improved than most other arts; and Homer speaks of houses built of polished stone, with large and numerous apartments. Other mechanic arts were not exercised as distinct trades; and even princes were frequently their own carpenters. Ornamental works, however, in metals, wood, &c. were not uncommon in those days; but the greater part of the trinkets and more luxurious utensils in use among the early Greeks appear to have been procured from the Phenician merchants. Their principal study, and most constant practice, was the art of war; and they seem to have improved considerably upon that tumultuary warfare, which is generally practised among barbarous nations. Their infantry were commonly heavily armed with helmet, breastplates, greaves, and shield; and were regularly drawn up in close ranks or phalanges, marching in steady silence under their respective leaders. Cavalry were not yet employed in their battles; but chariots were generally used by the chiefs, as the means of conveying them more rapidly along the line, and of annoying more effectually a flying army. The skirmishing of the commanders, however, in front of the troops, and their mixing with the soldiers in the heat of the fight, left little room for the exercise of generalship; and their fashion of stopping in the midst of the action to strip the slain, sufficiently marks their want of military discipline and skill. They encamped with much regularity, sleeping under their cloaks, or sheltering themselves with huts; and generally fortified their post, when exposed to the attack of a powerful enemy; but, though a small guard might be placed at an out-post, they were unacquainted with the important precaution of stationing and relieving a line of sentinels. In the frequency of war, courage was regarded as the highest virtue; and the manners of the early Greeks were decidedly barbarous. Quarter was rarely granted to a fallen enemy; and the capture of a city was succeeded by the massacre of all the men who were able to bear arms, and by the captivity of the women and children. The spirit of hospitality, however, was generally diffused, and tended often to alleviate the miseries of military devastation. Women appear, as well as men, to have united the highest rank with the humblest occupations, but evidently enjoyed a greater degree of influence and freedom, than has been usual in subsequent ages among oriental nations. There has been supposed to exist, a striking resemblance between the manners and sentiments of the Greeks in the heroic age, and those of the Gothic nations of Europe, except that the latter displayed more generosity in war, and gentleness towards the female sex, than their ancient prototypes.

The period immediately succeeding the Trojan war, affords few lights to history, and is even involved in deeper obscurity than the heroic age. Supposing Homer to have lived within a century, or rather half a century of the Trojan war, his works may be allowed to supply a tolerable record of the previous events best authenticated by tradition, and of the most important occurrences which took place during his own life. His history terminates with the accession of Orestes to the throne of Argos; and total darkness thenceforth rests upon the historian's path, relieved only by a few uncertain glimmerings, till the first Persian invasion of Greece. About 80 years after the destruction of Troy, a great revolution took place, which dissipated ancient traditions, stopped the progress of civilization, and changed the governments, and even the population, of most of the Grecian states. The descendants and partizans of the celebrated Hercules had found a refuge in Doris from the persecutions of Eurystheus; but had never ceased to prefer their claims to the kingdom of Argos, and even to the dominion of all Peloponnesus. Twice had they attempted, without success, to make their way through the isthmus. But, at length, the great grand-son of Hyllus, the oldest son of Hercules, crossed the Corinthian gulf with a powerful armament, and speedily overran the whole peninsula, with the exception of Arcadia and Achaia, where Tisamenus, son of Orestes, made a resolute and successful stand. All the rest of the conquered country was divided among the princes of the Heraclides, and their allies from Doris and Ætolia; and the greater part of the old inhabitants either emigrated from the oppressions to which they were subjected, or were reduced by the invaders to a state of servitude. A new distinction of the Grecian people was the consequence of this revolution. The Pelasgian name, which had prevailed on the continent, and the Lelegian in the islands, had, at an early period, but for reasons not clearly ascertained, given place to the Æolian and Ionian; the latter designation being applied principally to Attica with its colonies, and the former to all the rest of Greece, both within and without the peninsula. Out of these two, four distinctions of the Grecian people arose, after the irruption of the Heraclides. In all the immediate establishments and distant colonies of these invaders, the Doric name and dialect prevailed. The Athenians rose to such pre-eminence, as to give rise to a new designation, namely, the Attic. Excepting them and the Megarians, who retained the Doric name, all the other Greeks, without the isthmus, claimed Æolic origin; and the Ionian name and dialect was retained only by those Ionians who had migrated to Asia and the islands. Except in the rugged province of Arcadia, nothing remained unaltered; and the Dorian invaders brought every thing back to that ruder state, in which they had lived among their native mountains. Disputes soon arose among these allied princes, respecting the partition of the conquered countries. Internal dissensions, occasioned by their turbulent subjects, were continually raging in their respective governments. The enterprising Arcadians seldom suffered them to rest from external hostilities. And, by all these concurring causes, Peloponnesus was rapidly falling back into that state of anarchy and barbarism, in which it had been before the time of Pelops and Hercules. Nothing tended so effectually to resist this tendency to disunion and turbulence, as the revival and regular establishment of the public games, by Iphitus, sovereign of Elis. These athletic games, as is evident from the writings of Homer, had been occasionally celebrated under the superintendence of different princes; and at the funerals of eminent men, many traditions prevailed,

Margin notes: dicine. — hitec-ture. — of war. — nners. — Invasion by the Heraclides. — New distinctions of the Grecian people. — Period of anarchy and barbarism. — Revival of public games. B. C. 776.

that Eleia in Peloponnesus had frequently been the chosen scene of these contests, and the resort of princes from various parts of Greece. Iphitus, therefore, having procured a favourable response from the oracle at Delphi, established a regular festival for that purpose, to be held every four years at Olympia, in the territory of Elis. Solemn sacrifices were to be offered to Jupiter and Hercules, and games celebrated in honour of these divinities. In these games, all Greeks were free to partake; and, for a certain period, before their commencement, as well as after their conclusion, a general armistice was ordained to take place. The territory of Eleia particularly, was to be at all times counted sacred, and secured from every hostile encroachment. This Olympian meeting, instituted about half a century after the return of the Heraclides, served as a common capital to the Grecian people, and contributed more effectually than could possibly have been anticipated, to the advancement of arts, science, and civilization, in all the different states.

General abolition of monarchy.

A general revolution in the government of every state, began about the same period to take place, from causes very imperfectly known. The republican spirit, which seems to have existed in all of them, even under their early monarchical constitutions, acquired so much strength, that, in a few ages, monarchy was every where abolished, and the name of tyrant applied to all who attempted its support, even under the mildest form. For a sketch of the peculiar political institutions, and separate history of the several states of Greece, we must refer to their respective names, which form distinct articles in this work, especially to ATHENS and LACEDEMON; and shall, at present, restrict our attention to those more extensive events which affected the Grecian people in general. The first important occurrence of this description which communicated a new and powerful spring to the genius of the Greeks, and greatly influenced their future progress in every path of art and science, was the unparalleled struggle which they so long and successfully maintained with the whole power of the Persian empire. See OLYMPIC GAMES.

Power of Persia.

In the reign of Darius, the son of Hystaspes, the power of the Persian arms was extended on every side of that vast empire. All was subdued to the west, as far as Macedonia. Amyntas, the king of that country, acknowledged subjection to the Persian monach; and the Grecian islands soon began to feel his ambitious and overwhelming influence. Cyprus, Samos, Lesbios, Chios, and most other islands on the Asiatic coast, were either persuaded or compelled to admit his supremacy. Most of them, according to the uniform policy of the Persians, were nevertheless allowed to retain their own magistrates and laws. One of their own nation was appointed to preside as governor; and this person, whatever was his personal character, was always, from his official situation, denominated Tyrant by the Greeks. Athens itself, hard pressed by the powerful alliance, which the Lacedemonians had formed against them, had begun to solicit the protecting aid of Persia; but Artaphernes, satrap at Sardis, having patronised the pretensions of the tyrant Hippias, whom they had driven from his power, they were filled with detestation of the Persian name, and the more readily consented to assist the Ionians in Asia, who had revolted against the authority of Darius.

Origin of the war with Greece.

These, however, were speedily reduced; and the Persian monarch, in order to punish Athens and Eretria, who had given aid to the insurgent states of Asia, or rather in prosecution of his ambitious views for the enlargement of his dominions, sent a powerful army into Greece under the command of his son-in-law Mardonius. Darius had previously dispatched heralds to each of the Grecian states, demanding earth and water as an acknowledgment of his supremacy; and, if wholly independent of each other, the greater part would probably have soon submitted to the Asiatic yoke.

United ... of Greec...

But, happily for Greece, its little commonwealths were at that period so united together by reciprocal treaties and obligations, and especially by a formal confederacy under the Lacedemonians, that a kind of general tribunal existed for the punishment of treachery or cowardice, which enabled them, in a great measure, to act as one nation. Macedonia, which had formerly paid homage, was more effectually subdued, and compelled to pay tribute to the Persian king. Thebes, by the influence of a faction, and a few other cities, particularly Ægina, made submission to his demands; but the Lacedemonians and Athenians were so indignant at the requisition of Persia, that, forgetting the law of nations and of humanity, they put the heralds to death with the utmost ignominy and barbarity. The Athenians, who had been at war with the Æginetæ, and were thus the more excited to adopt opposite measures to their hostile neighbours, accused them at Sparta of desertion from the common cause of Greece; and the chief persons of that state were instantly ordered to be seized as traitors to their country.

Progress of the Pe... army.

Little progress was made by the invading army. The Persian fleet lost nearly three hundred vessels by a storm in doubling the promontory of Athos; and the land forces suffered so severely from the Brygians, a people of Thrace, that the season for military operations was lost, and the whole armament was led back to winter in Asia. A second army, under the command of Artaphernes, son of the late Satrap of that name, and of Datis, a Median nobleman, avoiding the circuitous march by Thrace and Macedonia, sailed from Cilicia in a numerous fleet, reduced every island and appurtenance of Greece in their way, and approached the frontiers of Attica, with the exiled tyrant Hippias as their guide, before any measures had been concerted by the Greeks for the general security. A messenger was now dispatched from the Athenians to Sparta with the intelligence of the capture of Eretria, and, at the same time, with a request for assistance to themselves.

Dilat... condu... of Lace...

The Lacedemonians readily promised their utmost aid; but, in conformity to a superstitious law, unworthy of their boasted political wisdom, declared, that they could not take the field before the full moon, of which it then wanted five days. Immediate assistance from Sparta being thus denied, it became a question with the ten generals, whom the Athenians had chosen to command their army, whether they should venture to meet the enemy in the field, or apply their whole exertions to prepare for a seige. Opinions were equally divided, and the decision was, by ancient custom, referred to the polemarch Archon, who was persuaded by Miltiades to recommend an immediate engagement; a measure obviously contrary to all principles of defensive war, but rendered necessary by the dread of internal factions in the city.

Battl... of Mar...

The Persian army, amounting, according to the lowest calculation, (though even that is probably overrated) to 100,000 infantry, and 10,000 cavalry, accustomed to conquer, and having frequently engaged the Greeks of Asia and Cyprus, advanced with confidence as to certain victory. The amount of the Athenian force has been stated as low as 9,000 heavy-armed infantry, and 1,000 Platæans, who had bravely hastened to share the desperate struggle for the freedom of their

Greece. country. Various considerations,* however, make it probable, that the regular Grecian troops, now opposed to the Persians, were not much less than 20,000, with about an equal number of armed slaves. With this army, still fearfully inferior to the invading host, the genius of Miltiades, who was well acquainted with the nature of the Persian troops, seconded by the determined bravery of his soldiers, gained, on the plain of Marathon, a most decisive victory, and drove the routed Persians to their ships with great slaughter. But this distinguished commander, having failed in a subsequent expedition against the Ægean islands, which had submitted to the Persians, was, by the base machinations of party spirit, condemned to pay a fine of 50 talents, and died in prison of the wounds which he had received.

Second Persian invasion. B.C. 480.

The death of Darius, the revolt of Egypt, and the disputes which arose about the right of succession to the throne of Persia, procured to the Greeks a respite of several years from any farther attempts against their independence. But Xerxes, the young Persian monarch, was sufficiently ardent to revenge the disgrace, which the arms of his nation had sustained, and to prosecute those schemes of conquest, which his predecessors had planned. Four years are said to have been employed in preparations for the punishment of Athens, and the reduction of Greece; and an army was collected, more numerous than had ever before, or than has ever since been known in the annals of the world. To prevent the disasters, which might attend the conveyance of the armament by sea, as well as to provide for the future security of the intended conquest, a canal, navigable for the largest galleys, was, (according to the united testimony of all the Greek historians and geographers,) actually formed across the isthmus, which joins mount Athos to the continent of Thrace. Two bridges of boats also, the one to withstand the winds and the other the current, were extended across the Hellespont nearly between Abydos and Sestos, where the street is about seven furlongs in breadth. Early in the spring, the army moved from Sardis, the principal place of rendezvous; and seven days and nights are said to have been occupied in passing the bridges of the Hellespont. The land and sea forces met at Doriscus near the mouth of the Hebrus, where, according to Herodotus, the Persian monarch reviewed his enormous army, which is said to have been composed of twenty-nine different nations. This historian (whose testimony, as he lived so near the time of the expedition, ought to be most worthy of credit, but whose detail of many incredible concomitant circumstances casts a doubt over his whole narration) estimates the effective strength of the infantry at 1,700,000 fighting men, and the cavalry at 80,000, exclusive of attendants and followers, whose number defied calculation. The fleet consisted of 1207 galleys of war, carrying about 277,600 men; besides transports, store-ships, and a variety of smaller vessels, amounting, at a gross calculation, to 3000, and their crews to 240,000. The land forces marched from Doriscus in three columns, every where adding to their numbers, by compelling the youth of the countries through which they passed, to follow their standards. They met again at Acanthus, where they were joined by the fleet, which then proceeded through the canal of Athos, into the bay of Therme, where the whole army coming up, formed an encampment, extending from Therme and the borders of Mygdonia to the river Haliacmon, near the confines of Thessaly. The Greeks, in the mean time, were slow in concerting any measures for their common defence; and many of the smaller republics readily made the required submission to the Persian monarch, whose sway had been experienced by many Grecian states to be much less oppressive than that of the domineering rule of the Spartan oligarchy, to which the greater part of them had long been subjected. The determined resistance of the Athenian people first arrested the progress of the Asiatic host; and to them chiefly belongs the honour of having preserved Greece from a foreign yoke. To this daring resolution they were prompted, not entirely by the love of freedom, but by the dread of certain punishment. The whole armament was ostensively prepared for their destruction, and their courage therefore was nearly that of despair. Their success at Marathon may have thrown a ray of hope through the gloomy prospect before them; and, at this critical moment, they happily possessed in Themistocles a leader of extraordinary talents, peculiarly fitted for conducting the arduous contest. Deputies from the confederated states at length assembled at Corinth, to consult respecting the conduct of the war; and an attempt was at first made to defend the passes into Thessaly. An army of 10,000 men from the different states, joined by all the Thessalian cavalry, was actually sent to occupy the vale of Tempe; and was competent to have defended the pass against any number of assailants. But the Grecian leaders, alarmed by the accounts which they received of the multitude of their invaders, and understanding that there was another opening into Thessaly, which they did not think themselves strong enough to occupy, were struck with a sudden panic, and, embarking their troops, returned to the Corinthian isthmus; while the Thessalians, now left to their fate, made an immediate submission to the demands of Xerxes. It was next resolved to make a stand at the pass of Thermopylæ, which afforded every possible advantage to an inferior force; but their mutual jealousies and selfish anxiety to reserve their strength for their proper defence, prevented the assembling of a sufficient body of troops; and not more than 4000 men, most of them Arcadian mountaineers, were collected to dispute the passage with the whole Persian army.

Amount of invading army.

Tardy measures of the Greeks.

Resolute resistance of Athens.

Battle of Thermopylæ, B. C. 480.

Xerxes having halted several days at Therme, to procure proper intelligence and guides, resolved to proceed by Upper Macedonia into Thessaly, and reached the neighbourhood of Thermopylæ without opposition. His fleet, after suffering immense loss by a storm in the bay of Casthanæa, entered the Pelasgian gulf; and the Grecian fleet, which was stationed off Artemisium to support the army at Thermopylæ, succeeded in capturing fifteen galleys, which had been dispersed by the tempest. This favourable event at once revived their spirits, and added greatly to the strength of their little navy. Xerxes, in the mean time, having fixed his head quarters at the town of Traches, in the Malian plain, waited four days, in expectation that the Greeks would yield to his numbers, and leave him an uninterrupted passage. A herald also was dispatched to Leonidas, who commanded at Thermopylæ, requiring him to deliver up his arms; to whom the Spartan replied, with laconic brevity, "Come and take them." The Persian monarch, therefore, on the fifth day, ordered the Medes and Cissians of his army to bring Leonidas and his Greeks into his presence. These being quickly repulsed, the Persian guards, called "the immortal

* See a very satisfactory statement in support of this opinion in Mitford's History of Greece.

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band," were marched to the attack. Their numbers were unavailing on so narrow a field; their short spears were very inferior in close fight to the longer weapons of the Greeks; and their repeated and courageous efforts, to which Herodotus bears ample testimony, made no impression. The assault was renewed on the following day, in hopes that wounds and fatigue might exhaust the little army of the Greeks; but still without the smallest prospect of success. A Persian detachment, however, having penetrated during the night by another pass, and surprised the Phocians, who had been intrusted with its defence, shewed themselves, on the morning of the third day, far in the rear of the Grecian army. Information of this fatal advantage being conveyed to Leonidas, it was immediately resolved that they should all retreat to their respective cities, and preserve their lives for the future wants of their country. Leonidas, however, in obedience to a law of Sparta, which forbade its soldiers, under whatever disadvantage, to flee from an enemy, resolved to devote his life to the honour and service of his country. Animated by his example, every Lacedemonian and Thespian under his command, determined with him to abide the event. The Thebans also, on account of the disaffection of their city to the Grecian cause, were detained, rather indeed as hostages than as auxiliaries.* Leonidas stationed his little band at the wall of Thermopylæ, where the pass was scarcely 50 feet wide; and all of them resolved to sell their lives to the enemy at the dearest rate. With the fury of men resolved to die, they rushed against the advance of the Persian army, and made a dreadful slaughter of the crowded and ill-disciplined multitude. Numbers of them were forced into the sea, and many of them expired under the pressure of their own people. Leonidas fell early in the fight, at the head of his troops; but the engagement was continued, with advantage on the side of the Greeks, till the Persian detachment came in sight in their rear. They then retreated to the narrowest part of the pass, where the Thebans began to sue for mercy, and were most of them taken prisoners. The surviving Lacedemonians and Thespians gained a little rising ground, where they fought in the midst of a surrounding host, till they were utterly cut to pieces. In the conduct of the Spartan prince, there was wisdom as well as magnanimity. His example checked the disposition which prevailed among the Greeks to shrink from the Persian power; and gave a convincing proof to the invaders, at how vast a price of blood they would purchase their conquest. During the transactions at Thermopylæ, the Grecian fleet gained several advantages over that of the Persians; and about two hundred galleys of the latter, attempting to take the Greeks in the rear by sailing round Eubœa, were totally lost in a storm. Having received intelligence of the fall of Leonidas, and the retreat of the rest of the army, the Grecian fleet retreated from Artemisium, and sought the interior seas of Greece. The Persian army experienced no opposition in their march through Doris and Bœotia, which, excepting the cities of Thespiæ and Platæa, had always been adverse to the confederacy of the Greeks. Phocis alone, of all the provinces between Thessaly and the isthmus, remained faithful to the cause of Grecian independence. Its territories, therefore, were ravaged without mercy by detachments of the enemy; while the main body advanced in a direct course to the devoted city of Athens. The Peloponnesian troops having resolved to confine their operations to the defence of the peninsula, Attica was completely abandoned to the whole weight of the invading host. Athens was filled with alarm, and all were convinced that their destruction was inevitable. The oracle at Delphi, however, having recently pronounced, that "the wooden wall" alone would afford an impregnable refuge to themselves and their children, Themistocles, who had probably himself suggested the response, persuaded his countrymen that they were thus directed to embark on board their fleet. Their families and effects were, in conformity to his advice, immediately transported to Salamis, Ægina, and Træzene; and all the males who were able to bear arms repaired to the ships. A few of the poorer citizens, who were unable to bear the expence of a removal, and some others, who conceived the answer of the oracle to point out their citadel, which was built of wood, as the place of safety, refused to abandon the city. The Persian army, advancing from Thebes, burned the forsaken cities of Thespiæ and Platæa; and experienced no resistance till they reached the citadel of Athens, which was immediately invested; and, being taken by assault, all within its gates were put to the sword. The commanders of the Grecian fleet, which was now assembled in the bay of Salamis, alarmed by the intelligence of the fall of Athens, had resolved in a council of war to retreat without delay, when Themistocles, addressing Eurybiades the Lacedemonian, who had the chief command, threatened, if such a resolution were adopted, to withdraw the whole of the Athenian ships, which composed nearly one-half of the allied fleet, and either to make peace with the enemy, or seek some distant settlement for his deserted people. His advice prevailed; and it was determined to await the approach of the enemy in the straits of Salamis. This Athenian chief, however, still fearful lest some of the squadrons should depart, is said to have accelerated the approach of the Persians, by causing their monarch to be privately informed, that the Greeks were planning a retreat, and that he would thus lose the most favourable opportunity of destroying their whole navy at one blow. His stratagem was attended with entire success. The Persian fleet hastened to make a general attack; while their army lined the adjacent shores, and their monarch himself was seated upon an eminence to view the approaching battle. His fleet amounted to 1200 galleys, and that of the confederated Greeks to 300; but the narrow strait prevented the numerous ships of the Persians from being regularly brought into action, and the crowded situation rendered it impossible for the Phenician squadron to avail themselves of the superior swiftness of their galleys, and skill of their seamen. The very zeal of the Persian commanders to distinguish themselves in the presence of their monarch, tended to increase the confusion. The resolute and persevering attacks of the Greeks, aided by the united talents of Themistocles and Aristides, allowed not a moment's respite to the enemy to restore order, or recover from alarm. The confusion soon became so general, that even flight was impracticable, and the sea itself (according to the description of the scene by the poet Æschylus, who fought on board the Athenian fleet) became scarcely visible from the quantity of wreck and corpses floating on its surface. Forty Grecian galleys are said to have been sunk or destroyed; but most of the crews saved themselves on board of the other ships, or on the neighbouring shore of Salamis.

Advance of the Persians to Athens.

Battle of Salamis.

* In the army at Thermopylæ there were originally 300 Lacedemonians, 700 Thespians, and 400 Thebans.

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But the Persians had no refuge; and their defeat was attended with immense loss. Still the remains of their fleet were so large, that the principal port of Attica could not admit half its numbers; and the Greeks were expecting a renewal of the action on the following day. But the Persian commanders appear to have concerted no measures on the supposition of a retreat; and a hasty order during the night, directed the whole fleet to steer immediately for the Hellespont. The army, thus destitute of the supplies derived from the ships, and unprovided with sufficient magazines on land, fell back upon the friendly province of Bœotia, and speedily retreated into Thessaly. Three hundred thousand men were chosen to remain, under the command of Mardonius, to complete the conquest of Greece in the following summer. Of this number, 60,000 of the best troops were selected as a royal guard, to accompany their monarch as far as the Hellespont on his return to Persia.

Sufferings of the Persian army in its retreat.

The rest of the immense multitude which he had led into Greece, left to their own resources, suffered beyond description, from the haste of their march, and the want of magazines. They subsisted by rapine from friends as well as foes; and were reduced at last to eat the very grass from the ground, and the bark from the trees. Disease destroyed whom famine had spared; and the towns of Thessaly, Macedonia, and Thrace, were crowded with the sick and the dying. Upon reaching the Hellespont, the bridges were found to have been destroyed by the violence of the current and the storms; but the fleet had arrived to transport the wretched remains of the Persian host; and its discomfited monarch proceeded to Sardis, not indeed entirely unattended, as some of the Greek historians relate, but with such a diminished retinue as might almost be called nothing, when compared with the incalculable numbers who formerly surrounded his person, and obeyed his command.

Renewal of hostilities by Mardonius.

Early in the following spring, the Persian fleet assembled at Samos; and Mardonius, having attempted without success to detach the Athenians from the Grecian confederacy, compelled them again hastily to abandon their country; and, without opposition, regained possession of Athens. The Athenian people, under the protection of their fleet, withdrew to Saliams; and there, though deprived of their country, and disappointed of the timely assistance which they ought to have received from the Peloponnesian states, still rejected, with the most enthusiastic magnanimity, all the conciliatory proposals of Persia. The Lacedemonians, who were at the head of the allies, at length ashamed of their ungenerous and dastardly delays, dispatched an army of 5000 Spartans and 35,000 Helots, under the command of Pausanias. These were joined at the isthmus by the other Peloponnesian troops, and by the Athenian army under Aristides. Mardonius, secretly apprized of their march, gave up the city of Athens and its surrounding territories to be pillaged by his troops, and fell back upon his magazines in Bœotia, where he extended his camp along the course of the Asopus to the frontiers of Platæa.

Battle of Platæa. B.C. 479.

The confederated Greeks, animated by the propitious omens which had been indicated at their solemn sacrifices, advanced with confidence to meet the Persians, and pitched their camp at the foot of Mount Cithæron, on the opposite side of the river Asopus, composing a force of 110,000 men. Mardonius, who appears from the account given by Herodotus (the most impartial historian of the Persian invasion) to have been deficient neither in courage or policy, anxious to draw the Greeks from their advantageous position, harassed them greatly with incessant charges by his cavalry; and more than ten days were spent in various evolutions on both sides to gain the superiority of the ground, and to induce each other to commence the attack. In one of these movements, the greater part of the Grecian troops, excepting only the Tegeans, Lacedemonians, and Athenians, actually fled to the walls of Platæa; and the Persian commander, imagining the retreat to be general, hastily advanced with his infantry as to certain victory. A fierce engagement ensued, in which the Persian soldiers, though insufficiently armed for close fight, and unequal to the Greeks in the practice of war, discovered no inferiority in point of courage and enterprise; and were often seen, in their vigorous assaults, seizing and breaking with their hands the long spears of their opponents. Multitudes perished in these vain attempts to penetrate the Spartan phalanx. Their efforts, after repeated failures, began to relax. The Greeks advanced in their turn; and confusion soon became general among the Persian infantry. Their commander Mardonius, while leading on a chosen body of cavalry to support his broken troops, received a mortal wound; and his fall was the signal for flight to the whole Persian army. Artabazus, next in command, who is said to have dissented from his general in the conduct of the battle, as soon as he was assured of the rout of the main body, retreated with 40,000 men towards Phocis; but the Persian and Bœotian cavalry still kept the field, and afforded considerable protection to the flying infantry. The Lacedemonians and Athenians, however, having succeeded in carrying the Persian camp by assault, a dreadful slaughter ensued; and, excepting the detachment which had escaped under Artabazus, only 3,000 finally survived of 260,000 Asiatics, who composed the rest of the army of Mardonius. In the mean time, the Grecian fleet, which had remained during the summer inactive at Delos, was encouraged, by a private assurance of the favourable disposition of the Ionians, to attack the Persian fleet at Samos. The Persian admiral, having suffered the Phenician squadron to depart, in the idea that the season was too far advanced for naval operations, as soon as he received intelligence of the approach of the Greeks, hastily sailed from Samos; and, passing to the opposite promontory of Mycale, drew his galleys upon the beach, and prepared to defend them on shore.

Battle of Mycale.

The Greeks, resolving to attack the fortified camp, disembarked their forces in two divisions, one under the command of Xanthippus the Athenian, and the other led by Leotychides the Lacedemonian. The former arriving first at the Persian entrenchments, immediately commenced the assault; and, aided by the Greeks in the Persian service, had entered the rampart, before the Lacedemonians came up. The other Asiatics instantly fled from the Athenian assailants; but the native Persians resisted with the utmost bravery, till the arrival of the Lacedemonians, when they were completely overpowered, and almost entirely cut to pieces. The victorious Greeks, after carrying off the most valuable part of the spoil, set fire to the camp, and consumed the whole of the Persian fleet on the very same day that their army was annihilated at Platæa. This successful resistance of Greece to the Persian invasion, holds out an encouraging example to all free states, to maintain their independency against any power, however formidable; and clearly shews, that an obstinate determination never to submit, accompanied with wise counsels and steady discipline, will

Greece.

Farther successes of the Greeks.

rarely fail of ultimate success. The Persian war, indeed, was not yet terminated. The Greeks, in their turn, became the assailants and invaders. They prepared to protect the Ionians, who had thrown off the Persian yoke, and particularly to restore freedom to those Grecian cities in which the Persians had left garrisons. Under the Spartan general Pausanias, but especially under Cimon the Athenian, they carried their victorious arms to Byzantium, to the island of Cyprus, and even into Egypt. By a double victory gained on the river Eurymedon, under the last mentioned commander, both over the fleet and army of Persia on the same day, its naval strength was so broken, and its land forces so disheartened, that offensive operations against Greece were totally intermitted; and it became the boast of the Grecian states, that no armed ship of Persia was to be seen westward of the Chelidonian islands, or the entrance of the Euxine, and that no Persian troops dared to shew themselves within a day's journey of the Grecian seas. But the ambitious views, and political jealousies, which arose among the confederated states of Greece during the prosecution of these successful operations, prepared greater evils for their country than all that they had endured, while struggling under the pressure of the Persian hosts. The Athenians, though apparently the greatest sufferers by the invasion, derived the greatest benefits from its effects. They found their country laid waste, and their city in ruins; but, in consequence chiefly of their naval superiority, and a succession of great commanders, they rapidly attained that supremacy in Greece, which the Lacedemonians had hitherto enjoyed; and by the able conduct of Cimon, the most distinguished of all their leaders, soon reached the summit of their political influence and military power. The Lacedemonians had not been inattentive observers or inactive opponents of the growing consequence of the rival state; but, usually slow in their counsels, (and weakened by an earthquake which laid their capital in ruins, and by a consequent insurrection of the Helots, which reduced them to the necessity of requiring aid from their neighbours,) had long evaded an open rupture with the Athenian republic. The latter people, however, accustomed to war, elated with success, swayed by a turbulent democracy, and unable longer to disguise their ambitious designs upon the liberties of Greece, not satisfied with repeated interferences and aggressions against the ancient allies of Lacedemon, proceeded at length to make a direct and unjustifiable attack upon its armies, while returning from the protection of Doris, against the inroads of the Phocians. Aided by the Argians and Thessalians, they met the Lacedemonians and their Peloponnesian allies at Tanagra in Bœotia. After a severe action of two days, and great slaughter on both sides, the Athenians were compelled to retreat, and the Spartans pursued their march without farther obstruction.

Divisions among themselves.

In the view, however, of raising a state without the peninsula, to balance the power and curb the ambition of Athens, they formed a close alliance with the Thebans, and willingly seconded their attempt to recover that supremacy in Bœotia, which they had been accustomed to claim before the event of the Persian war. But the Athenians under Myronides speedily regained the influence which they had lost by their defeat at Tanagra; and all Bœotia, with the exception of Thebes, was brought either into their alliance, or under their dominion. Burdened at length by the variety of their military operations, and even by the extent of their conquests, they were disposed to enter into negotiations with their Peloponnesian adversaries; and by the good offices of Cimon, whom they recalled from exile, and who had always been greatly esteemed at Lacedemon, a truce for five years was concluded between the rival powers. But, after the death of that distinguished commander, who had uniformly exerted himself to divert the military spirit of the Greeks from internal wars, hostilities were again renewed. The Athenians, however, being hard pressed, and even invaded by the Peloponnesian confederates, as well as encumbered by the numerous islands and colonies subject to their empire, a second time sought an accommodation; and a truce was concluded for the space of thirty years, upon terms by no means advantageous to their influence. But the constitution of Greece, composed of so many small and independent states, was unfavourable to a long continuance of general tranquillity. Its governments were so distinct, that no common authority could prevent the occurrence of partial wars; and yet so connected, that war in any part always endangered the peace of the whole. This was more especially the consequence of a practice, which had become universal among the weaker states, to provide for their protection by courting the alliance, or rather acknowledging the dominion of one of the two leading republics of Lacedemon or Athens. These two rival powers also differed considerably in the political principles which they respectively favoured, the former being generally the patroness of aristocracy, and the latter of democracy. Hence their influence was extended according as one or other of these opposite factions prevailed in the different states; or rather, according as their arms were severally crowned with success, the party to which they were friendly gained the ascendency, and succeeded in bringing the state which it ruled to the side of Sparta or of Athens. This constant rivalship, never wholly dormant, and kept in continual excitement by the frequent quarrels of the minor commonwealths, at length gave rise to the long and bloody contest of the Peloponnesian war. The Athenians, having assisted the Corcyræans against the Corinthians, were formally accused by the latter people, joined by many other complainants, of having broken the truce, and insulted the Peloponnesian confederacy. An assembly of deputies from the different states, of which that confederacy was composed, having met at Sparta, a great majority decided for an immediate recourse to arms; and even the historian Thucydides admits, in the most explicit terms, that a general sentiment of indignation had been excited among a large portion of the Grecian people, by the arbitrary and oppressive sway of the Athenian republic. See Aristides, &c.

Greece.

B. C. 44[illegible]

Circumstances unfavourable to tranquillity in Greece.

Origin of the Peloponnesian war.

The two hostile confederacies, though very differently composed, divided between them very equally the force of the Greek nation. All the Peloponnesian states, except the Argians, who remained neutral, joined the Lacedemonians. In Northern Greece, the Megarians, Bœotians, Locrians, Phocians, &c. formed a part of the same alliance; and external assistance was expected from the king of Persia, and the Grecian colonies of Italy and Sicily. The Athenians had few allies, and some of them not very zealously inclined to their cause. The principal were the Thessalians, and Acarnanians, and the islands of Corcyra, Zacinthus, Chios, and Lesbos. But all the other islands of the Ægean Sea, except Melos and Thera, and all the wealthy Grecian cities of Thrace, of the Hellespont, and of Asia Minor, were tributary subjects of Athens, and entirely subject to its controul. The Spartan king Archidamus,

State of the contending parties, B. C. 4[illegible]

Greece.

who had the chief command of the Peloponnesian forces, amounting to 60,000 men, advanced slowly to the invasion of Attica; but, before actually commencing hostilities, he once more proposed the terms of accommodation, which the Athenians had formerly rejected. The celebrated Pericles, who had long directed the councils of Athens, and who is supposed to have plunged his country into war, for the purpose of prolonging his personal influence in the state, easily induced his fellow citizens to refuse all farther negociation; but all his extraordinary talents were necessary to persuade the Athenian people to adopt the measures of defence, to which they were reduced by the power of their enemies. Abandoning their country to the ravages of the hostile army, they were compelled to secure themselves and their effects within the walls of the metropolis, filling the temples, the turrets of the ramparts, the tombs, even, and the lowest hovels, with their wives and children. Pericles, reproached and threatened as the principal author of their calamities, and vehemently urged to meet the invaders in the field, directed all his attention to the defence of the city, and the preservation of good order. The Lacedemonians and their allies, having exhausted the means of subsistence, and loaded themselves with plunder, returned to Peloponnesus, and dispersed to their respective cities. The Athenian fleet, in the mean time, ravaged the coasts of Peloponnesus, taking, in its return, the island of Ægina; and, towards the end of autumn, Pericles, with the whole of the land forces, laid waste the neighbouring territory of Megara. At the commencement of the second summer, the confederates under Archidamus again entered and ravaged the country of Attica; while a more dreadful scourge, a pestilential fever resembling the modern disease of the plague, raged in the crowded streets of the city. The war, however, was not arrested by this awful calamity; and, for several years was regularly conducted in the same manner. The Peloponnesian states were so superior in land forces, that they annually invaded the territories of the Athenians, who could not risk a general action, without exposing themselves to certain ruin; yet the confederates were, on the other hand, so ignorant of the art of attacking fortified places, that they could make no impression upon a city like Athens, defended by 30,000 men, and supplied by a powerful fleet. The war thus continued to rage, for many years, with nearly the same success, and equal losses on both sides. It consisted in a succession of partial engagements, hasty excursions, and distant sieges, which never affected the main object in view, or brought the contest one step nearer to a conclusion. Partaking also in a great degree of the nature of a civil war, it was carried on with a spirit of ferocity rarely exemplified among civilized nations; and, though the time of its continuance, the very age of Socrates himself, was an era, at least in the history of Athens, characterised by the high perfection to which arts and sciences, philosophy and refinement, had been brought; yet, in no period of Grecian history, were more atrocious barbarities committed. Every transaction has been minutely recorded by the Athenian historians, Thucydides, and Xenophon, who were contemporary with most of the events, which they describe; and our account must be greatly compressed, not from the scarcity, but from the abundance of materials. The league, headed by the Athenians, was almost entirely under their command; while that of Peloponnesus, being composed of independent states, was continually changing in its component parts, and liable every instant to be utterly dissolved. Had the Athenian people therefore steadily adhered to the plan of Pericles, and, renouncing every idea of conquest, confined themselves to a defensive war by land, and offensive operations by sea, they might ultimately have triumphed over their numerous opponents; and, at least, have inflicted more serious injuries than they could have received. From the excessive diversity and disproportion of the forces engaged in the contest, the one over-running the land, and the other scouring the seas and coasts, the war was inevitably spun out to an indefinite length; and often were both parties, wearied of their accumulated sufferings, desirous of peace; but proposals for negociation were as often prevented by the vain ambition of Cleon, who had succeeded, at the death of Pericles, to the direction of the Athenian counsels, and by the warlike spirit of Brasidas, the bravest of the Spartan leaders. After their death, a truce was concluded for the space of fifty years; and every thing was restored to the same situation in which it had stood at the commencement of hostilities: but mutual hatred, and boundless ambition, had acquired such hold of the minds of the principal men on all sides, that the appearance of concord was of short duration. New leagues and dissensions arose, which led to reciprocal recriminations and partial hostilities; but it was not till the expiration of nearly seven years, that they again came to an open rupture. Athens was the aggressor, and the ambition of Alcibiades was the sole cause of the renewal of hostilities. This celebrated character, with all his accomplishments and talents, was guided by principles so inveterately vicious, that he alone may be charged with having accelerated the ruin of the Athenian state, and completed the corruption of its citizens. He persuaded the people, without any other reason, except that the city Egesta in Sicily had solicited the assistance of the Athenians, to undertake the conquest of that island; but, scarcely had the expedition, in which he was appointed a commander, commenced its operations, when he was recalled to stand his trial, upon a charge of impiety. Aware of the caprices of his countrymen, he took refuge in Peloponnesus; and, enraged by the sentences pronounced against him in his absence, he instigated the Lacedemonians to assist the Syracusans, and to attack the Athenians, while their army was engaged in the remote and romantic enterprize which himself had planned. The Sicilian expedition terminated in the most disastrous manner; and almost the whole of the Athenian army was destroyed or taken captive. The Lacedemonians, supported by a powerful confederacy, and assisted even by the Persian viceroys, invaded Attica, blockaded the city of Athens, and would speedily have terminated the war by its reduction. But Alcibiades, having been expelled from Sparta on account of his licentious practices, exerted himself to detach their Persian allies, and to retrieve the falling hopes of his country. Recalled by the army, and raised to the chief command by the unanimous acclamations of the people, he recovered many of the lost colonies, defeated the fleet of the confederates, and so alarmed the Lacedemonians, that they were ready to have treated for peace. But the Athenians, intoxicated with success, prolonged the war; and, insensible to their interest, again threw away the instrument of their victories. Their fleet having sustained a trifling loss while Alcibiades was absent, and employed in levying contributions in Ionia, for the support of the forces, he was instantly disgraced by the fickle voice of the populace;

Truce concluded B. C. 422.

War renewed.

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Greece.

and the power of Peloponnesus again acquired the ascendency. The confederates, taught by experience, had exerted themselves to increase the number of their ships, and had at length succeeded in attaining also a portion of that maritime skill, which had hitherto given to the Athenians so decided a superiority by sea. The Athenian navy, however, trusting to their long acknowledged eminence, and elated by a victory which they had gained over the Spartan fleet at Arginusa, near Lesbos, despised their enemies, and neglected all ordinary precautions, with unexampled imprudence. Lysander, the ablest of the Lacedemonian generals, having succeeded to the command of the allied fleet, and taken the city of Lampsacus upon the coast of the Hellespont, resolved to avail himself of that self-confidence which guided the counsels of the Athenian captains. In order to increase their insolent security, he repeatedly declined battle, which they daily offered him, but kept his own crew prepared for action at a moment's warning. Having learned that they regularly drew their fleet ashore on the open beach at Aigospotami, on the opposite coast, not more than two miles from his own station, and then suffered the soldiers and crews to disperse over the adjoining country in quest of lodgings and provisions; he easily found means to surprise them in this unguarded condition, made himself master of their whole fleet except nine galleys, and took prisoners the greater part of their forces, by which it had been manned. A striking instance now occurred of that savage barbarity, with which the different powers in the Peloponnesian war were generally chargeable. The Athenians had resolved, in their assurance of victory, to cut off the right hand of every prisoner whom they should capture; and this intended cruelty, with many similar acts which they had perpetrated, was immediately requited by a general massacre of the captives at Aigospotami. Lysander, with his own hand, cut down their general Philocles, after reproaching him with having first set the example among the Greeks of such violations of the laws of war; and, upon this signal, about 3000 Athenian citizens were butchered in cold blood, by the allied troops. The Lacedemonian commander, now completely master of the seas, speedily reduced the principal colonies and dependencies of Athens; and then hastened, with a fleet of 200 galleys, to blockade the port of that devoted city, while the land forces of the confederates, at the same time, surrounded its walls. No assault was attempted, and its reduction was left entirely to the sure operation of famine. The haughty and turbulent citizens discovered not even the courage of despair in their defence; but were solely anxious to avert the sentence of utter extermination, with which they were threatened by some of the allied states. The Lacedemonians, however, probably as much from policy as generosity, secured for them more favourable terms, and saved their persons from servitude and slaughter. But it was determined, as a measure absolutely necessary to the safety and repose of Greece, that their tyrannical spirit should be effectually humbled, and their power as a state entirely broken. They were spared upon the following conditions; that all their ships of war should be surrendered, except 12; that the long walls and the fortifications of Peiræus should be destroyed; that all exiles and fugitives should be restored to the rights of the city; that the Athenians should hold always as friends or enemies those states, who were the allies or the adversaries of Lacedemon; and should be ready to attend the Spartan power, by sea or land, as they might receive orders. These terms being accepted, the Spartan fleet entered the Peiræus, and the army took possession of the walls. The fortifications, which had been condemned, were instantly thrown down, to the sound of military music, and their demolition celebrated with triumph as an æra of recovered freedom to Greece. The popular assembly was abolished; the government changed from democracy to oligarchy; and thirty magistrates were appointed to form the new administration of the commonwealth. Such was the termination of the Peloponnesian war, in its twenty-seventh year; and Lacedemon, now in alliance with Persia, having again become the leading power in Greece, the aristocratical interest reigned paramount in almost every Grecian state. See Alcibiades, &c.

Decisive defeat of the Athenian fleet at Aigospotami, B. B. 404.

Athens reduced to the last extremity.

Sparta having recovered her influence in Greece, acted not less tyrannically than on former occasions; and, under the ambitious projects of Lysander, became daily more corrupted in her principles of policy. The thirty magistrates, who had been placed at the head of the Athenian state, were supported by assistance from Lacedemon in the most atrocious acts of cruelty and injustice; and the other Grecian cities were prohibited even to afford a refuge to the unhappy Athenians, who fled from their oppressors. Not contented with cutting off their political adversaries, the thirty tyrants, under the direction of Critias, proceeded to murder, upon frivolous pretences, all persons whose riches they wished to seize; and the slightest murmur against their oppressions was punished with imprisonment, exile, or death. In the space of eight months, fifteen hundred citizens were sacrificed to their avarice or vengeance; and Xenophon goes so far as to affirm, that their short reign was more destructive to Athens, than the preceding war of thirty years. At length, however, Thrasybulus, at the head of his exiled countrymen, drove the tyrants from their seat of abused power, and restored the ancient democratical form of government at Athens. By his wise moderation, the spirit of retaliation was restrained, a general amnesty proclaimed, and tranquillity restored to the Athenian state. But whatever was the form, tyranny was too generally the spirit of the Grecian governments, and especially of the pure democracy at Athens. Equally unjust and cruel as the most lawless despots, they were often much more inconsistent with themselves, and fickle in their proceedings. While they allowed their poets, for their amusement, to ridicule the gods upon the stage, they punished their sages, who endeavoured, for their instruction, to introduce worthier sentiments of religion. By their sentence, the celebrated Socrates, (whom even the thirty tyrants had spared, though he often opposed their measures,) was iniquitously put to death.

Opp... of ... by ... thirty ... rant...

Tyr... char... Gre... vern...

The Greeks were again involved in a contest with Persia, by the attempt of Cyrus the younger to dethrone his brother Artaxerxes. That ambitious prince being governor of Asia Minor, and friendly to the Spartans, persuaded them to join his standard with 13,000 Grecian troops; but, excepting their leader Clearchus, they are said to have been entirely ignorant of his views upon the Persian crown. The celebrated retreat of the remains of this army, after the death of Cyrus, generally called the retreat of the ten thousand, is considered as one of the most extraordinary exploits recorded in the annals of the military art; and, by proving the weakness of Persia, is supposed to have had considerable influence in promoting the Macedo-

The... assi... aga... A... taxes. B. ...

ece.

nian invasion, and conquest of that extensive but feeble empire. It had the more immediate effect of encouraging an expedition, under Agesilaus king of Sparta, to recover the liberty of the Grecian colonies in Asia. Assisted by 30 captains, with Lysander at their head, he filled all Asia with a dread of his arms; and was preparing to carry the war into the heart of the empire, when he was suddenly recalled for the protection of his own country. The Persian monarchs had discovered a more easy and effectual defence against Grecian valour, than their most numerous armies had been able to provide; and, by a seasonable distribution of bribes among the leading men of the different states, succeeded in turning the arms of these warlike republics against one another. The Thebans were first gained to their interests, who easily succeeded in persuading the Athenians. Even Argos and Corinth, two Peloponnesian states, joined the confederacy, to which were added Acarnania, Ambracia, Leucadia, Eubœa, part of Thessaly, and Chalcidice in Thrace. The haughty tyranny of Lacedemon furnished sufficiently ostensible reasons for the union; and Persian gold readily supplied the arguments which were wanting. The confederates sustained a severe check in the vicinity of Corinth, and were afterwards defeated by Agesilaus at Coroneia with great loss on both sides; but Pharnabazus, assisted by the Athenian commander Conon, having defeated the Lacedemonian fleet, completely destroyed their influence in Asiatic Greece. They proceeded even to ravage the coasts of Laconia; and, assisting the Athenians to rebuild their long walls, which connected the Peiræus with the city, again laid the foundation of their naval power. After various vicissitudes and intrigues, all parties became tired of war, and disposed to peace. The Lacedemonians, though still superior in the field, yet destitute of the aid which they had formerly derived from the Persian treasury, were straitened in their pecuniary resources; and Pharnabazus, the friend of Athens, having been succeeded in Lydia by Teribazus, the new Satrap became favourable to the interests of Sparta. By the able negociations of Antalcidas the Lacedemonian, the Persian monarch was brought in as mediator, or rather dictator, for a general pacification among the states of Greece, of which the conditions were simply these; "that all cities on the continent of Asia, together with the islands of Clazomene and Cyprus, should belong to the Persian empire; and that all other Grecian cities, small and great, should be completely independent, except that the islands of Lemnos, Imbros, and Sciros, should remain as formerly under the dominion of Athens." Against all who should refuse these terms, the court of Persia declared itself ready to unite with those who accepted them, and to render every assistance, by land and sea, to reduce the refractory. The weaker states were well pleased to be secured in their independence. The Athenians were gratified, by the exception in their favour. The Thebans, anxious to preserve their authority over the smaller towns of Bœotia, wished to stipulate for that superiority; but were compelled to concur in the terms. And the Lacedemonians, while they lost nothing by abandoning the Asiatic Greeks, whom they had already been obliged to desert, gained the great object of the war,—the separation of the states which had combined against them, and the emancipation, especially, of the Bœotians from the growing power of Thebes. They soon shewed that they accounted themselves to have established their supremacy; and were the first to disturb the general tranquillity. They demolished the fortifications of Mantinæa, as a punishment for the disaffection of its citizens to the Lacedemonian interests, during the preceding wars. They marched against Olynthus, a Grecian city of Thrace, because, by associating the smaller towns in its vicinity under one government, it was considered as infringing the conditions of the late treaty; though its only offence was the increase of its strength by a wise and liberal policy, which ought to have been emulated, rather than opposed by the other Greeks. They interfered also, in the most unjustifiable manner, in the political contests which agitated the Theban state; and, by this rash measure, gave rise to a long and complicated struggle, which ended only with the general overthrow of Grecian independence. Their general Phœbidas, returning from an expedition against the Olynthians, was persuaded to join the leader of the aristocratical party in Thebes, and to occupy the citadel with a Lacedemonian garrison. This unauthorised step, though at first disapproved by the government of Sparta, was finally sanctioned by their retaining possession of the fortress thus treacherously seized, and by their bringing to trial and punishment the chief of the adverse faction, as if they had been the constituted judges of Thebes. For the space of four years, they succeeded in holding the Thebans under the most humiliating subjection; but suddenly the Theban exiles, with the assistance of the Athenians, by one of the boldest and best conducted exploits recorded in history, recovered possession of their power in the city, and compelled the Lacedemonians to evacuate the citadel. With difficulty the Thebans at first withstood the armies of Sparta, by acting on the defensive; but gradually improving in military skill, they learned to face in the field, and to combat, even with inferior numbers, the experienced troops of their powerful adversary. Under the able direction of Epaminondas and Pelopidas, they ventured, though then without an ally, to persevere in the unequal contest; and, in the famous battle of Leuctra, the bloodiest action hitherto known in Greece, these distinguished commanders, by their skilful dispositions, and the enthusiastic courage which they inspired their troops, defeated an army nearly four times the number of their own. Never had the Lacedemonians, before that day, retreated from an inferior force, or lost in any one engagement so many of their citizens. Another of their boasts, "that never had the women of Sparta beheld the smoke of an enemy's camp," was now also done away.

Their occupation of Thebes. B. C. 382.

Defeated at Leuctra. B. C. 370.

City of Sparta threatened.

The victorious Thebans, headed by Epaminondas, and joined by many of the Grecian states, ravaged the Lacedemonian territories to the very suburbs of the capital; and on their return reinstated the Messenians, whom the Spartans had driven from their country. The Lacedemonians, alarmed not merely for their supremacy but their safety, secured assistance from Athens, from Syracuse, and even from Persia, while the Thebans were hard pressed by a war in Thessaly, against Alexander, tyrant of Pheræ. Pelopidas, however, having been dispatched to the Persian court, succeeded in recommending himself to the esteem of the monarch, and in turning his friendship to a state which had never been at war with Persia. Thebes, intoxicated with her rising power, which she owed chiefly to the abilities of her leaders, obstinate in maintaining her authority over the cities of Bœotia, which was perhaps necessary for her resistance to Lacedemon, and aiming to become the arbitress of Greece, which her sudden elevation provoked many of the states to regard as unpardonable presumption, may be considered as at this period the cause of the continuation of hostilities among the Greeks.

Greece.

Sparta, however, was equally obstinate in refusing to acknowledge the independence of the Messenians, and war was prolonged for some time with little effect, chiefly between the confederates of the two principal powers. The Thebans, having at length terminated the war with Thessaly, with the loss of their able general Pelopidas, were at liberty to take part more effectually in the transactions of Peloponnesus. A civil war having broken out in Arcadia between the cities of Mantinæa and Tegea, the Thebans supported the cause of the latter, while the Athenians and Lacedemonians declared for the former. The very existence of Sparta was threatened by the bold and enterprising measures of Epaminondas, who had nearly taken the city by surprise; but, frustrated in his plan by the activity of Agesilaus, he returned and gave battle to the Lacedemonians and their allies at Mantinæa, where he was mortally wounded in the moment of victory, and where with him the power of the Theban state expired. A general pacification succeeded, upon the basis of the former treaties prescribed by Persia, that every city should be independent; but the Lacedemonians still persisting in their wish to reduce the emancipated Messenians, were excluded from the treaty, and remained nominally at war with the confederates of Thebes. Exasperated by the friendly dispositions which the Persian court had manifested to the Thebans, and perhaps expecting to acquire some pecuniary resources for the recovery of their power in Greece, they sent an army to aid the insurgents in Egypt. After the death of Agesilaus, on his return from Africa, little occurs in the history of Greece deserving of notice, till the appearance of Philip of Macedon. A great change had taken place in Grecian politics. There was now no leading state, either of the aristocratical or democratical interests; and, though every city exercised a jealous watchfulness to prevent any overbearing superiority in another, there were no extensive confederacies or hostilities; but lassitude, indecision, and divisions, pervaded the nation, and paved the way for the universal subjugation of their liberties by the Macedonian monarchy. See Agesilaus, Epaminondas, &c.

Battle of Mantinæa. B. C. 363.

Spartan army sent to Egypt.

Irregular and ineffective administration at Athens.

In consequence of the blow given to the Spartan power in the battle of Mantinæa, and the decline of Thebes after the loss of Epaminondas, Athens remained the most prominent and respected of the Grecian republics. In want, however, of any salutary check from a powerful rival, its government became extravagant and irregular in the most extraordinary degree; the inconsiderate voice of the multitude deciding every measure, frequently ratifying at night what they had rejected in the morning, and ready to follow every varying scheme of every flattering orator. The citizens also, sinking into unbounded luxury, declined all military service, and resorting to the aid of mercenaries, engaged in hostilities chiefly for the purpose of collecting plunder, or of extorting tribute. Every marauding expedition was approved, provided the leaders brought home a sufficiency of treasure to provide amusements for the people, and to bribe the orators to silence. The official men, in short, inadequately rewarded by their regular salaries, learned, as is almost uniformly the case, to recompense themselves; and the people, either become necessitous by their idle attendance on political matters, or injudiciously supported by the public funds as an encouragement to population, actually depended for their subsistence upon the sacrifices, feasts, and spoils connected with their military expeditions. While Athens was in this situation, strangely feeble in the whole constitution of its government and population, yet by means of its naval force still the principal republic in Greece, a rival to its power arose in a quarter, which had hitherto attracted little attention, and had even been regarded by the Grecian states as undeserving of their notice. Though the kings of Macedonia pretended to be the descendants of Hercules, the Greeks considered them as no part of their nation, but always treated them as barbarians. This kingdom had existed more than four hundred years, but had generally stood in need of protection from Athens or from Sparta; and had never risen to a capacity of partaking in the eminence of these republics. But it now furnished an example, similar to that of Thebes, of the power of one distinguished individual to accomplish, in favourable circumstances, the most important revolutions. It was in Thebes, indeed, that the new leader of the Macedonians had received his best instructions in the arts of policy and war. Philip had been taken to that city as a hostage when he was only ten years of age, and had been carefully educated under the eye of Epaminondas, assisted by the celebrated Pythagorean philosopher Lysis. At twenty-four years of age he ascended the throne of Macedon, and gave early indication of his talents for government. At the period of his accession, he found himself at war with the Athenians, who supported one of his competitors for the kingdom. Having defeated his adversary, who was slain in the action, he instantly liberated, and loaded with favours, all the soldiers of Athens whom he had taken prisoners. Having discovered, that the Athenians were intent upon the recovery of Amphipolis, which they claimed as one of their colonies, but which he had seized as the key of his dominions on that frontier, he was equally reluctant to put it in their power, or to come to a rupture for which he was not prepared. With his usual consummate policy, therefore, he declared it in the mean time a free city, and left the inhabitants to maintain their own independence. A peace and alliance were ratified between the Macedonian prince and the city of Athens; but their agreement was of short duration. A contest speedily commenced, which led to the subversion of Grecian freedom by the arts and arms of Philip; but which owed its origin as much to the unprincipled aggressions of the Athenian democracy, as to the ambitious views of the Macedonian monarch. While in full alliance and co-operation with Philip against the Olynthians, they suddenly indicated their hostility to his interests, by detaching the town of Pydna from his kingdom, and making a direct attempt to possess themselves of Amphipolis. Failing in their design, it was soon after occupied by Philip, and rendered a strong barrier between his dominions and those of the Grecian states. Before this time had commenced "the Sacred War," undertaken by the Bœotians, Locrians, Thessalians, &c. in order to punish the Phocians, who had ploughed a field sacred to Apollo at Delphos, and had refused to discharge the fine which the council of the Amphictyons had sentenced them to pay, as an atonement for the sacrilegious deed. They were supported by the Lacedemonians, Athenians, &c. and Philip, well pleased to leave the Grecian states to exhaust their strength against each other, had employed himself in the meantime in extending his power in Thrace, and in attaching Thessaly to his interests, by delivering its cities from the oppressive sway of the tyrants of Pheræ. Irritated, however, by the defection of Olynthus from the Macedonian to the Athenian alliance, he laid siege to that city; and, having gained possession of the place

Grec[...]

Growi[ng] power [of] Maced[on].

Acces[sion] of Ph[ilip] the th[rone] of Ma[cedo]nia. B. C.

Rup[ture] betw[een] Athe[ns and] Phil[ip]. B. C.

Orig[in] of the S[ac]red War

Greece. by bribing a party of its inhabitants, he razed its walls to the ground, and sold the people for slaves. The Sacred War, which was still carried on by both parties with the most sanguinary retaliations, next afforded him a fair opportunity of bringing his power into full contact with the Grecian states. Professing to adjust, as arbitrator, the matter in dispute, promising to the Phocians his protection against the fury of their enemies, and soothing the Athenians by the reports of his friends, that he was secretly intending to humble Thebes rather than Phocis, he marched an army into Greece; gained quiet possession of the Phocian cities; secured to that people, as he had promised, their personal safety; but procured, or at least sanctioned, a decree of the Amphictyonic Assembly, annihilating their political existence as a nation, and expelling them from the number of the Grecian states represented in the council. He was himself elected in their place as a member of the Assembly; invested with the double vote which they had enjoyed; and usually denominated in their future operations the Amphictyonic general. The Athenians refused to acknowledge his election; and manifested, in all their measures, an ambition even more unprincipled and indefensible than that of the Macedonian monarch. Guided rather by the inflammatory eloquence of Demosthenes, than by the pacific counsels of Phocion, they plunged at length into a destructive contest with their powerful rival and neighbour.

Termina... by Phi... B. C. 347.

A second sacred war again drew Philip into the midst of Greece. The Locrians of Amphissa having encroached upon the consecrated ground of Delphos, and having refused to obey the decrees of the Amphictyonic council, the Macedonian monarch was invited, as their general, to vindicate their authority by force of arms. Many of the Grecian states were now alarmed, and not without reason, by the forwardness of Philip to interfere in their politics, and by the reluctance which he shewed to withdraw his army, after the punishment of the Amphissians. Demosthenes hastened to Thebes, where he succeeded in rouzing the utmost enthusiasm for the liberties of Greece, and persuaded the Thebans to adopt the immediate resolution of uniting with the Athenians, to resist the dangerous progress of the Macedonian influence. In vain did Phocion recommend, and Philip request, the Athenians to lay aside their measures for instant hostilities. They excluded the former from the command of their army, and marched without delay to join their Theban allies against the enemy. The two armies, consisting of about 30,000 on each side, came to a general engagement at Cheronea. The battle was long doubtful. Alexander, who was only seventeen years of age, at the head of a chosen body of noble Macedonians, cut down the Sacred Band of Thebes; and the Athenians, for a time successful, but urging their advantage with imprudent impetuosity, were overwhelmed by the Macedonian phalanx under Philip. The vanquished were treated with a degree of clemency and generosity, of which there had been few examples in Grecian warfare. Philip hastened to stop the slaughter of the flying Greeks, and dismissed the Athenian prisoners without ransom, and voluntarily renewed his former treaty with that republic. To the Thebans he readily granted peace; but stationed a Macedonian garrison in their citadel. By this decisive victory, he secured the most entire ascendancy in Greece; and, on that side, there was little farther left for his ambition to desire.

...w reli... war.

...e of ...onea. ... 338.

Either, however, with a view to extend his conquests, or in order to unite the Greeks more firmly under his power, he planned the invasion of the Persian empire, and procured himself to be appointed generalissimo in the expedition. No measure could have been conceived more popular in Greece. A general council of the states was summoned, and the quota determined which each of them was to furnish. Philip exerted himself with extraordinary activity to complete his formidable preparations; and his whole army, in the most perfect state of military discipline and equipment, was in readiness to cross the Hellespont. But, in the midst of his greatest splendour, while solemnizing, before his departure, the nuptials of his daughter Cleopatra, surrounded by his guards and principal officers, and receiving, among the assembled states of Greece, little less than divine honours, he was stabbed to the heart by a desperate assassin. See DEMOSTHENES, and PHILIP.

Philip meditates the invasion of Persia; but is cut off by an assassin. B. C. 336.

Upon the accession of Alexander to the throne of Macedonia, when only twenty years of age, the different nations whom his father had brought under his dominion made an attempt to regain their independence; and Demosthenes exerted all his powers of persuasion to engage the Greeks to unite against the youthful successor of the formidable Philip. But Alexander, having punished the Thracians, Illyrians, and other barbarians, for their indiscretion, turned, with the utmost expedition, the whole weight of his arms upon Greece. The Thebans, who had massacred the Macedonian garrison, which Philip had placed in their citadel, having refused the offer of a free pardon made to them by Alexander, upon condition of their surrendering the principal leaders of the insurrection, were defeated with great slaughter, their city given up to be pillaged, and the inhabitants sold as slaves. These dreadful acts of severity filled the Athenians with alarm, and an embassy was instantly dispatched to implore the clemency of the Macedonian prince. Alexander at first insisted that ten of their principal orators should be delivered into his hands; but was at length satisfied with the banishment of Charidemus, and expressed the highest regard for the republic of Athens. The other states hastened, in like manner, to make their submission; and, in one campaign, the whole nation of the Greeks acknowledged his supremacy. Having assembled their deputies at Corinth, and renewed the proposal of invading the Persian empire, he was appointed, as his father had been, to the chief command. His rapid conquest of Persia, which would form too extensive an episode in this brief sketch of Grecian history, and which must therefore be passed over without detail, produced one of the most extraordinary and important revolutions in the political aspect of the world. No national contest recorded in history was ever more interesting in its progress, or involved consequences of greater magnitude, than the struggle which had so long been maintained between Persia and Greece. Its object was to decide the great question, whether Europe or Asia should have the ascendancy; and at length, under the auspices of the Macedonian prince, the former gained a superiority, which it has preserved to the present day. During the progress of Alexander's conquests, various attempts were made by the Grecian states to shake off the yoke of Macedonia. The Spartans especially, under the direction of their king Agis, excited a powerful insurrection in Peloponnesus; but Antipater, who had been left to govern in Macedonia, marching a powerful army into the peninsula, completely broke their spirit by a decisive defeat of their

Accession of Alexander, who destroys Thebes, and conquers Persia. Insurrections in Greece.

forces, and the death of Agis, who fell in the pursuit. Harpalus, one of the officers of Alexander, who had incurred the displeasure of that prince by his extortions, when governor of Babylon, took refuge in Athens; and, by means of his treasures, succeeded in attaching them to his cause; but, upon the report of a powerful army being dispatched by Alexander to punish their treachery, they expelled Harpalus from their city, and banished Demosthenes, who had been convicted of accepting his bribes. A new commotion also had been excited throughout all the states of Greece, by a proclamation of Alexander to restore the exiles to their respective countries and possessions; and, upon the event of his death being known, the revolt which had already commenced instantly became general. Demosthenes was recalled, and a powerful army of confederated Greeks, under the Athenian commander Leosthenes, marched against Antipater. Elated by the success which attended their first operations, they despised, as usual, the prudent warnings of Phocion, and began to calculate upon the return of their ancient greatness. But Antipater having been joined by Craterus with a part of the victorious army of Alexander, speedily reduced the insurgent states in succession; and, advancing towards Attica, as the great object of his vengeance, though in some measure softened by the intercession of the virtuous Phocion, he abolished the democracy of the Athenians, and established the aristocratical government, as it had existed in the days of Solon; obliged them to pay the expences of the war; and placed a Macedonian garrison in the port of Munychia. Similar changes were made in most of the other states; and, though the people loudly complained, in the first instance, of these infringements upon their liberties, they began at length to feel, that their freedom was in reality greater than it had hitherto been, and acknowledged their obligations to Antipater, by entitling him the Father and Protector of Greece. After the death of Antipater, the Grecian states largely shared in the revolutions and dissensions which agitated, for so many years, the empire of Alexander. Polysperchon, who had been associated with Cassander, the son of Antipater, in the regency of Macedonia, being engaged in a contest with his ambitious colleague, sought to attach the Greeks to his interests, by displacing the governors whom Antipater had placed over them, and by restoring the power of democracy. Several of the cities, particularly Megolopolis, resisted his decree, and drew upon their heads a bloody revenge. Athens, on the contrary, gladly hailed its recovered liberty; and proceeded, in its moments of renewed turbulence, to put to death the friends of Antipater. Among these perished the greatest ornament of their city, the incorruptible Phocion, who had served in the armies and councils of his country till he was above eighty years of age; and whose distinguished merit his fellow citizens soon after acknowledged, with their accustomed inconsistency, by erecting a statue to his memory, and inflicting punishment upon his accusers. But Cassander, by the aid of Antigonus, having recovered his influence in Greece, restored the aristocracy, replaced the Macedonian garrison, and appointed Demetrius Phalerius governor of the city, who conducted himself in his office with so much wisdom and moderation for ten years, that more than three hundred statues are said to have been erected in testimony of his benefits. The power of Cassander prevailed also in Peloponnesus; and, excepting a very few cities, Greece was again entirely subjected to the Macedonian dominion. See ALEXANDER.

General revolt at the death of Alexander. B. C. 323.

Antipater settles the affairs of Greece.

New changes by Polysperchon.

Athenians put Phocion to death.

Prosperity of Athens under Demetrius Phalerus, B. C. 317.

During the revolutions which agitated Macedonia, after the death of Cassander, it was invaded and overrun by an immense body of Gauls, who pursued their course like a torrent, and poured upon the enfeebled states of Greece with the utmost fury. They were successfully resisted in the defiles of Thermopylæ, by the Grecian army under Calippus the Athenian; but, forcing their way by the path over mount Oeta, by which the Persians had penetrated under Xerxes, they directed their march to Delphos, with the design of plundering the temple of its accumulated treasures. But, meeting with a brave resistance from those who were assembled to protect the sacred spot, and, being thrown into confusion by a violent storm and earthquake, they fled in the utmost terror, and turned their arms upon one another, in the darkness of the night. They were keenly assailed by the Greeks in their flight, and the greater part of them cut to pieces. Scarcely recovering from the inroad of those barbarians, the states of Peloponnesus were involved in new calamities, by the ambitious arms of Pyrrhus king of Epire, who had reduced the greater part of Macedonia, and having been invited by Cleonymus, an exiled Spartan prince, to redress his grievances, led a powerful army to the gates of Sparta, while their king and the best of their troops were absent in Crete. But the inhabitants of the city, even the women, assisting in its defence, made so heroic a resistance, that time was allowed for the arrival of reinforcements; and Pyrrhus, being compelled to retreat, was slain in an attempt to enter the city of Argos. Antigonus, the son of Demetrius Poliorcetes, being again replaced on the throne of Macedonia, began to meditate the complete subjugation of Greece, and commenced his operations with the siege of Athens, which he speedily reduced, and garrisoned with Macedonian troops. Pursuing his schemes of conquest, he gained possession of Corinth by artifice, but was arrested in his ambitious career by the hand of death. His son Demetrius maintained a commanding influence in the different states of Greece, not by attempting to hold the sovereignty himself, but by supporting those who found means to usurp the supreme authority. His successor Antigonus Doson, a prince distinguished by his justice and moderation, avoided all interference in the affairs of foreign states; and the cities of Greece, imitating the example of the Achæan league, made one last attempt to recover their long lost independence.

Invasion Greece ... the Ga... B. C. 2...

Appear... of Pyrr... in Gre...

During the distracted times of Macedonia, under Lysimachus and Ptolemy Ceraunus, the cities of Achaia gradually recovered their liberties, and renewed their ancient confederacy: (See ACHÆANS.) Aratus of Sicyon, having freed his native city from the government of Nicocles, joined the Achæan league, and was chosen prætor of the associated states. Intent upon delivering Peloponnesus from foreign dominion, and hoping to render the Achæan confederation a barrier against future invasion, he surprised the Macedonian garrison in Corinth, and attached the liberated city to the Achæans. He persuaded the governor of Megalopolis to abdicate his power, and follow the example of the Corinthians. Protected by the king of Egypt against the Macedonians, the Achæan confederacy was thus extending on all sides, and might soon have united all the peninsula as one nation, under one government, when its progress was interrupted by the hostility of Sparta. The ancient institutions of that distinguished city had fallen into

Acha... league revived B. C. 30...

Imped... the ... of the Spar... tans

total disuse, and the manners of its inhabitants had become entirely changed. Many of its kings had incurred deposition, exile, and death, by their attempts to resist the torrent of corruption; and Agis particularly, a young and virtuous prince, had fallen a sacrifice to his well-intended, but ill-executed scheme for restoring the laws of Lycurgus. Cleomenes, one of his successors, revived the prosecution of the plan, but pushed its accomplishment with the spirit of a tyrant, rather than of a reformer. Having massacred the Ephori, and banished the citizens who were unfriendly to his views, and rendered himself despotic at home; he turned his arms against the Achæans, either for the purpose of gratifying his ambition, by acquiring the direction of the confederacy, or, perhaps, only with a view of securing his usurped authority in Sparta, by having an army at his disposal. So strong was the antipathy of the Achæan republics to the prospect of Spartan domination, and so great at the same time their dread of its powerful tyrant, that Aratus was urged to the ruinous resource of calling in the aid of Antigonus Doson, king of Macedonia. * Cleomenes defeated by Antigonus in the famous battle of Selasia, abandoned his ambitious projects, advised his subjects to submit to the conqueror, and sought a refuge for himself in Egypt. The Spartans were treated by Antigonus with the greatest moderation; but, from that period of its subjection to a foreign power, it sunk into insignificance, and the race of the Heraclidæ became extinct with the successor of Cleomenes. The Achæan league was still preserved entire and powerful, by the able conduct and prudent measures of Aratus; but having sought assistance from Philip of Macedonia, the son of Antigonus, against the Etolians, the inveterate enemies of Achaia, that ambitious ally, conceiving a design to subjugate the cities of Greece, and regarding the integrity of Aratus as an insurmountable obstacle in his way, caused the virtuous patriot to be secretly taken off by poison. The Romans, however, having formed an alliance with the Etolians, in order to occupy the arms of Philip, who had become the active ally of their formidable opponent Hannibal of Carthage, thus acquired a footing in Greece, which gradually led to its final subjugation, as a part of their empire. Philopœmen, the successor of Aratus, supported the cause of Philip as the professed protector of the liberties of Greece, and inspired the confederated states with an ardent love of independence, which long withstood the encroachments of the policy and power of Rome. The struggle maintained in Greece between the Macedonian and Roman interests, was languid and indecisive, while the latter were intent upon reducing the power of Carthage. But, after the conclusion of the second Punic war, more active measures were pursued against Philip. Titus Quintus Flaminius, the consul, partly by the vigour of his arms, but still more by his political dexterity, detached the Etolians, Achæans, and the most considerable of the other states, from all connection with Macedon; compelled the discomfited Philip to accept the most humiliating terms of peace; made a pompous proclamation, at the public games, of the freedom of Greece; withdrew, according to his promise, every Roman garrison from the different states; and left them in full possession of all that political independence which was compatible with the alliance of Rome. Antiochus, king of Syria, instigated by Hannibal, and aided by the Etolians attempting an invasion of Greece, recalled to that devoted country the armies of Rome, and afforded them an opportunity which they did not fail to embrace, of subjecting all that part of Europe to their growing dominion. After reducing and dismembering the kingdom of Macedonia, they were invited to assist the Spartans in a contest with the Achæan states: they soon succeeded in breaking the power of the confederacy, by seducing a part of the cities of which it was composed; and Philopœmen, generally designated the last of the Greeks, having fallen in an expedition against the revolted Messenians, it became no difficult task to accomplish the total overthrow of the confederacy, of which he had been so long the principal ornament and support. Above a thousand of the Achæan chiefs, accused of having acted in concert with Macedonia, were transported to Rome to answer for their conduct, at the tribunal of the senate. The Achæan constitution was, soon after, entirely dissolved; the whole of Greece reduced to the state of a Roman province, under the name of Achaia; and, from that period, its history comes properly to be included under that of Rome. See ACHÆANS, MACEDONIA, and ROME.

Death of Philopœmen, and subjection of Greece to Rome. B. C. 146.

But Greece, though subject to the Roman arms, soon acquired, by her arts of peace, a silent superiority over her conquerors. The victors became the disciples of the vanquished; and the most distinguished Romans learned, in the Grecian schools of philosophy, to regard the country which they held in subjection, with the gratitude and respect due to a benefactor. These considerations probably contributed to secure to the inhabitants of Greece a milder exercise of authority, and more distinguished marks of favour, than were enjoyed by any other province under the yoke of Rome. Of these arts and attainments, to which this singular people were thus indebted for higher honours and advantages than all their military prowess had been able to command, we now proceed to offer an abridged view, as a suitable conclusion to the preceding sketch of their eventful history.

The arts, literature, and science, of the Greeks.

Of the state of society and knowledge among the earlier Greeks, particularly in what has been called the heroic age, as described in the writings of Homer, some account has already been given, when narrating the events of that period: and the remarks which follow apply chiefly to those times which were posterior to the first Persian war.

Agriculture.

To agriculture, as an object of study, the Greeks paid little attention; and the care of its operations was almost entirely left to slaves. The Athenians considered themselves as having first received the common principles of the art from Egypt, and as having communicated the knowledge of it to the other countries of Greece. Attica itself, however, was adapted rather to the cultivation of fruits than of grain. Olives and barley formed its principal produce, and the citizens of Athens received their great supplies of wheat from the neighbouring states of Bœotia, or from their own colony of Byzantium. Their writers on the subject, among whom was Xenophon, have done little more than merely detail the common practices of their own times.

* The cities of Greece being so much decayed in strength, and unable to assume the attitude of independence, Aratus may be regarded as having adopted, if not the wisest, at least the only measure of security in his power. His object was to render the kings of Macedonia the allies and protectors, in place of the masters and tyrants of the united commonwealths; and, by yielding so far to an influence which could not be withstood, to procure a free regulation of their internal concerns, and particularly an exemption from the odious and oppressive presence of foreign garrisons.

Greece. **Navigation.** The inhabitants of Greece, though possessing a maritime country, surrounded with islands, and provided with excellent harbours, were extremely slow in availing themselves of these advantages; and made little progress in navigation and commerce, till after the expedition of Xerxes into Peloponnesus. After the example of Athens, especially in the course of the Peloponnesian war, the other states at length directed their attention to the maintenance of a navy; but chiefly for the purposes of warfare. The voyage of Alexander's fleet from Patala to Susa, after sailing down the Indus, was the first instance of Greeks navigating the ocean; and, previous to that expedition, they were entirely confined to the waters of the Mediterranean.

Commerce. Excepting Corinth and Athens, it was principally in the smaller states, such as Megara, Sicyon, Cos, and Cnidus, (which possessed not sufficient political influence to interfere in the general affairs of Greece,) that the arts of commerce were most sedulously prosecuted. Athens, however, was the great seat of commercial views, where every circumstance favoured the acquisition, and encouraged the expenditure of wealth. Its port, Piræus, was then the centre of the traffic of those times, and there every commodity was to be found in abundance.

Fine arts. The fine arts appear to have attracted earlier attention in Greece, than the more useful occupations; and some of the ancient medals, long prior in date to the oldest historians, exhibit a chasteness and grandeur of design, both in architecture and sculpture, for which it is difficult to account.

Architecture. The customs and circumstances of the Grecian states tended directly to encourage the progress of these arts. Three public buildings were indispensible in every city; a temple, a theatre, and a gymnasium, to which were afterwards added the baths, and portico or place of shelter for walking and conversing. In larger towns these edifices were soon multiplied, especially those for the service of religion; and every city almost forming a distinct community or nation, each required to possess these different buildings within its own walls, and strove to surpass its neighbours in the solidity and beauty of its public structures. The exertions of the Greek artists in this at once useful and ornamental study, are not therefore very wonderful; but, when it is considered, that its first architects derived their skill from those of Egypt and Persia, and that the Doric order, the foundation of all the rest, and the source of pure taste to all the architecture of Greece, was actually the most ancient, it is not easy to conceive by what accidental or intended principle of the art, a beautiful simplicity, so opposite to the enormous masses of the Egyptians, and cumbrous ornaments of the Asiatics, should have been so happily introduced; unless we ascribe it to the mere circumstance of necessity (the origin of so many human improvements) which obliged the early architects of that country to work with wooden materials: (See Civil Architecture, vol. vi. p. 529.) But in whatever way we may account for the rise of Grecian architecture, its principles have received the approbation of every enlightened people in modern times; and its three orders, the Doric, Ionic, and Corinthian, still continue to form the invariable standard of good taste in the art. *

Sculpture. The same causes which rendered the skill of the architect so much in request, equally tended to encourage the labours of the painter and sculptor; and it is a remarkable circumstance, that, in the most turbulent periods of Grecian history, the fine arts received the most distinguished patronage, and made the most rapid progress. At Athens, particularly, the genius of Greece was nourished by Pisistratus, and brought to perfection by Pericles. The most eminent sculptors of those times were Phidias, Alcamenes, and Myron, of Athens; Polycletes and Lysippus, of Sicyon; Praxiteles and Scopas of Paros; and many of the ancient statues which have escaped the ravages of time, furnish ample testimony of the progress which had been made in the art. See Drawing and Sculpture.

Painting. Of the state of painting among the Greeks, many exaggerated and incredible accounts have been given by ancient authors. They used only four colours, black, white, red, and yellow; and knew nothing of painting in oil. They are considered also as having been very imperfectly acquainted with the effects of light and shade; and many pieces of ancient Mosaic, still preserved, are not much admired as performances in painting. Both in painting and statuary, the Greek artists produced representations of the human form, which could scarcely be called natural. By taking collective views of the species, and studying accurately the physical constitution of the body of man, they combined its various and scattered excellencies in one figure, and thus exhibited, what nature never does, a model of abstract and ideal perfection. Among the celebrated painters may be mentioned Polygnotus, who received the thanks of the Amphictyonic assembly for his painting of the Trojan war, placed in one of the porticos of Athens; Apollodorus, who is supposed to have invented the art of painting in clear-obscure; Zeuxis, who displayed himself at the Olympic games, dressed in purple and gold, and, having become wealthy, gave his works as presents, because he said they were above all price; Parrhasius, who insolently presented himself to public view with a crown of gold upon his head; Pamphilus, the first who applied the principles of science to his art; Timanthes, who produced the celebrated painting of the sacrifice of Iphigenia; Apelles, who exposed his works to public view, that he might derive improvement from the remarks of passengers; and Protogenes, the rival of Apelles, who censured the extreme minuteness of his contemporary, by saying, that "he knew not when to lay down his pencil."

Music. Few things are more remarkable in the manners of the ancient Greeks, than the great importance which they attached to the musical art, which, in many of the states, was even regulated and recommended by the laws. It was considered as one of the most powerful means of influencing the sentiments of the people, and formed an essential part in the education of the youth. The ancient musicians are supposed to have been wholly ignorant of the art of performing pieces of music in different parts at the same time; and their compositions, especially the pathetic and warlike, are generally understood to have derived much of their effect from the poetry and sentiments with which they were combined.

The honours and rewards lavished upon those who excelled in the fine arts, were doubtless one principal cause of the improvement which they reached; but often were they carried to a hurtful excess, exhausting the wealth which was wanted for the support of the state, and engrossing the rewards which were due to more essential services.

* See an examination into the grounds of this preference in the Rev. Mr Alison's *Essay on Taste*, vol. ii. p. 156.

of war.

But the great occupation of the Greeks as a people, were war and politics. Leaving the ordinary labours of agriculture and the mechanical trades to the slaves, the citizens of the different states considered it as their peculiar privilege to share in the government of their country, and to fight in defence of its rights, or for the advancement of its power. Every citizen, therefore, being bound to serve in arms, was enrolled as a soldier at a certain age; and one of their regular employments was the exercise of the gymnasium, as a preparative for the toils of war. The armies were composed principally of heavy-armed infantry, attended by a number of slaves to carry the baggage, and serve in the camps, and sometimes to act as light armed troops. The arms of the infantry were a helmet, corselet, large brazen shield, leathern greaves or boots, long pike, and short sword. They were long accustomed to advance, in a compact body, to close fight; but Iphicrates, an Athenian general, introduced the employment of a greater proportion of light infantry, diminishing the weight and size of the buckler, exchanging the metal corselet for one of canvas, lengthening considerably the lance and sword, and accustoming the troops thus accoutred to the most active evolutions. That celebrated commander, describing an army as a human body, compared the general to the head, the heavy-armed infantry to the breast, the cavalry to the feet, and the light troops to the hands. Chariots were little used after the heroic age; and, for want of horses, cavalry were never numerous, generally consisting of the wealthier citizens, or of soldiers fitted out at their expence. Till the time of Philip of Macedon, the Greeks were little acquainted with the art of conducting sieges, but commonly limited their operations to a general assault, or inactive blockade. In long or distant wars, especially in the later ages of Greece, the citizens received pay, while serving in the field; but the constant object of every Grecian state was to support their troops at the expence of the enemy. Even in the most civilized periods, Grecian warfare was conducted with a spirit of rapine and barbarity, which seemed to increase, instead of diminishing, as knowledge and refinement spread among the people. Retaliation was considered as justifying the most atrocious measures, of which, in the course of the Peloponnesian war particularly, many instances occurred, in the proceedings of all parties. The Lacedemonians regularly massacred the crews of the Athenian merchant vessels, and even of neutrals, whenever they came in their way; and the Athenians deliberately decreed the extermination of the Æginetans and Scyonians, whom they put to death without distinction.

P. ics.

The Greeks distinguished six simple forms of government, namely, monarchy, hereditary or legally established oligarchy, aristocracy, democracy, tyranny, and assumed oligarchy, of which the two last were considered as illegal and inadmissible. The title of King never implied among them the possession of absolute power, but only a legal and regulated superiority, particularly in directing the observances of religion, and the operations of war, and sometimes also in dispensing justice, but rarely in enacting laws. After the general abolition of monarchy in Greece, whenever a citizen of a commonwealth was raised by any means to monarchical authority, he was denominated Tyrant, not originally as a term of reproach, though in future times it came too justly to be applied in that sense. In Athens especially, as early as the days of Theseus, the nobly-born formed a distinct class of the community, and were invested with great privileges; but hereditary nobility declined every where along with monarchy, and wealth became the principal cause of distinction among the citizens. Those who were able to serve in war on horseback at their own expence, began to be regarded as a superior rank; and to the same circumstance may be traced the order of knighthood in most countries. Aristocracy, however, was less a regularly instituted form of government, than an assumed title adopted by the rich and the noble in those states where they held the chief power; but, as their administration was generally oppressive, oligarchy, or the government of a few, became a more frequent, though less honourable form of polity; and the term aristocracy was at length employed rather to signify those persons who, on account of distinguished merit, were elected by the people to undertake the management of public affairs. This last was commonly the mode adopted in the most democratical states; and pure democracy, in which all the freemen of the republic, in assembly, formed the supreme and absolute administration, was very rarely exemplified, and was usually denominated ochlogracy or mob-rule. Most of the Grecian governments contained a union of two or more of these forms; and, from these various mixtures, new distinctions and designations arose, which it would be tedious and unprofitable to trace. Of political economy the Greeks seem to have been extremely ignorant; and very little is known respecting their mode of managing the public finances. On the subject of population, it does not very clearly appear what was their regular system. They certainly employed many regulations for keeping up at least, if not for increasing, the number of their citizens; yet they shewed a decided aversion to any augmentation of their strength by the admission of foreigners to the privileges, or even to the protection of their state. They studied to preserve their townships completely insulated and distinct from all others; and prohibited intermarriage with the members of a different community, with all the jealousy of feudal clanship.

Literature and science.

Amidst all the turbulence of the Grecian states, and the almost perpetual hostilities in which they were engaged, there were many circumstances favourable to the cultivation of literature and science. Few individuals possessed large properties, but many of them lived in great leisure, following no occupation themselves, and principally maintained by the labour of slaves. Assembled generally in towns, and having free intercourse with one another, polite manners were formed, and various opportunities were presented for the display of taste and genius. A lively imagination, and love of novelty, were general characteristics of the Greeks, and disposed them to welcome every ray of knowledge which beamed upon their limited society. Many, possessed of active and intelligent minds, yet less daring in their dispositions, or more scrupulous in their integrity, shunning the stormy paths of political ambition, sought employment and distinction by attainments in literature or science. Even those who aimed at the offices of statesmen, found a degree of general knowledge, especially in the pursuits of taste, and the arts of eloquence, highly advantageous to enable them to command attention in the public assemblies, and to assist them in swaying the minds of their fellow citizens. As knowledge increased among the members of a community, these qualifications became not merely useful, but essential to every political leader; and many, who were unable, or unwilling, to mingle in the struggle for public situations, found a less splendid, but often more

Greece. Literature and science.

gainful occupation, in communicating to others those literary acquisitions which had become so subservient to the success of public men. At length every city in Greece, but especially Athens, abounded with those persons, who, under the name of Sophists, undertook to teach every branch of science; and, at a time when books were few and expensive, the oral communication of knowledge was obviously a matter of the utmost importance.* These professors of wisdom studied the accomplishments of eloquence, to render their instructions more attractive; and frequenting all the places of public resort, strove to recommend themselves to notice by an ostentatious display of their abilities, especially by public disputations with one another, or with any who chose to converse with them amidst a circle of hearers. Grecian philosophy is generally admitted to have originated with Thales of Miletus, the contemporary of Solon, and the founder of the Ionian school. Soon after him arose Pythagoras, a native of Samos, who was compelled, by political troubles, to take refuge in Italy, and thus became the leader of what has been called the Italian school. Both these sages are understood to have acquired their learning in Egypt and Persia; but so much was it the practice of the Greeks to claim as their own, what they had merely purloined from the literary treasures of other nations, that it is impossible to ascertain what portion of their science was indigenous, and what of foreign growth. Both Thales and Pythagoras inculcated many valuable moral precepts, but they were not teachers of ethics as a system; and their countrymen of the Asiatic Greeks were more delighted with those metaphysical enquiries, respecting the nature of matter and spirit, the formation of the world, and laws of the heavenly bodies, which gratified their imagination, without proposing any restraint to their passions. It was during the administration of Periander at Corinth, and Pisistratus in Athens, that the love of these sciences was first kindled in Greece; but the growth of every liberal art was entirely checked by the violent political contests and revolutions which ensued, and particularly by the general alarm of the Persian invasion, which left no leisure for speculative pursuits. But when the commanding talents of Pericles had quieted the tumults of faction in Attica, the pursuits of science revived at Athens with new vigour; and, together with the fine arts, continued to receive improvement during all the turbulence which attended the progress and effects of the Peloponnesian war. During this period it was, that Anaxagoras of Clazomene introduced the best principles of the Ionian school, that Socrates dispensed his more practical instructions, that Plato wrote and taught his more refined speculations, that Lysias and Isocrates pleaded in the forum, and that Aristotle and Demosthenes studied in the schools of Athens.

Theology.

Anaxagoras first taught in Athens the existence of one eternal and supreme Being, or, as he is said to have expressed himself, "a perfect mind, independent of body," as the cause or creator of all things; and, by enabling his pupils to calculate eclipses of the sun and moon, proved these hitherto reputed divinities to be mere material substances. But his doctrine was so directly repugnant to the whole religious notions of the Grecian people, that he was accused of impiety, and obliged to withdraw from the Athenian territories. Socrates, early impressed by the sublime principles of theology taught by the exiled philosopher, yet, perceiving the inutility, or at least the unpopularity of such discussions respecting the nature of the Deity, applied himself rather to investigate the duty which man ought to render to such a Being, as Anaxagoras had described the great Creator. He seems to have settled it as a first principle, that, if the providence of God interfered in the government of the world, the duty of man to man must form a distinguished branch of the divine will. He therefore applied himself to examine and inculcate the social duties; and, possessing a most discriminating and ready eloquence, he rendered his conversation (the only mode of teaching which he employed) at once amusing and instructive. He was always to be found wherever there was the greatest resort of company, and was ready either to receive or to communicate information; but he would neither undertake the office of private instruction, nor accept a reward for his public labours. While he maintained the perfect wisdom and perfect goodness of the Supreme Being, and the constant superintendence of his providence over the affairs of men; he continued to observe and to recommend the various acts of religious worship, which were practised in his native country. But all his caution and worth were unable to secure his protection against the jealous tyranny of Athenian democracy; and, either from an impression that he disapproved of their popular constitution, or from a dislike of his purer system of morals, he was rendered so obnoxious to his fellow citizens, that a decree was easily procured for his death. After the time of Socrates, the Greek philosophers were divided into two opposite sects, the Theists and Atheists. The latter, among whom were Leucippus, Democritus, Epicurus, &c. supported the opinion of Anaximander, that, without the aid of a supreme intelligence, all things were produced by a necessary action of matter, assuming all kinds of forms; and the former, among whom were Plato, Aristotle, Zeno, &c. adhered to the doctrine of Anaxagoras, respecting the existence of a Deity, while they held different notions as to his nature and attributes. Even those, however, who possessed the more correct ideas of the Supreme Being, almost without exception conceived the world to be governed by a number of inferior divinities, to whom different departments of the universe had been committed; and, as they readily conformed to the existing religious usages of their respective countries, their philosophical system and private example, rather countenanced than counteracted the popular poly-

* If an attempt were made to estimate the literary and scientific attainments of the ancient Greeks, the following would probably be found to be a few of the principal results; namely, that, in *literature*, it was rather in the entertaining than in the instructive branches that they made any extraordinary progress, and, even in history, produced merely exquisite narratives of events, without any exposition of their causes or relations;—that, in *moral science*, they excelled in acute disputations upon practical questions, and elegant manuals of useful precepts, but never ascended to any enquiry deserving the name of philosophy;—that, in *political science*, they described the most striking phenomena of government in the different states of their own country, or of the neighbouring nations, but made no researches into the principles, the ends, the safeguards of national constitutions;—that, in *physical science*, their progress was astonishing in the single branch of geometry, while they never thought of investigating the properties of physical bodies, or the order of physical events;—that, in *the philosophy of mind*, the logic of Aristotle contains an ingenious but unsuccessful analysis of the process of general reasoning, while his metaphysics explains only the various uses which were made of general terms, and vainly attempts to penetrate the essences and causes of things, but nothing is done to arrange the phenomena of thought, or to ascertain the order of their succession; that "not one, in short, of the ancient philosophers had any conception of the real nature of general terms, or of the operation of mind which is called abstraction; and that it was chiefly by this radical defect, that they were perpetually perplexed, and led into all their trifling and absurdity."

theism of antiquity. The origin and progress of the Grecian mythology, it is now impossible to trace with any probable degree of certainty. Whether it arose from the Chaldean hypothesis of the planets and elements being inferior divinities, and established mediators between man and the one supreme God; or from the allegorical mode employed by the Egyptians of describing the attributes of the Deity; or from a poetical personification of the operations of nature; or from a fabulous embellishment of real events, in the first periods of Grecian history; or from mutilated traditions of the lives of the Hebrew patriarchs; or rather, which seems the most likely, from a mixture of all these, and perhaps other unknown sources;—one thing seems evident, that if it ever possessed the symmetry of a philosophical system, its unity was destroyed before it was described by any writer of antiquity whose works are now extant.

The theogony of Hesiod may be considered as the earliest and most entire account of the religious tenets of the Greeks; but it is affirmed by Herodotus, that, along with the divinities of the first inhabitants of Greece, the poet has mingled the gods of Libya and Egypt. The system, in short, admitted in some degree by the philosophers, assumed and altered by legislators, as best suited their purposes, embellished and expanded by the poets, as their imaginations pleased, became at length an inextricable mass of mysterious absurdities, and ideal beings, of which we cannot attempt to furnish any consistent account. Neither can we afford space for enumerating the leading sects, and distinguishing tenets, and scientific attainments of the different philosophers of Greece; but the most important and authentic information on these topics will be found under the articles devoted to their respective names. (See particularly ACADEMICS, ATOMICAL PHILOSOPHY, PERIPATETICS, STOICS, ANAXAGORAS, ARISTOTLE, EPICURUS, PLATO, PYTHAGORAS, SOCRATES, ZENO.) It may be observed, in general, that the great defect of their physical science was, the want of experiment; and thus, having no fixed principles upon which to proceed, they had recourse to mere hypothesis and conjecture, amusing themselves with framing fanciful systems, while they should have been employed in actual observations. Hence a taste for sophistry and subtilty prevailed in every school of Grecian philosophy; and it became the boast of their teachers of wisdom to be able to support either side of a question, and to give plausibility to the most paradoxical opinions. This pernicious practice was soon transferred from the more abstruse speculations, to the more practical, political, and moral obligations. Its prevalence naturally gave rise to the sect of the Pyrrhonists or Sceptics, whose distinguishing principle was universal doubt, which they carried to such a degree of extravagance, as to pronounce every external object a mere illusion, and the life of man a perpetual dream. Neither the speculations of the philosophers, nor the fictions of the poets, were much calculated to favour the obligations of moral duty; and, even where their tendency was most unexceptionable, their influence was feeble.

Morals of the Greeks.

At no period of Grecian history does there appear any thing deserving the name of evidence to prove the existence of that virtuous age, which more modern declaimers have delighted to describe rather in the spirit of poetical romance, than of historic accuracy. In the earlier ages, violence and rapine, except in as far as they were occasionally restrained by the solemn obligation of oaths, form the prevailing feature of the people and their leaders. In the more enlightened periods, in the times even of Plato and his disciples, the clearest principles, we do not say of moral purity, but even of moral integrity, were not better understood, and still less better observed, than in the days of Homer. Philosophy relaxed the hold of superstition upon the conscience, without substituting any efficacious restraint in its place; and "it is evident," to use the words of Mitford, "from the writings of Xenophon and Plato, that, in their age, the boundaries of right and wrong, justice and injustice, honesty and dishonesty, were little determined by any generally received principle." The philosophy of Epicurus had completely gained the ascendency in the age preceding the Christian era; and the greatest characters, and most learned scholars, wavered between the tenets of the theistical and atheistical systems. Corruption of manners, and the subtilties of scepticism, had reached a height of extravagance, which it seemed scarcely possible to exceed. Human reason had lost itself in the labyrinths of philosophical speculation; and human virtue had been abandoned to the wayward direction of the fancy or the passions. The history of the world had demonstrated (and it is the best lesson, which a review of its most interesting portions can teach) the necessity of some surer and more authoritative guide to man than what the wisdom of the world had been able to afford him, either as a member of society, or a being formed for immortality. See *Ancient Universal History*; Millot's *Elements of General History*, vol. i.; Goldsmith's *History of Greece*; Rutherford's *View of Ancient History*; Gillies's *History of Greece*; Gillies's *History of the World*; Potter's *Antiquities of Greece*; Anacharsis's *Travels in Greece*; Leland's *History of Philip of Macedom*; Pausanias' *Description of Greece*; *Religion of the Ancient Greeks illustrated, by* M. Le Clerc; Newton's *Chronology*; Bossuet's *Universal History*; and particularly Mitford's *History of Greece*, a historical work, unequalled in modern times for extensive research, judicious conclusions, and well-arranged narrative. *(q)*

GREECE, MODERN. See TURKEY.

GREEK MUSIC, *Ancient*. It appears from the writings of Aristoxenus, the earliest writer on the music of the Greeks whose works are extant, that before his time, their scale of music had been extended to two octaves, by the raising of a major tone, and then three succeeding minor fourths, upon the lowest of the notes of this double octave, and by the descending of two such succeeding minor fourths, from the upper note of this double octave: each of these fourths, or diatessara, being exactly of the same magnitude, and alike constituted, as to the situations of its two interior notes, throughout each of their several genera, and the colours or species of each.

The *fourth* being thus made the unvarying boundary of every one of the numerous Greek systems, as the *octave* is now with us, and as the major *sixth* was with Guido, in the formation of his scale: In the genus DIATONICUM (which see) each fourth was made up of a semitone and two tones; in the genus CHROMATICUM, of two semitones and a minor third; and in the genus ENHARMONICUM (see GENERA) of two quarter tones or diesis, and a major third; each of which semitones, tones, thirds, and diesis, were varied, or have different values assigned them, by almost every different writer, as references to our articles above mentioned will shew; but so as always to preserve the fourth entire and perfect: and it has been concluded, that every one of these writers intended five of the *fourths* which he has described to be disposed within two octaves, from A to A, as above mentioned; the third of these fourths, tuned from below, overlapping the second of those two tuned from above, by a grave or comma-deficient minor third, as will be best explained by giving an example of the *Dialonicum intensum* of Ptolemy, which can be done, with reference to the notes of Mr Liston's scale, (see Euharmonic *Organ*), using the artificial commas of Farey's *Notation* (which see,) for expressing the magnitudes of the several intervals; viz.

		Σ	Σ		Σ	Σ	
	A		1224	Second Octave.			
	G		1131			93	5th 4th.
	F		1027			104	
	E		970			57	
	D		877			93	4th 4th.
D'		866				104	
C	C	773	773		93		3d 4th.
	B		716		104	57	
B♭		669				104	
A		612	612	First Octave.	57		
G		519			93		2d 4th.
F		415			104		
E		358			57		
D		265			93		1st 4th.
C		161			104		
B		104			57		
A		0			104		
Notes in Liston's Scale		Values of the Notes above A.			Intervals of the several adjacent Notes.		

The first of the above three columns contains the notes of Mr Liston's scale, and opposite to each of these, its value in the artificial comma (Σ) is placed. In column three, intermediary to the lines of the first two columns, the difference of the adjacent numbers in column two are placed, by which it will appear that each of the five tetrachords or fourths, BE, EA, AD'; and BE and EA are exactly alike constituted, that is, rise each by the intervals 57, 104, and 93 artificial commas each, answering to the major semi-tone, the major and the minor tones respectively.

The interval AB, is in each case 104, or the major tone; and thus, exclusive of the notes B♭ and D', the system comprised in these two octaves may be more simply expressed thus, viz. T + 4th + 4th + T + 4th + 4th = 2 VIII, forming thus far two similar octaves. The interval D'B or 866 — 716 = 150, is the comma-deficient minor third, by which interval the two series of fourths over-cap each other.

It would be easy for the musical student to prepare a similar table to the above columns two and three, for each of the many Greek systems, whose fourths are given in ΣS, in our articles on the *Genera* above referred to, and to place Liston's corresponding notes against them, in column one, as far as is practicable, by reference to the values of his notes in the *Philosophical Magazine*, vol. xxxix. p. 419, whence the above numbers were derived, by adding 161 from C to C, and 773 from C to a; that is, by reducing Liston's series to A as a bass or key-note, instead of C. (ϛ)

GREENHOUSE Plants. See Horticulture.

GREENSTONE. See Mineralogy.

GREEN, Matthew. Of this author of a popular poem, *The Spleen*, very few particulars are known. He was nephew to a Mr Tanner, the clerk of Fish-mongers Hall, and belonged to a reputable family among the Dissenters. But though bred among the sectaries, he grew disgusted with their precision, and probably left them without being reconciled to the mother-church, as he is said to have thought freely on points of religion. He had a post at the custom-house, which he discharged with great fidelity, and died at a lodging in Nag's-head Court, Grace-church street, at the age of forty-one, in 1737. Green's character is given by his intimates as that of an exceedingly honest man, witty and original in conversation, though slenderly educated; and agreeable in manners, though subject to the hip. Once when his friend Sylvanus Bevan, a Quaker, was complaining at Batson's coffee-house, that, while bathing in the river, he had been saluted by a waterman with the usual cry of *Quaker Quirt*, and wondered how his profession could be known while he was without his clothes; Green replied, "by your swimming against the stream." A reform took place at the custom-house, while he belonged to it, by which, among other articles, a few pence, weekly allowed for milk to the cats, were taken away. On this occasion, Green wrote a petition from the cats, which prevented the regulation from taking place. The poem of the Spleen was never published in his lifetime, nor any of his fugitive pieces. Glover, his warm friend, presented it to the world after his death; and, it is much to be regretted, did not prefix any account of its interesting author. It was originally a very short copy of verses, and was gradually and piece-meal enlarged. Pope speedily noticed its merit; Mr Melmoth praised its strong originality, in Fitzosborne's Letters; and Gray duly commended it in his correspondence with Lord Oxford, when it appeared in Dodsley's Collection.

It would be as superfluous here to enter upon a serious defence of the poem of the Spleen, as it was absurd in the last editor of the British Poets to attack it upon the grounds of its author professing to offer no religious consolations for the cure of splenetic temperaments. Religion would have been quite as much misplaced amidst those light views of life which the author exhibits, as in a sentimental comedy. The views of life which he takes, are not indeed marked either by strong sensibility, or profound observation; but the *light* in which he arrays familiar scenes and situations, is peculiarly original. The matter of his precepts is common, while their manner of expression is happy, and all his own. The concluding allegory, for instance, in which life is compared to a sea voyage, is extremely hackneyed, yet nowhere has the allegory been renovated by so many, and by so fine picturesque circumstances. Reason at the helm; the Passions forming the crew; Philosophy putting forth the lights; Experience employing the glass and lead; the careening places of Bath and Tunbridge; and the dolphins sporting round, all compose a picture of animated and amusing effect. Many of his scattered thoughts and detached sentences, fairly rival the best in Butler; and, upon the whole, leave it much to be regretted, that so ingenious a mind should have been destined, by a short life, and by the bondage of a confined vocation, to leave such scanty relics of its powers. (η)

GREENLAND.*

Greenland.

Progressive Geography.

Greenland is the most northern country of the western hemisphere of the globe. It reaches as far as the land is discovered, from Cape Farewell, in Latitude 59° 30′ to the 78th degree of North Latitude. Its eastern coast runs north-east towards Spitzbergen, and is bounded by the Atlantic Ocean. Its western coast has a northwest direction, and is bounded by Davis Straits and Baffin's Bay. Its southern coast is very narrow, not occupying one degree. The borders of its northern coast are entirely unknown. The eastern coast is commonly called East Greenland, and Osterbygd by the old Icelanders and Norwegians; the western, West Greenland, and Westerbygd; *bygd* signifying, in the old Icelandic language, settlement. From the date of its discovery, the former is called Old Greenland, the latter New Greenland. The whale fishers, speaking of Greenland, include under this name the islands of Spitzbergen, so called from the many sharp-pointed mountains with which it abounds, and they call the whole west side Davis Strait. The Danes further divide the west coast into South Greenland, a distance from 59° 30′ to the 68th degree, and into North Greenland from the 68th degree to the most northern point. That Greenland joins the continent of America on the end of Baffin's Bay, is nearly ascertained.

The discovery of Greenland between the years 830 and 835, is mentioned in the chronicle of Snorre Sturleson, a learned Icelander, who wrote about the years 1212, or 1215. Another Danish writer, Claudius Christofferson, places the discovery in the year 770. An Icelander, Eric Raude, or Eric the Red, so called from his red hair, having killed another powerful chief of that land, was obliged to quit the country, and determined to make a voyage of discovery, a practice very common at that time. Soon after he set sail, he reached the point of a cape on the continent of Greenland, which cape he called Heriolfsnæs in commemoration of one of his ancestors. Turning from this to the south-west, he entered a very large inlet, which he called Eric's Sound, probably the sound called by the natives Ikareseksoak, which separates Cape Farewell from the continent of Greenland; he then stopped and remained on an island in the vicinity of it. The following summer he explored the continent, and returned in the third year to Iceland, where he boasted very much of the fertility of the new country which he had discovered, to which he gave the name Greenland, hoping thereby to induce a great many people to follow him. Of 25 vessels which set out with him for Greenland, only fourteen arrived safe. These settlers were soon followed by others, both from Iceland and Norway, and their number in a very short time increased so much, that they occupied part of the east and west coast of Greenland. Eric Raude and his sons Leif and Thorstein afterwards made excursions from time to time to the opposite side of Davis Strait, or the North American coast, and founded colonies there, to which they gave the name of Winlandia. In the year 999, Leif made a voyage to Norway, and was persuaded by King Tryggegon to embrace the Christian religion; he took priests with him to Greenland, for the conversion of his countrymen; and his father Eric Raude, with many of the people, went over to the Christian faith, and there was afterwards established a bishopric, and a great number of churches. The old Icelandic and Danish writers tell us, that there existed 12 parishes on the east coast of Greenland, containing 190 villages; and four parishes, containing 100 villages on the western coast. The last Bishop Andrew was sent there in 1408, and after that year Greenland was no more thought of for a very long time.

Antonio and Nicolo Xeno, A. D. 1380.

Amongst the foreign travellers who visited the coast of Greenland very early, about the years 1379 and 1380, were the Venetian noblemen Antonio and Nicolo Xeno, to whom we are indebted for the first map of Greenland, published with a description of their voyage, by Francesco Marcolin, at Venice, in 1558. From the year 1408, all intercourse was cut off, and all knowledge of Greenland has been buried in oblivion. Previous to that time the Esquimaux, now called Greenlanders, began to shew themselves on the western coast. It cannot now be ascertained whether these Esquimaux, harassing incessantly the Icelandic and Norwegian settlers, have at length prevailed against them, and extirpated the whole race. Some suppose that the plague called the black death, which devastated the north of Europe, from the year 1402 to 1404, reached this land, and carried off a great number of the settlers, so that, by their diminution, they were weakened to such a degree, that at last it became an easy matter for the Esquimaux, (called Skrællingers by the settlers) to make war upon them, and to extirpate them. In this forgotten and neglected state Greenland still remained, until the beginning of the 16th century, when a new spirit burst forth in Europe, to explore the unknown regions of the earth.

Frobisher. A. D. 1576.

Martin Forbisher, or Frobisher, was, in the year 1576, the first that navigated this coast, and called it *Meta Incognita*. A sound which, according to him, divided that continent, was called Forbisher Strait. He was sent out again by Queen Elizabeth, in the year 1578; but he lost two of his vessels, and could find neither the sound nor the land. The Forbisher Strait is marked on all charts of Greenland, but it does not exist anywhere on the whole coast.

John Davis, A. D. 1586.

Baffin, A. D. 1616.

John Davis followed the same course, in the year 1585, and discovered that strait which now bears his name, viz. Davis Strait, which reaches to the 70th degree. Some public-spirited gentlemen sent out Robert Bylot as captain, and William Baffin as pilot, with the ship Discovery, in the year 1616: they reached Davis Strait, and advanced as far as the 77° 30′.

The Danish government, animated by these discoveries, began also to think of their lost Greenland, or the Osterbygd, (eastern settlements,) and during the reigns of seven kings, spent considerable sums upon it, but without success; the eastern coast having become inac-

* The Editor has been indebted for the following article on Greenland to the Chevalier Charles Louis Giesecke, Professor of Mineralogy to the Dublin Society, who resided many years in that country, for the express purpose of examining its mineralogy and natural history.

Greenland.

cessible by the floating ice. Finally, in the reign of Frederic the Fourth, Hans Egede, a clergyman from Vogen, in the North of Norway, animated by a religious enthusiasm, offered himself for the conversion of the Greenlanders, and, accompanied by his wife and children, left his office, and his native country. He was furnished by the Danish government with two vessels; and, being provided with the necessary stores, he embarked on the 2d of May, in the year 1721, and, after struggling with many dangers, landed on the 3d of July, at Baal's river, in 64° 5′ of N. Lat. The Greenlanders did not like their new guests; but, by degrees, they were influenced, by friendly treatment and presents, to entertain those who visited them. The trade had a very poor appearance in the beginning, but all succeeded very well in the course of three years. From time to time, the establishments both for the mission and the trade were increased, and Mr Egede built the first European house in Baal's river, calling the settlement, metaphorically, Gotthaab (Good Hope.) The three first missionaries of the German *Unitas Fratrum*, or the Moravian Brethren, were sent out in the year 1733. They established their first settlement in the vicinity of that of Mr Egede, and gave to it the metaphorical name New Herrnhut, their first settlement in Germany being called Herrnhut, that is, protected by our Lord.

Hans Egede.

Moravian Missionaries.

The Danish government were not discouraged by the unpromising appearance of the missions and the colonies, but made ample provision for upholding and extending them, and formed permanent settlements for the best possible cultivation of the land. Horses and soldiers were sent over to Greenland, that the settlers, by their aid, might travel over land to the east coast, or the lost Greenland; but the icy vallies, and glaciers crossing the interior of the country, were found impassable; the horses perished, and all those endeavours proved abortive. The only possible way to come there, would be with Greenlandish leather boats, which are easily transportable over the floating ice, travelling round Cape Farewell, and never losing sight of the coast. But the reports of the Greenlanders, who dwell in the most southern part of the country, give sufficient reason to suppose, that none of the old settlers will be found there; it being probable, that a coast incessantly surrounded by ice fields, which have lain there from time immemorial, and increase every year, as is ascertained by the whale-fishers, who go to Spitzbergen, will be now much colder than it was some centuries ago, when the sea was still open for sailing from Iceland and Norway, and free from floating ice during the whole summer.

Colonies and settlements.

The colonies and settlements existing at this time on the whole coast of West Greenland, in a line from south to north-west, are,

1. *Nennortelik*, or Bear-island, lying on the east of the promontory of Cape Farewell. The Greenlanders, who live on the remotest places in the south, come there, if the floating ice permits it, with their articles of trade, such as the skins of the blue and white fox, and of the white bear. The island is only inhabited by one Greenlandish family.

2. *Lichtenau*, the most southern establishment of the Moravian Brethren, lying in the Firth Agluitsok, in the 60° 34′ of latitude.

3. *Julianeshaab*, established in the Firth Kakortok, in the 60° 43′. In its vicinity are the ruins of an old Icelandic or Norwegian church.

4. *Fredrikshaab*, in the 62° 30′, is one of the oldest colonies, established in 1742.

5. *Fiskerness*, a Danish lodge, in the 63° 20′. Four leagues from this is,

6. *Lichtenfels*, a settlement of the Moravian Brethren, founded in the year 1754, on an island called Kikertarsoeitsiak.

7. *Godthaab*, in the 64° 5′, in Baal's river, the first settlement for the mission and trade, established in the year 1723, by Mr Hans Egede, the first missionary of Greenland. A dwelling-house of stone was built by him in the year 1726, the walls of which are three feet in thickness; it is 27 feet long, and 16 feet broad. Some hills, at the distance of one league, separate Godthaab from New Herrnhut, the first Moravian settlement in this country. The governor of South Greenland resides here.

8. *New Herrnhut*, which has also a very large dwelling-house, built of stone, by the Moravian Brethren.

9. *Zukkertoppen* (*Sugar-loaf*,) so called from a conical mountain in the vicinity of the settlement, established in 1755, in 65° 40′ North Lat.

10. *Holstein-burg*, established in 1770, in 67° 10′ North Lat. the last colony of South Greenland.

11. *Egedesminde* (that is, *Memory of Egede*) is established in honour of the first missionary, Hans Egede. It lies in 68° 40′ North Lat. on the most southern point of Disko Bay, generally called on the charts South East Bay, and Fish Bay, which is one of the most convenient places for the whale fishery.

12. *Christianshaab*; 13. *Clanshavn*; and, 14. *Jakobshavn*, in 68° 50′, are the settlements established round the continent of Disko Bay.

There are two other colonies, called, 15. *Klokkerhuk*, and, 16. *Rittenbenk*, situated in 70° N. Lat. on islands in the Waygat, which is a sound that separates those islands from Disko island.

17. *Omenak*, another settlement, established 1768, in 70° North Lat. is situated on an island of the same name in James's Bay, which, in the English charts, is called Cornelius Bay. The most northern colony which existed, was,

18. *Upernavik*, on one of the Women Islands, 72° 32′ North Lat. although now abandoned by the settlers, for want of intercourse with, and support from, the other settlements. It is still inhabited by some Greenlanders, who have very little intercourse with the Europeans, and never venture farther to the north than to the 73d degree.

There is another settlement, *Godhavn*, on Disko island, where the governor of North Greenland resides, and two others at *Kronprinz island* and *Hund island*, called, on the charts, Whale Island. The English whale-fishers visit frequently those places. On the whole coast are five Protestant Lutheran Danish churches, where the gospel is preached both in Greenlandish and Danish; there are also three meeting-houses of the Moravian Brethren. The Lutheran churches are at Frederikshaab, Godthaab, Holsteinsburg, Jakobshavn, and Claushavn. The Moravian meeting-houses are at Lichtenau, Lichtenfels, and New Herrnhut. The Moravians have no mission farther to the north.

Greenland was always considered to be a property of the King of Denmark, the Danish flag having been hoisted there so early as in the 13th century. The trade with the Greenlanders was several times interrupted, as already mentioned, the inhabitants wishing to avoid all intercourse

Greenland. with foreign countries. The religious zeal of the venerable Lutheran clergyman, Hans Egede, by degrees attached the Greenlanders to the Danes: the uninterrupted communication with the Greenlanders made the Danes acquainted with the language of the country; and as the natives began to feel the want of some European articles, a commercial intercourse was established. The trade was always a monopoly, undertaken at first by a company of merchants, and afterwards conducted on account of the government. Each settlement is managed by a trader and his assistant, both of whom are paid by the government. These officers and their workmen are subjected, besides the Danish law-book, to another regulation of trade, called Instruction. The general inspection of the trade, and the administration of the laws, is placed by the king under the care of two governors, or general inspectors, one of whom resides at Godthaab in South Greenland, the other at Godhavn (Good Harbour) on Disko island. Their power is very extensive, but is restricted to the settlements; the natives being without laws, except such individuals as are in the pay of the Danish government. The trade and the navigation to the colonies is governed by the royal direction of the Greenland trade at Copenhagen. The Danish missionaries, their installations, functions, and residences, are settled by the royal Danish college for converting the heathens. The Moravian Brethren there are under the immediate direction of the *Unitas Fratrum* of Herrnhut in Germany.

Exports. The exports from Greenland are, feathers and eider-down, horns of the sea unicorns (*Monodon monoceros,*) skins of seals, of the blue and white foxes, white bears, white hares, and rein-deers, whale-bone and blubber, or oil of every kind.

Imports. The imports directly from Copenhagen to Greenland are, guns, powder and shot, all kinds of iron-mongery, particularly knives, files, axes, needles, nails, arrow-heads, linen, and hosiery; articles of luxury for the women, such as cottons, ribbons, gloves, looking-glasses, snuff-boxes; tobacco is an article in great demand everywhere. They are also anxious to obtain rye-bread, barley, tea, coffee, beer, and brandy. The latter article, however, is strictly prohibited from being sold, or even given to any Greenlander. Every spring, in the beginning of May, five or six vessels go out from Copenhagen to Greenland with the articles of trade for the natives, and the necessaries and comforts of life for the Europeans. The cargoes of these vessels may be calculated at 65,000 rixdollars (£13,000 sterling.) The value of the productions carried to Copenhagen may amount, on an average, to 85,000 rixdollars (£17,000 sterling.) But the communication between Greenland and Copenhagen was entirely suspended for five years, in consequence of the war between Great Britain and Denmark. The buildings and stores of the Greenland company have suffered very much, from not having been repaired, in consequence of the want of timber and other materials; and it is now supposed that the establishments will be reduced to a smaller scale.

Natives. The natives inhabiting the western coast of Greenland, from the 59th degree to the highest north, belong to the Mongolic race of mankind. They were called Skrællingar by the old Icelanders and Norwegians, on account of their little stature; but they call themselves, in their own language, Innuit, that is, men or human beings, in opposition to other creatures, and this not from presumption. They are called Esquimaux, or Eskimos, by some authors. They speak the same language as the inhabitants of Labrador and part of Hudson's Bay, and their mode of living is very similar. They are probably spread over Bhering's Strait, and part of Nootka and William's Sound, as it appears from the maps of the late Captain Cook, where some islands are marked with names used by the Greenlanders in Davis Strait. They resemble one other in their stature, their complexion, and their customs. Living under a rigorous climate, which presents very few productions, the size of their bodies is reduced by the nature and scarcity of their food, and the extreme cold. Although the stature of the Greenlanders is in general below the common standard, their persons are not proportionally slender, being usually pretty plump, but very seldom muscular. Their face is large and broad, the nose not very flat, but small and short; the nostrils somewhat wide, the cheek bones high, the cheeks round and plump. The face frequently appears fallen in quite across between the temples. The forehead is low, the eyes little and black, dull and drooping, but having the power to distinguish accurately at a very great distance. The eyelids are drawn towards the temple; the mouth is generally little, and round; the teeth very regular, and beautifully white; the lips thick, and turned outwards; the under lip somewhat thicker than the upper. The beards and eyebrows are thin, but they have abundance of hair on their head, which is black, long, coarse, and straight. Their necks are short, their legs thin, but their feet and hands are small and very well formed; their heads are uncommonly large. The shape of the women is very similar to that of the men, and they resemble them so nearly, that one cannot at first distinguish the sexes, their dresses being nearly the same. The appearance of the women is by no means feminine; they have high breasts and broad shoulders, being accustomed, when very young, to labour hard, and carry great burdens. The Greenlanders are of a yellowish grey colour, which approaches somewhat to olive green; but this may be attributed not only to the climate, but to their dirty habits, and to the great quantity of smoke and soot which their houses contain; for their children are born as white as any European child.

The oily nature of their food contributes probably somewhat to deepen their colour; their blood becoming so dark, dense, warm, and oily, that their skin has the smell of oil, and their hands and feet are as clammy as bacon. Their bodies being very fleshy and fat, and coated as it were with a varnish of oil and dirt, they can bear the cold better than an European. They sit commonly naked in their houses; and the effluvia from their bodies is such, that an European who sits by them can scarcely endure it. Their children are in general very healthy; and one rarely sees among them a human being misshapen from its birth. They consider themselves to be very well educated and informed; and when they meet together, nothing is so customary among them, as to ridicule the Europeans and their manners. The women in particular, understand that sort of humour extremely well. They use a mode of very expressive mimicry, consisting of certain grimaces, by means of which they can make themselves understood from one corner of the house to the other; and a European coming to their country will instantly be characterised by a nickname, expressive of his manners, or behaviour, or personal defects. They reckon themselves the most modest people in the world: and seeing a modest foreigner, they say, *innucksisimavok*, or *innungorpok,* that is, "he is as modest as a Greenlander." Although there may be some presumption in this, yet it cannot be denied, that they are modest, friendly, and not litigious; generally compliant; but, when exasperated, they are so desperate, that no danger deters them from their revenge. Although very ignorant, they are by no means stupid. They learn easily to read and to write their language, not only the children, but also men advanced to 20 and 30 years of age. Some of them, besides their maternal tongue, speak Danish very well, and they have a great inclination to mechanics. As their supply of food is but precarious, their patience in hunger is astonishing. Their strength, in proportion to the size of their bodies, is not less wonderful. Pinched with hunger for some days, the man is nevertheless able to row out, and to manage his kajak in the most boisterous sea.

Dress.

Their manner of clothing is quite correspondent to the climate. Men, women, and children, from the time they are three years old, are clothed nearly in the same manner. Their ordinary dress is a sort of close frock, or rather robe, which reaches to the knees. It has at the upper part a round hole, sufficient to put the head through, and not large enough to admit the cold. The sleeves are rather wide on the shoulders, becoming narrower as they reach the wrists. A hood similar in shape to the cowl used by monks, is attached to the back of the frock. This is drawn over the head in winter or bad weather. In warm weather they generally walk bareheaded. Some of them now use the round hats of the Europeans. Their breeches are nearly like those of Europeans. Their stockings are in summer of seal-skin, in winter of dog or rein-deer skin; and those of the women are of fowl-skin. Their boots are made in a very neat and ingenious manner; sometimes of seal-skin, sometimes of rein-deer skin. The frocks are also made of seal or rein-deer skin. At the seams where the different skins are sewed together, they are usually adorned with narrow thongs of different skin, sometimes coloured red; they are worn with the hairy side outwards. In cold weather they use under the frock a shirt made of fowl-skin, of the *Alca pica*, or *Anas mollissima*, or *Pelicanus carbo.*

When at sea in their small canoes (called *kajak*), they use a sort of frock impenetrable to water, with the hair taken away, called *Erysak.* The bottom part is fastened round a ring or hoop made of bone; and this hoop is joined to the hole in which the Greenlander sits, so that no water can penetrate it. They have also another frock made very ingeniously from the intestines of whales, dolphins, or seals, prepared with such skill as to resemble, in a great measure, our goldbeater's leaf. The clothes of the women differ very little from those of the men. The sleeves are very high and wide on the shoulder, and reach only to the elbow. They are cut out downwards from the top of the thigh, and form a long tongue-formed flap both behind and before, the end of which reaches to the knee. It is very carefully sewed, and bordered round the body with narrow thongs of white or coloured leather, sometimes of red cloth. They wear breeches, with very short drawers underneath. Their common boots are made of black or brown seal-skin, their dress boots of white or red coloured seal-skin, reaching over the knees. Shoes are rarely used either by the men or women.

They live in winter in houses, and in summer in tents. When the summer is over, which is generally at the end of August, the women belonging to the family or to the house are very busy in repairing an old or in building a new house. It is done in a very few days; and this labour resembles the liveliness of an ant-hill. Some carry stones, others bring sod; several turf, timber, shrubs, or earth. The walls are made of water-worn stones, put together with turf or sod instead of mortar; and the roof is formed of pieces of floating timber. It is flat, and is covered with shrubs, turf or sod, and earth. The stones are taken from the shores, as they never build a house at a greater distance from the sea than 20 or 30 paces; the timbers are picked up from the sea during the summer. Their houses are sometimes regular, sometimes oblong squares; being from 12 to 18 feet in length, and from 10 to 12 feet in breadth. The height is generally six feet. The walls are at their base two feet, and on the top one foot thick. The entrance is usually under the earth, two feet high, two feet broad, and from 12 to 15 feet long. It is in the centre of the house, and generally faces the south. The house has no door, and one must always creep in on hands and feet. Above the entrance is one, and sometimes two windows, which are made of the intestines of whales, or dolphins, or seals, sewed together. The house consists of only one room, at the back of which there is a kind of stage, raised from one foot to one and a half from the ground, and extending the whole length of the house. It is covered with seal-skin, and is used as bench, chair, table, and bed-stead. Being divided in the front by perpendicular standing timbers, it has the appearance of low cow-sheds or stables, separated by skins. Each family occupies such a division. They sit on this bench the whole day, the men with their legs hanging down, the women generally cross-legged. Each family has at least one burning lamp, made by the Greenlanders themselves of pot-stone. All round the margin of the vessel oiled moss is placed, which serves instead of a wick; and the vessel contains about a quart of oil. The lamp serves them as candle, chimney, and cooking fire; and is attended by the women. On the roof of the house, over the lamps, are racks for the purpose of drying clothes, boots, gloves, &c. The extremities of the large bench on both sides of the house are considered to be the best places, being most removed from the entrance, and therefore given to the first women of the house, or to travellers of distinction. A narrow bench runs along on both sides, and under the windows of the house; and in this place strangers of less consideration sit and sleep. The houses are very well heated, and the heat is increased by the uncommon evaporation of the natives. A European is obliged to go out occasionally, to get fresh air. The interior of their houses looks very well at the beginning of the winter, as long as any degree of order exists in them. But this is over in a very short time; and even this irregularity and confusion is exceeded by their nastiness and stench. They not only keep a number of dead seals, fowls, &c. in their warm houses, but they also gut them there. This, together with the bones, and rotten or half eaten fragments of boiled and raw flesh, occasions several heaps of filth, which are never removed, till, from their bulk, it becomes troublesome to pass over them. Every thing about the house smells of train oil and smoke; and every part of it is as filthy as can be imagined. It is revolting to Europeans to see their dirty hands and face, almost always dripping oil; their meat dressed and eaten in such a disgusting manner; and their nasty clothes, literally alive with vermin. They are also very dirty in cooking their meat; they seldom wash a

Houses.

Greenland.

vessel; the colour and the odour of the last dish must remove that of a former one. They lay their boiled meat in wooden dishes of fir wood, made by themselves, which are never cleaned; and first drink the soup, or eat it with spoons made of bones or wood. Their undressed meat lies on the bare ground, or on an old seal-skin. They have no determined time for dinner or supper; but, when the men of the house return with the game, which generally happens in the evening, part of the day's spoil is immediately boiled, and all the people who live in the neighbourhood are invited.

The men get their meal first, sitting upon the ground, round a large wooden dish, and taking the meat with their fingers. When this is over, the women begin in the same stile, but at the opposite end of the house. If there be a European guest, or any other stranger, the woman of the house takes a piece from the kettle, licks it clean from blood and scum, and presents it to him with her own hands. It would be considered a high degree of impoliteness to decline it.

Tents.

Their time of removing from their houses to their tents is not exactly fixed. It takes place generally at the end of April, or in the middle of May, as the snow melts sooner or later; and it frequently happens that part of the badly supported roof of the house gives way and falls down, an accident which forces them to remove to the summer place. The tents are larger and smaller, in proportion to the size of the family and its fortune, but rarely exceeding the length of 12 feet, and the breadth of 10 feet. A wall one foot high is first made of stones and sods, on which they rest the poles, which form an acute angled triangle with the ground. The poles are then covered with seal-skin; and a curtain is placed before the entrance, made from the intestines of the whale, dolphin, or seal. The bed-places are similar to those in their houses. The tents are, like the houses, near the shore, as the sea supplies them with all their wants, and the seal provides them with all the necessaries of life. The instruments to procure their food are very simple, but they are admirably adapted to their purpose. The principal of them is the harpoon, called *erneinck*, and *unnereek*, which is the largest of them all, being two yards and a half in length. The second is the lance, called *angoviak;* the third, a smaller lance, is called *kapput:* these three are generally used for seal-game, the first to attack, the two others to kill the animal. The first was also formerly used to attack the whale; but now the Greenlanders do it in the European manner, with large harpoons. A fourth instrument, called *akligak*, is a kind of javelin with a head of iron, barbed, to prevent its becoming disengaged from the animal. It is generally used when they pursue their game in company. For catching birds, they use the *nugit*, or fowling-pike, headed with iron like the last, and furnished, towards the middle of the shaft, with three notched forks made of bone, that one of these may reach the bird, if he escapes the apex, which is of iron. For land-game they formerly used the common Indian bow, with its arrows made of fir, and stiffened with sinews of animals, with a string likewise made of sinews; but the use of it was nearly abolished on their being provided with guns by the Europeans; although they were obliged, during the time of the late war, to resort to their old method of shooting, which succeeded very badly, from the want of that dexterity which they formerly possessed. The Greenlanders being a very pacific people, none of the dreadful instruments of war used by other Indians are found among them. They use for fishing the same apparatus as other nations, the lines being generally made of very thinly shaved thongs of whalebone.

Instruments and weapons.

Greenland.

Canoes.

Their canoes are of two different sorts; the one large and open, the other small and covered. The framing of both consists of slender pieces of wood, covered on the outside with skins of seal sewed together. The wooden framing is joined by thongs, cut from seal-skins, or by thinly shaved whalebone. This manner of putting them together, gives to the canoes so great a degree of flexibility, or rather elasticity, that they very seldom can go to pieces, even in the most boisterous sea. The large canoe, called umiak, or the canoe for women, is generally twenty-four or thirty feet long, four or five feet wide, and two or three feet deep, terminating acutely at both ends. The bottom is flat. It is used in summer to transport the whole family, and its utensils and tent, from one place to another; and is in the evening always taken up on land, in order to be dried, repaired, and varnished on the outside with old thick rancid oil, called Minnek, to prevent the water from penetrating the seams.

The other small canoe is called kajak, and is only used by the men; it is sharp at both ends, and its entire shape and appearance is not unlike a weaver's shuttle. It is from four to five yards in length from one extremity to the other, about a foot and a half wide in the middle, and scarcely one foot in depth. In its centre is a round hole, with a prominent ring of bone or wood, in which the man seats himself, and fastens the underpart of his frock round that ring, forming thus one body with his canoe. Upon his kajak he has his instruments, striking the sea alternately on both sides with a paddle called pautik, four fingers broad at each end. He can row in a very boisterous sea, and if overturned by the billows, he is able to raise himself again. All their sea game is procured in these small boats. The boy is employed by his father in his earliest age, that is, in his sixth or seventh year, to prepare himself to perform the business of a man. The first sea-fowl caught by a boy gives occasion to a great festival, and dinner of the family, for the purpose of doing homage to the rising master of the house. Another kind of sea-amusement, or rather ice-amusement, is used in winter, in the north of Greenland, from the 70th degree to the highest northern latitude, by means of sledges drawn by 6 to 12 dogs. The Greenlanders drive them over the frozen sea, a distance of 50 and sometimes more miles from the lands, to the rifts and clifts of the ice, and catch there the dolphins, sea-unicorns, and seals, which come there in great numbers to take air. The spoil is carried home by the assistance of the sledges. The velocity of the dogs is astonishing; they may be driven 100 miles in 9 or 10 hours.

The men take no charge of any of the domestic operations. The women must make clothes, boots, canoes, and tents, dress leather, clean and dry clothes and boots, gut and dismember the spoil, cook the meat, cut the pot-stone-lamps, prepare oil and wicks, and build houses and tents. The girls are employed to this business from the time they are twelve years old. The boys are, from their first childhood, regarded as the future masters of the house. The Greenlanders never strike their children, who are very untractable until their sixth and seventh year; afterwards they follow their parents very willingly, and shew with their increasing age a still more respectful behaviour towards them.

Greenland. Marriages. The men seldom marry before the twentieth year of their age; and the women in their seventeenth or eighteenth year. The bridegroom never concerns himself about marriage-dowry; he is well satisfied if his bride understands housewifery; that is, all the business which we have already mentioned as belonging to the female. The parents never interfere, but they always wish that their son-in-law should be a good hunter; and on the other hand, that the wife should understand housewifery. The girl always makes great difficulties, runs to the mountains, or cries *pro forma*, and the bridegroom generally takes her by force from the house of her parents, and puts her, supported by some old women, in his umiak, which is lying on shore. He brings her to his house, and they are considered as married. They never marry their relations. Polygamy is not very common among the unconverted, and is strongly prohibited among the baptized. It occurs, however, though very rarely, that a heathen has three or four wives. The most respected of them is she who is so fortunate as to have boys. They are not very prolific, the number of children seldom exceeding five or six. If a wife has no children, she herself often requests the man to take a second wife, it being thought ignominious among them not to have a family. The second and third wife is always inferior in rank to the first. Their marriages are not indissoluble; the man sometimes puts his wife away, and the wife also occasionally elopes, and generally retires to her parents, if she is not satisfied with the man, or with his conduct. The women bring forth their children very easily, and perform their usual business in the house to the last moment, and go out again the day after the delivery; they are assisted in the delivery by some old women, as many as there are in the neighbourhood; they rarely bring forth a child before the proper time; the birth of a child is always followed by a dinner. As the people are not very prolific, the coast is very thinly inhabited; the population of which was stated to have been about 20,000 souls, on the arrival of the first missionary, Mr Hans Egede. The small-pox, carried hither from Europe in the year 1733, swept away more than 3000 souls. Other diseases diminished the number of the natives from time to time very much, which, according to the latest accounts given by the governors and missionaries, does not surpass the number of 7000 on the whole coast, from the 60° to the 73° of Latitude. Venereal diseases are unknown. It is a curious circumstance, that the fruitfulness of the native women increases, when they are married to Europeans. This is still perceptible at this day in Greenlandish families, mixed with Europeans at the time of the first mission (1721), the European features being still visible.

Population.

The Greenlanders are very sociable; although they do not live in towns or villages, they like to visit and to be visited. A man or woman never pays a visit to a person residing at a distance, without making some present at the house she visits, either a skin or fowl, or some sinew. They are very fond of making bargains, and often part with their most useful utensils in exchange for trifles, particularly to satisfy the capricious frivolity of their wives. No one desires to usurp any authority over another, to make regulations for him, or to call him to account for his actions; for, as they have no riches, one individual supports another; the helpless finds refuge in the house of the more fortunate, without being related to him, and each Greenlander has his landed property where he resides. They may therefore change their residences as often as they like. Whatever the sea drives on shore, particularly floating timber, is the property of him who has taken it up, and brought it on shore. Notwithstanding, however, their honesty towards each other, they are not scrupulous in stealing from Europeans.

Religion. It is very singular, that the heathens inhabiting this country, have no worship. It was believed by some navigators, who saw the Greenlanders observing the rising sun in the morning, that this people worshipped the sun. They were confirmed in their opinion by the squares of stones, which they saw erected for the purpose of their tents, and supposed that they were places of worship; but they have no religion at all, although they are not without some notion of a Divine Being, and of a future state.

They frequently speak of a Supreme Being, called by them Tornarsuk, a compound of bad and good, probably a remnant of the religion of the old Norwegians. He is the oracle of the Angekut, or Greenlandish philosophers, (if this word may be so improperly used,) who are alone admitted to have intercourse with that great spirit. Besides Tornarsuk, they speak of many inferior beings or spirits residing in every corner of their country. Each Greenlander may become an angekok or sorcerer, if he will submit to certain trials and ceremonies; but the angekok never enjoys any peculiar veneration from the Greenlanders. He profits by the superstitious credulity of his countrymen, pretending to cure the sick with magic art, and presenting amulets of seals, reindeers, &c. as a preservative to those in health. The angekut have their peculiar kind of language, a kirendum or jargon, understood only by themselves.

Language. The Greenland language might with more propriety be called the language of the Esquimaux, as it is spoken by the Esquimaux in Labrador, on the shores of Hudson's Bay, and in various other places of that coast, the Greenlanders being only part of that nation. It probably also extends to Behring's Strait, Nootka Sound, and William's Sound, and has no affinity to any of the other north Indian languages, as far as they are known. There is but little variation in the dialect on the coast of Greenland, but in the south it is spoken in a more singing tone. The letters *b, d, g, h, l, v* are never used in the beginning of a word; the letters *c, f, q, x,* and *z,* are not used in their language. It abounds with double consonants, particularly *k* and *r*, and is very guttural. The language is made extremely difficult, in consequence of the great number of polysyllables, by the use of which a whole sentence is put together in an elliptical manner. They have very few adjectives, and use the participles of the verbs to supply their place. In the language are a great number of *affixa verbalia*, by the use of which an astonishing variety is produced in the signification of their verbs. Thus from the radical verbs, *innuvok,* "he lives is a man," is derived *innugikpòk,* "he is a handsome man;" *innurdlukpòk,* "he is a mis-shapen man;" *innukulukpòk,* "he is an unfortunate man;" *innuksiorpòk,* "he is a good man;" *innukpilukpòk,* "he is a bad man;" *innuksisimavòk,* "he is a man as a Greenlander, (a modest man;") *innungorpòk,* "he begins to be a Greenlander. The third person *singularis præsentis* is its radix. Every verb has its corresponding negative, formed by the addition *ngilak* to the radix, thus: *pekkarpok,* "he has," *pekkangilak,* "he has not." Each

Greenland. Language. flexible word has its dual, ending with the letter *k*, the plural ends with *t*; thus, *nuna*, "land, country;" *nunæk*, "two countries;" *nunæt*, "countries." The articles, pronouns, and prepositions, are formed by suffixes, changing the termination of the noun thus: *nalegak*, "master, lord;" *nalegama*, "my lord;" *arnak*, "mother;" *arnamut*, "to the mother." A great number of augmentatives and diminutives are also formed, by varying and adding to the termination; and this circumstance contributes to make the language agreeable and expressive. Thus, *kikertak*, "island;" *kikertangoak*, "a small island;" *kikertarsoak*, "a large island;" *kikerteitsiak*, "a fine island;" *kikertarsoeitsiak*, "a large fine island." Their numerals are limited to five. They express numbers from six to twenty with the help of addition. Thus; five and one, five and two: twenty is expressed by *innùk*, man; that is, 10 fingers and 10 toes; numbers exceeding 20 are generally called innumerable.

They have no traditions from their ancestors, except an incongruous account of their battles with the old Norwegians; the history of the Greenlanders is therefore buried in impenetrable darkness. They have no chronology, no one can tell his age; but they are well acquainted with the north star. The angekut call the ursa minor *asellut* in the south, and *kuttak* in north Greenland, the ursa major *tukto*, or *reindeer*. They divide the day according to the tide, and reckon their years by winters. The distance of 32 miles, from one place to another, is called one day's voyage, (made with a canoe.) The different seasons are marked by the migration of birds, fishes, and other animals which regularly visit their coast.

Angekut, philosophers. The angekut are somewhat acquainted with physics, particularly meteorology; they observe the weather with great attention, and from the state of the atmosphere they make very accurate conclusions respecting its changes, even at a distance of three or four days; and as the natives procure their food from the sea, this habit is of great importance to them. The angekut are also the physicians of their countrymen, and prescribe generally a certain diet, as most of the diseases result from their very irregular mode of living. If diet is ineffectual, amulets are applied, presented in bones of different animals, particularly of rein-deers and seals. The most common diseases are eruptions of the skin; one is a sort of small pimple, which in a very short time covers the whole body; the best remedy, is to drink a decoction of *ledum groenlandicum*. The other is a kind of leprosy, which infects their whole body with cancerous boils and scurf. Those who are afflicted with it, are abandoned by their relations, and die in the greatest misery. The smallpox and measles were formerly unknown to them, but were conveyed from time to time by European vessels to these poor people, and committed dreadful devastations. These diseases are mortal to the Greenlanders, their skins being so dirty and oily as to prevent the eruption. In the year 1733, the first year of the mission, 3000 people died of the smallpox. But vaccination is now employed by the Danish government with great success. All the other diseases which arise, where the air is condensed by cold, and perspiration is obstructed, are very common in Greenland. A wounded or fractured limb is cured very quickly by themselves, but they have no remedies for internal diseases, such as consumption, blood-spitting, pleurisy and diarrhœa. Scurvy is not very common amongst them, as they do not use salt meat or fish. The want of food, to which they frequently are exposed in winter, produces very serious complaints, which are particularly perceptible in the following spring. It frequently happens in winter, when the frozen sea refuses the necessary supply to the wretched family, when the last thong of leather is swallowed up, and when there is no longer oil to burn in their lamps, that the hunter returns with an animal, and some of these poor creatures devour the raw or half-boiled meat, and falling victims to the indulgence of their appetite, instantly die of indigestion.

Burying the dead. They bury their dead generally on a small hill, in a sitting posture, dressed in their best clothes, and covered with seal-skin. The land being a mass of rocks, the inhabitants are obliged to build graves of stone, which are covered with plates of mica slate, or clay slate, to prevent carnivorous animals from destroying the bodies. Their kajaks (canoes), instruments, and utensils, are placed by the side of the grave. They return from the burial-place to the house of the deceased, to continue the lamentation, which consists of a dreadful monotonous howling, supported by all the attendants, who sit with their faces turned to the ground. When this is over, some refreshment is taken, and each returns to his own house.

Climate. The whole coast of Greenland, receiving the beams of the sun in a very oblique direction, is deprived of that general comfort which other parts of the earth enjoy. The soil being shallow, is frozen during the greater part of the year; and the ice, having taken possession of all the vallies of this barren and rocky land, the winds which blow over these are, even in summer, extremely cold. The prevailing winds are those from the east and north-east, north-west and north. The cold which the north-eastern wind brings in winter is almost insupportable; and the thermometer is very often at —35° or 36° of Reaumur (—48° of Fahrenheit). The winds which blow directly from the sea (Davis' Strait), are moist, and generally attended with rains, in winter with snow and sleet; and are more boisterous in spring and autumn than in other seasons. Winds reflected from the mountains, and striking through the vallies with great violence, are extremely dangerous to vessels sailing near the coast. Strong stormy winds from the west or south-west always break the sea-ice, even in the middle of winter. The cold sets in with the month of January, accompanied with but little snow, which generally falls either before or after that time. More snow falls in the south than in the north. The sea does not freeze before the beginning of January, forming thus on its surface clammy spherical concretions, which increase rapidly, and as they join together, present a crust of the thickness of an inch in a very few hours. This coagulation only takes place when the sea is calm. Previous to that operation of nature, the sea smokes, like burning turf-land; and a fog or mist arises, called *frost-smoke*. This cutting mist frequently raises blisters on the face and hands, and is very pernicious to the health. It appears to consist of small particles of ice, and produces the sensation of needles pricking the skin. The same icy particles carried up by the wind, cause probably another phenomenon which is frequently seen in winter round the moon, a ring of light, or halo, called by the Greenlanders *Illuparosek*; this ring appears at a great distance from the moon, and has a fine pearly lustre. It is seen at a time when the horizon is quite clear, and every star may be distinguished. Mock suns are also very frequently seen in this country, but only in winter. In

Greenland. January 1809, six were observed at the same time, all of a pale yellow colour. The remotest was paler than the others.—See Halo.

Aurora Borealis. Of all the phenomena peculiar to this country, the aurora borealis is the most beautiful. It streams here with peculiar lustre, and with a variety of colours, which, having great brilliancy, sometimes dart their sportive fire, and fill the whole horizon with the most beautiful tints of the rainbow. They are very rarely observed in the north of the horizon, commonly in the east and in the zenith. They appear sometimes to stand very low, and then they are much agitated, and a crashing and crackling sound is heard like that of an electric spark, or of the falling hail. They are more frequent and more powerful from the 60th to the 67th degree than in higher latitudes. The Greenlanders believe, that they are the souls of the deceased fighting together in the air.

Another very curious optical phenomenon presents itself, partly in clear, partly in thin foggy weather. The islands lying at a distance from the continent appear to approach to the spectator, and to increase in size. They form to the eye various and peculiar groups, very different from their proper shape. At other moments they appear to hang in the air. If this phenomenon appears with respect to the islands which lie in the south, southerly winds will follow; if the object be in the west, westerly winds may be expected. The winds decrease generally after sun-set.

Meteors. Fire-balls are rarely seen in this country, although one was observed in the year 1808, taking a direction from north-west to south-east. The comet of 1807 was first observed on the 4th October, in the north-west; and that of 1811 on the 4th September, in the north, and disappeared the 14th January. Thunder is very seldom heard, but sometimes flashes of lightning are seen. The air is extremely pure and light; the rains are not of long continuance; and the heat, particularly in the islets, is astonishing, being caused principally by the reflection of the solar beams from the mountains. The saline particles of the sea-water are frequently found crystallised on the shores. In the month of July, the thermometer of Reaumur rises in the shade to 24 degrees, (86° of Fahrenheit). The moskitos (*culex pipiens*) are at that time as painful and troublesome as in a southern climate.

Ice. The ice, which embarrasses the polar regions, and disturbs the navigation, is of different kinds, some of it being of fresh water, some of salt water. The former is clear, very hard, brittle, having an appearance entirely glassy, and presenting sometimes colours of the finest pale emerald green, or the brightest sky-blue; when cut in pieces, the fragments are as sharp edged as those of rock crystal. The ice of salt water has the appearance of frozen snow, is greyish white, not transparent, and has generally a clammy coherency; when very thin, it is flexible, to a certain degree, under the step of a man. It coagulates in small spheroidal particles; whereas that of fresh water presents rather acicular and prismatic forms. The fresh-water ice forms tremendous masses and mountains of different magnitudes, and wonderful shapes, sometimes rising more than 500 feet over the surface of the water. The salt ice occurs always in flakes, called by the mariners ice fields, sometimes of many thousand fathoms in length and breadth, divided by fissures, but following close to each other. These flakes of driving ice are not found so large in Davis Straits, as between the east coast of Greenland and Spitzbergen. The surface of the salt ice is generally covered with a crystalline crust, deposited by hoar frost or snow; it has a mealy or sandy surface, and becomes brackish by the tides. The salt ice never forms large mountains. On the shores, however, where the sea freezes, the mass becomes enlarged by the effect of the tides, and by stormy weather, which breaks the ice, and heaps it up.

Ice mountains. Ice mountains are formed, during a series of years, in the inlets and bays, in valleys, or on precipitous rocks reaching to the sea. As they melt in summer at the base, where they are in contact with the rock, they get rift; and at last, losing their points of support, they plunge into the sea with a thundering noise; an awful and imposing spectacle, which may be seen in the Ice Bay, near Disko island, particularly at the time of the tides. These mountains very often enclose vegetable substances, earth, and stones; and are sometimes so large as to reach to the bottom of the sea, a depth of more than 300 fathoms, until they lose somewhat of their mass, and roll over. Immense masses of ice are driven out from the Ice Bay in the tides, at the time of high water, covering the sea of Disko Bay, to a distance of many miles.

The driving ice which comes from Spitzbergen, is generally seen at Cape Farewell in the month of May, setting over to the eastern coast of Davis Straits; but it returns again with south-west and west winds, filling all the bays and inlets of the south of Greenland, and is again thrown out from the land by the easterly winds. This ice is always followed by impenetrable fogs; a circumstance, which makes it much more dangerous to navigators. The specific gravity of the ice depends upon its density or porosity.

Floating timber. The floating timber, mostly pine, which comes with the ice round Cape Farewell, affords great relief both to the poor Greenlanders and the European settlers. It furnishes materials to the natives to roof their houses, to support their tents, to strengthen their canoes, to shaft their instruments, and to prepare their utensils. It supplies the Europeans with building materials and fuel. It is very difficult to say from what country these timbers come; undoubtedly from a very remote land, washed away from shores covered with forests. The timber is always much injured, generally without bark or roots, and great part of it is worm-eaten by the *Pholas teredo*, (*Teredo navalis*, Lin.) It is mostly found in the small bays of those islands which are nearest to the open sea.

Islands. The continent of Greenland is surrounded by many thousand islands of different sizes, upon which the Greenlanders generally reside, on account of their good situation for sea-game. The continent of Greenland itself is intersected by innumerable bays, inlets, and firths, many of them 100 miles in length. Their direction is generally from south-west to north-east; and some reach as far as the tremendous glacier which covers uninterruptedly the middle of the continent, and separates the east coast from the west. The connection of these firths with the large continental ice causes the numerous ice-mountains which plunge down in the summer, and are driven by the currents into the open sea. The most remarkable

Firths. of the firths are, 1. *Tunugliarbik*, and 2. *Ikarcseksoak*, both in the 60th degree of latitude; these reach to the glacier, and are generally full of floating ice. 3. *Sermiliarsuk*, the same firth or bay which is marked on the charts with the name Forbisher or Frobisher Strait, but falsely, as this bay extends to the great continental gla-

Greenland. cier, which surrounds it. 4. *Baal's River*, one of the largest firths, is divided into several branches by large islands. 5. *Nerusutok*, remarkable for its violent currents. 6. *Sermilik*, or *Icefiord*, a firth, which presents the largest ice mountains on the whole coast. It is supposed to have been formerly a sound, which divided the continent, but is now shut up by ice. 7. *Omenaks Bay*, called *St James Bay* and *Cornelius Bay* on the English and Dutch charts, which is the most extensive firth on the whole coast, and contains more than twenty islands. It is situated in the 71° of latitude, and in all its different branches is connected with the large glacier. 8. *Kangerdluarsursoak*, in Baffin's Bay, called *Horn's Sound* on the charts, in the 74° of latitude, is likewise a most dreadful firth, on account of its monstrous masses of ice. In the months of May and June, the Greenlanders visit the firths, to provide themselves with a kind of small fish, the *salmo arcticus*, Fabricii, (*clupea villosa*, Mulleri,) which visits the firths in millions at that season. They are dried in the sun on the rocks, and used instead of bread. They are the principal food of the seal in summer, and followed by them in great numbers. Seals are also caught here.

Rivers. The *rivers* are neither numerous nor large. They can have but a small supply in that desolate region, where the valleys are covered with eternal ice, which does not melt frequently, and then only on the surface. In the vallies between precipitous mountains, there are occasionally very large lakes, which have their origin from the melting of the ice and snow on the mountains, and are confined by the rocky bottom of the valley. The springs and rivulets which come from the mountains, rapid as they are in the spring, generally dry up in summer. The inundation of these rivers in the spring, makes the soil marshy, and produces good vegetation on the shores of the firths. The old Norwegians and Icelanders formerly made all their settlements in such situations.

Springs. What are called *springs* by the Greenlanders, frequently consist only of ice-water, forced out of its accustomed channels by the power of the waterfalls running through the ruins of destroyed rocks. There are, however, some spring wells, one of which is very remarkable from its rising and falling with the tide, although it is situated more than 36 feet above the level of the sea. Its water is not brackish, perhaps from the circumstance of its being filtered in passing through a bed of very fine sand. The most interesting is a warm spring on the island Ounartok, which has a temperature of 32° of Reaumur (104° Fahrenheit) at all seasons. It is situated in the south-east of the coast, in the 60°.

Currents. *The streams or currents of the sea* have an easterly direction, and are in some places very rapid and dangerous, particularly during high tides. It is supposed, that these currents are produced partly by the unevenness of the bottom of the sea, and partly by the numerous islands, which increase the rapidity of the currents by diminishing their channels. The obstacles, which rise from the bottom of the sea, may assist in producing back currents and whirlpools. One of the most dangerous whirlpools exists at the mouth of a firth, (called by the natives Puiosortok,) in the south-east of Greenland.

Water. *The water of the sea* near the shores, is less salt than that at some distance from them, the former being always in contact and communication with the ice-water.

Tides. *The rising of the tides* is very unequal, in consequence of the number of islands through which the tide passes. They rise in the south (from 60° to 64° of N. Lat.) to eleven feet, and decrease gradually in the north of Davis Strait, (74°,) where they do not rise more than four and six feet. The highest flood is the third day after new moon, and the third day after full moon. The Icefiord, or Sermilik, in Disko Bay, has flood but no ebb. Greenland, from its most southern point to its most northern extremity, consists of insulated rocky mountains and sharp acuminated cliffs, separated by narrow valleys, which are rendered inaccessible by the glaciers. These places never enjoy the rays of the sun, and are mostly intersected by rapid torrents, which precipitate themselves from the mural cliffs of the mountains. Ice and snow accumulate here in dreadful masses, and fill the spaces with increasing devastation. Even the Greenlanders, so accustomed to the horrors of nature, call some of these spots places of desolation. The water, converted into ice, splits the rocks with mighty force, which are precipitated from the summits with thundering noise in the summer, threatening death to the wanderer. The mountains themselves are covered with a mourning veil of black lichens, variegated here and there with spots of crumbling snow, which, being dissolved by sun and rain, run in small torrents along the precipice. The view of the valleys watered by the inlets and firths is more agreeable, and presents the entire vegetation of that deserted country.

Islands. *The small islands* which surround the continent, are generally of a different character, forming small roundish elevations or hills, the base of which is inhabited by innumerable sea fowls, which breed there at the return of spring. The large islands are similar to the continent, and consist of barren insurmountable rocks, the valleys of which are filled with eternal ice. Amongst the largest, are particularly remarkable: 1st, Cape Farewell, called by the Greenlanders Kangekkyadlek, that is, the cape running towards the west. The entire island, which turns from west to east and south-east, has the name Sermesok, or Iceland, its narrow and dreadful valleys being always covered with ice. It has very little low land, and is therefore very seldom visited in summer by the natives. No family lives there in winter; but the ruins of old houses on the west side, shew that it was formerly inhabited. The most eastern islands nearest to Sermesok, or Cape Farewell, are Omenak and Kangersoak: The latter is called Statenhuk by the navigators, and both are uninhabited. In the east of Kangersoak, or Statenhuk, are more than 100 small islands called Kittiksorsoit. The Greenlanders of the neighbourhood visit these islands in the beginning of spring, to procure seal game, which is there very plentiful. The large islands, which form the promontory of the southern coast, extend $1\frac{1}{2}$° from the west to the south, and are separated from the continent of Greenland by a sound of five English miles in breadth, called Ikareseksoak, through which runs a very rapid current. The sound is generally filled with immense flat masses of floating ice, and innumerable ice mountains, which are driven out from the inlets and firths of that continent. Many vessels have been beset in this floating ice by currents from north-east, and have been lost on the coast. From this, a series of small islands border the continent as far as the 61° 21′, where the eye is terrified by another island, barren, precipitous, and of considerable extent. It presents so dreadful a view, that the older navigators, although accustomed to dangers and terrors, called it the *Cape of Desolation*. This cape, which reaches far to the open sea of Davis Strait, Greenland. Islands.

is always intrenched by floating ice to a great distance. The island is called by the natives *Nunarsoit*, that is, a great land, and is separated from the continent by a narrow sound called *Torsukatek*. It is uninhabited, and even the Greenlanders but seldom visit it. There is no island of importance between this place and the 64°, where Baal's River falls into the ocean. This river, or rather this firth, is one of the largest on the whole coast. It extends 64 English miles to the interior of the continent, and then divides into two arms, one of which runs towards the north-east, the other towards the south-east. Both arms are bounded by the glacier. In this firth are three large islands, *Sermitsiak*, *Kikertarsoak*, and *Karosut*, the first of which consists of one large and high mountain, called Saddle by the Danes, from its saddle-shaped top. It is seen at a distance of 30 leagues from the coast. Another large island (called *Omenak* by the Greenlanders, and *Kin of Saal*, or *Faal*, on the charts) is situated in the 65°, and being easily distinguished by its conical form, which resembles a sugar-loaf, it serves as a landmark to navigators. No large island occurs until the 69° 14′, where the *Island Disko* is situated. It is the largest on the whole coast, its length from the north to the south occupying one degree of latitude. It forms (with the continent) Disko Bay, called Fish Bay on the charts, and is separated from Greenland by a narrow strait called Waygat. It is uninhabited, except by the Danish settlement called Godhavn, which is established in Love Bay, or Lief de Bay, for the purpose of whale fishing. To the north of Disko is an island, which deserves to be noticed, called by some navigators *Haze*, or *Hazen Island*, by others *Waygat Island*; and in the mouth of Cornelius Bay is situated another, called *Unknown Island*. These places are visited by the whale fishers in the month of May. All the islands from the 71° northwards are small, and generally marked on the charts with the name *Vrowen*, or *Women Islands*. The height of the mountains decreases gradually towards the north.

Mineralogy.

Mineralogy.—The accumulation of the ice having rendered the interior of Greenland totally inaccessible, it can only be examined on different parts of the coast; and the promontory Cape Farewell, which is its most southern point, presents to the eye immense groups of precipitous mountain masses, insulated, barren and naked, sharp-pointed at the top, greatly decomposed at the surface, and cleft by the action of the snows and the ice. These rocks are intersected by narrow valleys, where immer . broken and scattered masses are borne along by irresistible currents, and carried immediately to the shores, where there is no low land to intercept their course. The Granite of this island is fine granular, consisting of pearl white felspar, greyish black mica, and very little quartz of an ash grey colour. The whole rock is very much ironshot, and disintegrated. At the foot of the granite rocks occur beds of common quartz of a milk white colour, (not milk quartz,) and flesh red felspar, with small crystals of moroxite, (foliated or common apatite). In another place are found flesh red felspar, with little quartz, common hornblende, magnetic iron-stone, and gadolinite, crystallized in longish four-sided pyramids. A bed on the east side of this promontory, contains garnets in a fine granular greyish white rock, very much resembling the rock of Namiest in Moravia, called by Werner weiss-stein, (white stone); but the crystals of garnet here are larger, and perfect dodecahedrons. The granite extends from Cape Farewell to the east and south-east of the coast, viz. over the islands of Staaten-huck and Kakasoeitsiak, Alluck, and Cape Discord, to a distance of more than 400 miles. Gneiss and mica slate lie upon it at Kippingajak, both rocks containing garnets. Talc slate forms a large bed in it at Akajarosanik, along with actynolite, which occurs in large masses. Near the coast of Akajarosanik, is the small island called Kakasoeitsiak. It consists of one hill, formed of a granitic rock, mixed with some horn-blende, slender crystals of zirkon, and the new mineral called *Allanite*. (See *Edin. Trans.* vol. vi. p. 371.) The rock here assumes the character of the Norwegian zirkon-syenite; but its constituent parts are of a finer grain. All the granitic mountains of the islands of Staaten-huck and Cape Farewell, are surrounded by numerous very small islands, presenting round-backed or flat conical low hills of primitive syenite. To the west of Cape Farewell, at a place called Niakornak, is a very extensive bed of yellowish white felspar, crystallized in large flat six-sided prisms, the crystals being only separated by black mica, which gives to the rock a porphyritic appearance. The place is very difficultly accessible, it being harassed perpetually by the most boisterous sea, and washed by the tide at high water. Not far from this, at an elevation of about 1000 feet, the granite is divided into immense columnar or quadrangular pieces, which, seen from a distance, present an appearance similar to the ruins of a town. The Greenlanders state, that the masses were carried thither by some giants, who inhabited the country in the oldest times, and, having been sorcerers, disappeared from the earth.

1. Granite. Allanite, new mineral.

As granite is the principal rock which constitutes the mountains of this vast coast, to enumerate all the places where it is found would exceed the limits of such an article as the present. Its most common colour is greyish white, flesh-red, and tile-red: the latter colours are characteristic of the coarse granular felspar. Magnetic iron ore is generally found either disseminated or imbedded in the red variety. In some places, molybdena occurs, and in others graphite imbedded in the rock. At Baal's river and at Disko island, iron pyrites is found; but, excepting there, the rock is not very metalliferous. Precious garnet occurs very frequently; also common schorl, tourmaline, common hornblende, jade, rock crystal, moroxite, calcareous spar, fluor spar, and the above mentioned substances. Rock crystal is only found in veins traversing the red coarse granular variety, and appears to be contemporaneous, the vein being intimately mingled with the rock, and presenting no walls. Beds of hornblende slate, mica slate, felspar, and quartz rest upon it; and on the red coarse granular granite at Kogneckpamiedluœk, there is an extensive bed of red ironstone mingled with massive iron-flint (eisenkiesel of Werner.) At the end of the north-eastern arm of Baal's river, in the vicinity of the great continental ice, the traveller, ascending from a narrow cliff, suddenly beholds a dreadful chaos of immense columnar granitic blocks detached from each other, and heaped together in the most fantastic groups, the planes of fracture being so fresh, that the points from which they are broken are distinctly observable. Places of desolation and devastation of this kind are very frequently met with in the mountains of Greenland. Most of the granitic rocks affect the needle.

2. Gneiss.

2. The next rock, which forms numerous mountains in this country, is Gneiss. It occurs very often alternating with granite, sometimes with mica slate. Its character or texture may be ascertained partly in the cliffs and on the shores, partly by the forms of the mountains. The granitic mountains are always more

decomposed, and therefore more precipitous, presenting very sharp-edged summits: the summits of the gneiss are more flat and round-backed. The texture of the gneiss is thick and thin slaty; its felspar generally pearl-grey and pearl-white, seldom flesh-red, fine granular: its mica grey, pinchbeck-brown, and blackish brown: it contains but little ash-grey quartz. The valleys and clefts round the mountains are filled with rhomboidal fragments, many of them of immense size. The smaller fragments were used by the old Norwegians, with mica slate, hornblende slaty, and slaty claystone, to build their houses; the walls of which, although not cemented, after a lapse of several centuries, still brave the power of this destructive climate.

Gneiss constitutes one of the most elevated points of this extensive coast, viz. the mountain *Kingiktorsoak*, situated in the 62d degree of latitude. It is covered with mica slate from the shore to a heighth of about 1000 feet above the level of the sea, where the gneiss again becomes visible, and continues to a heighth of nearly 3000 feet. The top of this mountain is similar in shape to the roof of a house, where the ridge is not much elevated. It is entirely free from snow in summer, except a few small spots, where it rests in the hollows of its summit.

The mica slate resting upon the gneiss presents a variety of beds of hornblende slate, whitestone, (weissstein) with small garnets, talc-slate, with common and indurated talc, potstone, actynolite, and precious splintery serpentine. The gneiss is traversed with numerous veins of greenstone, varying in thickness from one inch to six feet. The greenstone which occurs in the veins resembles basalt; but it is more crystalline in its texture, lighter in its colour, and not quite so hard. Common schorl, tourmaline, and precious garnet, occur imbedded in gneiss. It contains veins of tinstone, accompanied by arsenical pyrites, wolfram, fluor, and quartz, in a firth, called Arksat, situated about thirty leagues from the colony of Juliana-Hope, towards northeast. The same place is remarkable for two thin layers of cryolite resting upon gneiss; and it is the only place where this mineral has hitherto been found. One of these layers contains the snow white and greyish white variety, unmixed with any other mineral. Its thickness varies from one foot to two feet and a half, and it is divided from the underlying gneiss by a thin layer of mica, always in a state of disintegration. The other variety is of a yellowish brown colour passing into tilered. It occurs along with iron pyrites, liver-brown sparry iron ore crystallised in rhombs, earthy cryolite, quartz, compact and foliated fluor, earthy fluor, and galena. It is remarkable, that the galena is sometimes coated with a greyish white sulphureous crust, which burns in the flame of a candle with a bluish colour, emitting a sulphureous smell.

Cryolite.

These layers of cryolite are situated very near each other, only separated by a small ridge of gneiss, of a thickness of 27 feet: both are washed at high water by the tide, and for the most part exposed, the superincumbent gneiss having been removed. The white cryolite, seen at a distance, presents the appearance of a small layer of ice; small detached fragments have acquired, from decomposition, the shape of cubes. This mineral is called by the Greenlanders *orsuksiksæt*, from the word *orksuk*, blubber, to which it bears some resemblance. The same name is also given by the natives to white calcareous spar.

3. Mica Slate.

3. Mica Slate is likewise one of the most common rocks in Greenland, and an inseparable companion of gneiss: There are very few instances where they are not found in the vicinity of each other, and frequently in contact. Mica slate forms in this country a very extensive series of insulated mountains, which never rise to a considerable height, and appear generally to rest upon gneiss. Mica slate is frequently visible on the shores, and the gneiss itself forms also very extensive beds in it at Disko bay, where the white-stone also occurs in beds. The Greenlandish mica slate abounds in mica; it is generally thin-slaty, and only thick-slaty when the quartz prevails. Sometimes it has an undulating aspect; but when this is the case, it passes into primitive clay slate. The mica of this mica slate is mostly greyish-black and pinchbeck-brown, passing into brownish-black, seldom silver-white. Its quartz is pearl-grey. It is sometimes mingled with nodules of pearl-grey felspar, from the size of a pea to that of an orange, and this gives it the appearance of gneiss; but they may be easily and accurately distinguished, as the mica-slate presents a surface perfectly continuous, and easily separable in the direction of the plates of the mica. The strata dip towards north-west. Mica slate also occurs in beds in various parts of this country. One of the most remarkable, most interesting, and most extensive, is that in the firth Kangerdluarsuk, in the 61st degree of latitude, in the district of Juliana-Hope. It extends about five miles in length, and four miles in breadth; its thickness varies from six to twelve feet; and it contains, besides felspar, which is its principal constituent part, hornblende augite, actinolite, sahlite, garnet, and that new mineral which has been analysed by Dr Thomson and Professor Eckeberg, called *Sodalite*. It is of pale apple-green, leek-green, greenish white, and pearl-grey colour, partly massive, partly crystallised. Another mineral, which has not yet been analysed, occurs also with the sodalite: it is of a peach-blossom red and purple-red colour. On the shore, the underlying gneiss is visible in several places. In the superincumbent mica slate, granite is found of very fine texture, partly disseminated, partly imbedded. Calcareous spar and fluor occur in veins, both of which are sometimes coated with a thin crust of chalcedony, also galena in small veins. Blue phosphate of iron in detached pieces is found on the shores. The mica slate is generally decomposed and iron-shot, where the graphite is imbedded. In the firth of Arksat, a bed of very fine granular limestone is found in mica slate, which resembles the Carrara marble. The beds which occur in this rock on the mountain Kergiktorsoak have been already mentioned. Hornblende slate, forming beds in mica slate, is found in many places.

Sodalite, a new mineral.

Another new mineral.

In the 64th degree of latitude, in a firth called Ameraglik, in the south of the Danish colony Godthaab, (Goodhope,) a variety of mica slate is found, which passes into talc slate, forming a very small layer in coarse granular granite. It is very remarkable, on account of the large groups of tourmaline which occur, imbedded or rather involved in talcose mica; and which are the largest crystals of this fine mineral that have been met with. At the end of the same firth, at Auaitsirksarbick, in the neighbourhood of the great continental glacier, the finest garnets are found. They are of a lamellar texture, and surpass the oriental specimens in colour, lustre, and hardness. At the same place, dichroite and hyperstene of a beautiful blue colour occur, along with precious garnet, in decomposed mica slate.

All the lower mountains from the 66th to the 71st degree of north latitude, and particularly all the mountains of the continent forming Disko-bay, with the greatest

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part of the adjacent islands, are composed of mica slate. There is scarcely a square mile where the rock is entirely free from garnets. A large mountain in Omenaks firth, called Sedliarusæt, presents on its surface only the powder of mica slate, and fragments of precious garnet. From the appearance of this powder, it is probable that the rock formerly contained great masses of imbedded iron pyrites. No snow rests on the surface of this mountain in the coldest winter. The fragments of precious garnet which are found here, when clear, are the most highly prized of any on the coast. Other minerals which are found in mica-slate in Greenland, are, emery, on the island Kikertarsoeitsiak, in South Greenland; granatite, on the island Manetsok; moroxite, in very large six-sided prisms, at Sungangarsok, in North Greenland; and dichroite, in six-sided prisms, on the island Ujordlersoak, in the 76th degree of N. latitude. Except iron pyrites, copper pyrites, and galena, no metal occurs in this rock.

White-stone.

White-stone, (Weiss-stein,) which has lately been determined by Werner, appears to belong to this rock. It presents a white and greyish-white granular appearance, which was formerly supposed to be compact or granular felspar. It is in this country characterised by very small and minute crystals of garnet disseminated through the whole mass. Here it is found in layers of inconsiderable extent, resting on mica slate, very seldom on gneiss. It is also found in detached pieces.

4. Clay-slate.

4. Clay Slate is very seldom met with on this coast, and consequently the different beds which are characteristic of this rock, viz. flint-slate, lydian-stone, alum-slate, but rarely occur. Nevertheless, at the mouth of the firth Arksut it forms two islands of some importance called Arksut and Ujorbik. The colour of the slate is ash-grey and bluish-grey; its fragments present a double cleavage, and it is traversed in all directions by numerous veins of massive and crystallized quartz, massive hornstone, and sparry iron ore of an isabella yellow colour. An extensive bed of flinty-slate and lydian-stone rests upon it on the east side of the island Ujorbik. In Ameraglikfiord, in the 65° 4′, there is a small island, where the clay-slate forms small layers in fine-grained granite, fine cubes of iron pyrites, with various truncations, occur in this slate, which is greatly decomposed. Some small islands in the south-east of Disko bay consist of clay-slate, with a variety of small beds and layers, viz. very ironshot hornblende-slate with small garnets, whet-slate, granular hornblende and greenstone. This clay-slate may perhaps belong to the class denominated transition rocks.

5. Porphyry.

5. Porphyry is very common in the south of Greenland, from Cape Farewell to the 64th degree of latitude; but it is generally found towards the interior of the continent, forming insulated rocks. In the interior of the firth Igalikko, at Akulliaraseksoak, hornstone-porphyry is found, very distinctly stratified, and resting upon fine-grained granite, containing large crystals of reddish-white, flesh-red, and tile-red felspar, and another mineral of a talcose appearance, crystallised in six-sided prisms, and hitherto unknown. The mass of the porphyry is brownish-red, and passes in some places into clay-stone, forming clay-stone porphyry, the crystals then becoming less distinct. Hornstone porphyry, with a few very small crystals of felspar, occurs also in an adjacent firth called Tunugliarbik. This rock rests upon old red sandstone. The porphyry is very much decomposed. It is of a brown-red colour, and called by the natives *aukpadlrtok*, that is, blood-red rock. It contains small layers of a kind of brown-red iron ochre, which the Greenlanders use as a dyeing material, to embellish their utensils, and the interior of their houses; a species of luxury they have learned from the Europeans.

New mineral.

6. Syenite.

6. Syenite, and all the porphyritic rocks belonging to the primitive and transition trap-formation, are found in great abundance in this country. Hornblende is a mineral which occurs almost every where. A kind of coarse granular syenite, composed of coarse granular Labrador-felspar, and crystallized common hornblende, rests upon fine grained granite at the mountain Illejutit, or Redekammen, in the 61st degree of latitude, in the neighbourhood of that extensive bed of sodalite, sahlite, and hornblende, which has been already mentioned before. This Labrador-syenite occurs also at the mountain Kognek, in the 62d degree, upon granite of a coarser grain. In the vicinity of the mountain Kognek, is a group of more than 50 islands, lying in a western direction, in Davis Strait, and called by the natives Kittiksut, from kitta, *west*. These islands form round-backed low hills, and consist of common felspar, of yellowish-brown and leek-green colours, and common hornblende of raven-black, and sometimes velvet-black colour, accompanied by small four-sided prismatic crystals of zirkon of red-brown, and purple-red colour, with fine-grained common magnetic iron-stone interspersed, and very little black mica. In some parts of the rock allanite occurs, of a pitch black colour. The rocks are somewhat ironshot, and disintegrated on their surface. Titanium iron ore is found in small layers, and fine granular chromate of iron. The rock itself has a striking resemblance to the zirkon-syenite, found at Friedrichswærn and other places in Norway, and described by Von Buch, Esmark, and Hausmann. The neighbouring mountains have no trace of that rock. At Narksak in the vicinity of Baal's river, brown titanite, or brunon, is found disseminated in syenite.

Granular porphyritic syenite is found at Nunarsoit, (Cape of Desolation.) Its stratification is not very distinct. It contains very extensive beds of coarse grained, tile-red felspar, and common magnetic iron-stone.

7. Primitive trap.

7. Primitive Trap. (*Greenstone.*) The islands which lie between the 62° and 63° of latitude, present a very complete series of the rocks that belong to the primitive trap formation. The greenstone first appears at Sakkak and Ujorbik in the mouth of Arksuts-fiord, where clay-slate predominates, and extends from those islands towards the east, that is, to the continent of Greenland, alternating with greenstone of a porphyritic structure, (*porphyrartiger grunstein* of Werner,) and green porphyry or *verde antico*. Another rock of slaty texture, consisting of compact felspar and hornblende, appears to be intermediate between hornblende slate and greenstone slate; it is here the only rock which presents very distinct stratification. The greenstone slate covers uninterruptedly both the greenstone and the green porphyry, and appears to belong to the transition greenstone formation; and perhaps the whole formation should be referred to it. It probably extends farther to the interior of the continent, as the fragments which are thrown out from the continental ice have an appearance exactly similar. Variolite is found there in small roundish rolled pieces. The greenstone, alternating with syenite, is found upon gneiss and mica slate, on the large island Nunarsoit.

8. Primitive limestone.

8. Primitive Limestone, of fine granular texture, is found only in beds and rolled pieces, and occurs very seldom in Greenland. Its beds are confined to gneiss and mica slate, and it is mingled with minute leaves of silver-white mica, seldom with grains of quartz. It is gene-

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rally accompanied by tremolite, asbestos, actynolite, sahlite, and seldom with rock-cork. Thus situated, it occurs at the island Akudlek, at the island Manetsok, at Kakarsoit and Kangerluluk, mountains in the vicinity of Jakobs-havn and Christians-haab, in Disko bay. It is very surprising, that no vestige of flœtz-limestone is found on this vast coast, nor does any petrifaction occur there. Very distinct impressions of the *salmo arcticus,* with its bones very little altered, occur in detached pieces on the alluvial land, which are forming daily. In the uppermost sand-stone, which belongs to the brown coal of the flœtz trap formation, fragments of *pecten Islandicus* are found, which have undergone but little alteration.

Flœtz trap formation.

The flœtz trap formation of Greenland, is perhaps the most extensive that has yet been discovered. It begins at the 69° 14′ of latitude, occupies the large island Disko, and the eastern coast of the Waygat, from Niakornak, on the northern cape of Arve-prinz island, round the Cape Noursoak, as far as the end of the southern coast of Cornelius Bay, where it reaches the great continental glacier. Hare island in the north of Disko island, Unknown island in the mouth of Cornelius bay, the islands Kakiliseit in the north of the latter, and many other northern islands, consist entirely of flœtz trap. From thence it extends over a part of the continental coast of Greenland, viz. London-coast, Svartenhuk, Ekalluit, Kangersoeitsiak, Karsorsoak, and disappears in the 76th degree under the most northern continental ice, or glacier, which precludes all further investigation.

The whole flœtz trap formation of Greenland, as far as it has been examined, rests on gneiss or on mica slate, these rocks alternating continually. The underlying primitive rocks, as well as the superincumbent flœtz trap, are always somewhat decomposed, where they come in contact. Trap-tuff generally rests immediately upon the primitive rock; it consists of balls and nodules of basalt and wacke, joined together by a cement of the same substance; the centre of the balls and nodules is very often filled with mesotype, blended with massive or crystallized apophyllite, the crystals of which are sometimes penetrated by acicular mesotype. This trap-tuff scarcely presents another mineral, and the apophyllite, or ichthyophthalmite, does not occur there in any other rock. The underlying primitive rock is very variable in its elevations, sometimes it does not surpass the level of the sea, sometimes, (for instance, at Godhavn,) it reaches a height of from 500 to 600 feet, which can be observed very exactly in the cliffs there. Columnar basalt lies upon trap-tuff; it presents four, five, and seven-sided columnar distinct concretions; the columns very seldom exceed a foot in diameter. This basalt does not include any mineral except sometimes very minute spots of greyish white glassy felspar. Wacke generally rests upon it, forming an amygdaloid with different minerals, viz. chabasite, stilbite, analcime, chalcedony, opal, heliotrope, quartz, zeolite, miemite, and basillar arragonite. At Hare island the chalcedony is found crystallized in cubes. At Kannioak, in Omenaks-fiord, miemite occurs in kidneys, along with chalcedony, opal, wavellite, arragonite, and some quartz in grey decomposed wacke. The wacke of the flœtz trap formation of this country is generally intersected by small veins of iron-clay and bole. Lithomarge and green earth occur in nodules. Olivine and augite are but seldom met with in the flœtz trap of Greenland. Laumonite, in a friable state, is found in very small veins, traversing wacke at Sergvarsoit, on the northern coast of Disko island. Most of the Greenlandish basalt affects the needle very powerfully. There are generally two, and sometimes three strata of columnar basalt, and one of them forms the summit, except at Hare island, where the summit consists of porphyry slate resting upon wacke. The shape of the mountains is very various, some of them present pyramidal, some conical forms, and some are entirely flat: Their stratification is very nearly horizontal, and the valleys between the mountains are generally narrow. There is no doubt that some of the mountains have been separated by very recent eruptions of rapid torrents.

Coal.

On some parts of Disko island beds of brown coal occur in flœtz trap: they rest upon yellowish-white coarse-grained sandstone, which is very friable;—large balls of iron pyrites are imbedded in it. The beds of coal are generally divided from each other by strata of fine-grained sandstone, and are of very unequal thickness. In some places of the east coast of Disko island, in the Waygat, the sandstone becomes harder, and carbonized impressions of leaves are found in it, which are similar to those of sorbus and angelica.

The coal of Disko island is common brown coal, of slaty texture: it burns very easily, but it leaves a great residuum in the form of white ashes, which have a slaty texture, and somewhat resemble the polishing slate from Bilin in Bohemia. A very remarkable variety of brown coal, passing into bituminous wood, occurs in a small bed at Hare island. It is of slaty texture; and honey-yellow amber, in numerous grains of various sizes, is disseminated parallel to the cleavage of the coal. It rests upon ash-grey coarse-grained sandstone, is covered with grey common clay, and belongs undoubtedly to the newest brown coal formation. At Koome, in Omenaks-fiord, native capillary and fibrous sulphate of iron, of a beautiful green colour, is found in the cliffs of the brown coal. All the Greenland coal is subordinate to flœtz trap.

Alluvial land.

Alluvial land has been formed at the end of every bay and firth of the coast, and, in addition to grey and greyish-white sandy clay, it contains fragments of the neighbouring mountains. This formation is daily increasing, and contains no metallic substance, except magnetic iron sand, with which it generally abounds.

Botany.

Botany.—Although Greenland affords a great variety of objects to the mineralogist, yet it offers but few to the botanist, when compared with other countries, the first efforts towards vegetation being repressed by the barrenness of the soil, and the want of the sun's genial influence. Those shrubs and trees, therefore, which in milder climates afford a comfortable shade to the wanderer, creep in this forlorn land under scattered rocks, to find shelter from their destroying enemies,—storm, snow, and ice. This land, however, presents a series of plants, which probably could not subsist in a milder climate; and in the interior of the inlets and firths may be found many species hitherto unknown in other countries. Some of the new species are published in the last number of the *Flora Danica.* There are also other spots which boast the most luxuriant verdure, but they are only places in the neighbourhod of the Greenland houses, which have been improved for many years by the blood and fat of seals and other animals. There are also small hills on the uninhabited islands, where the birds build their nests, and manuring the decomposed rocks, extort vegetation to their abode from the unfertile soil. These places, however, are but of rare occurrence, in proportion to the immense extent of the country. Innumerable cryptogamic plants, growing with great rapidity under snow and ice, supply the want of flourishing vegetation on the rocks and cliffs.

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The vegetation commences very late, not till the end of May or June, in proportion to the different latitudes, and is over by the end of August or September. The bottom of the sea in these climates appears to be better suited to vegetation than the surface of the land; there is a great variety of fuci, ulvæ, and confervæ. The plants which have been hitherto found, are,—

Flora Groenlandica.

I. Monandria.

Hippuris vulgaris. Lin. Very seldom; only in the 60°.

II. Diandria.

Veronica alpina. L.
saxatilis. L.
Pinguicula vulgaris. L.
Anthoxanthum odoratum. L.

III. Triandria.

Scirpus cæspitosus. L.
Eriophorum vaginatum. L.
capitatum.
angustifolium.
latifolium.
polystachium. L.
Phleum arcticum. Vahlii.
Alopecurus antarcticus.
Agrostis arundinacea. L.
Aira subspicata.
Festuca ovina. L.
rubra. L.
Arundo stricta. Timmii.
Elymus arenarius. L.
Koenigia islandica.

IV. Tetrandria.

Alchemilla montana.
alpina.
Plantago. (*Nova Species.*) Only in the 60°.

V. Pentandria.

Pulmonaria maritima. L.
Diapensia lapponica. L.
Primula farinosa. L. (Varietas.)
Menyanthes trifoliata. L.
Azalea procumbens. L.
lapponica. L.
Campanula rotundifolia. L.
uniflora.
Gentiana lutea. L.
Angelica archangelica. L. Eaten raw by the Greenlanders, and as pickle with oil.
Ligusticum Scoticum. Only found to the 67°.
Alsine media. L.
Statice armeria. L.
Sibbaldia procumbens. L.

VI. Hexandria.

Juncus arcticus. Wildenow.
campestris. Wahlenberg.
pallescens. Wahlenberg.
parviflorus. L.
pilosus. Wahlenberg.
spicatus. L.
trifidus. L.
Tofieldia borealis. Wahlenberg. (Anthericum caliculatum. L.)
Tofieldia alpina.
Rumex acetosa. L.
Rumex acetosella. L.
Rumex digynus. L. Rheum digynum. Wahlenberg.
An Uvularia amplexifolia, seu Streptopus?

VII. Heptandria.

VIII. Octandria.

Epilobium angustifolium. L.
latifolium. L.
alpinum.
fontanum. Wahlenberg.
Vaccinium vitis idæa. L.
uliginosum. L.
pubescens.
Erica vulgaris. L.
If it flourishes plentifully, the Greenlanders suppose that the following winter will be very severe.
Erica cœrulea. Wildenow.
Polygonum aviculare. L.
latifolium.
viviparum. L.
The root is eaten raw by the natives.

IX. Enneandria.

Rheum digynum. Wahlenberg. (Vide Rumex digynus. L.)

X. Decandria.

Ledum palustre. L.
groenlandicum. Retzii?
latifolium. Aiton.
Andromeda hypnoides. L.
cœrulea. L. (v. Erica cœrulea and Menziesia cœrulea.)
tetragona. L.
polyfolia. L.
Pyrola rotundifolia. L.
uniflora.
secunda. The leaves are eaten by the natives, and also used as tea.
Saxifraga cotyledon. L.
stellaris.
nivalis. Smith.
palmata. Smith.
oppositifolia.
bulbifera. L.
cernua. L.
rivularis. L.
cæspitosa. L.
groenlandica.
hypnoides.
tricuspidata. L.—It grows to the height of one foot; and the leaves are used as tea by the natives.
Saxifraga petræa.
Silene acaulis. L.—Eaten, mixed with oil, by the Greenlanders.
Stellaria groenlandica. Vahlii.
glauca. Wither.
humifusa. Rotboll.
cerastoides. L.
Arenaria peploides. L.
peploides (varietas)
trinervia.
Sedum annuum. L.
Oxalis acetosella. L.
Lychnis alpina. L.
varietas flore albo.
Cerastium alpinum. L.
hirsutum. Vahlii.
viscosum. L.
latifolium. L.

XI. Dodecandria.

XII. Icosandria.

Sorbus aucuparia. L. This tree is only found in the form of small shrubs, to the 61°, in the interior of some firths, and was probably brought to Greenland by the old Norwegians or Icelanders.
Rubus chamæmorus. L.
Potentilla aurea. L.
hirsuta. Vahlii.
nivea. L.
retusa.
Dryas octopetala.
integrifolia.
Comarum palustre. L.

XIII. Polyandria.

Papaver nudicaule. L.
radicatum. Rotboll.
Thalictrum alpinum. L.
Ranunculus acris. L.
hederaceo proximus.
nivalis.
sulphureus. Wahlenberg.
pygmæus. Wahlenberg.
Anemone pratensis. L. Rarely in the 60°.
Helleborus trifoliatus. L.
Anemone groenlandica.

XIV. Didynamia.

Ajuga pyramidalis. Only in the 60th degree.
Thymus serpyllum. L. Only to the 66° of latitude; it is used as tea by the natives.
Bartsia alpina. L.
Rhinanthus crista galli. L.
Euphrasia officinalis. L. Very small.
Pedicularis groenlandica.
flammea.
hirsuta.
lapponica.
Nova Species (Flora Danica.)

XV. Tetradynamia.

Draba alpina. L.
hirta. L.
androsacea. Wildenow.
alpicola. Wahlenberg.
incana. L.
muricella. Wahlenberg.
Nova Species. Now published in the *Flora Danica.*

Erysimum officinale. L.

Arabis alpina. L.

XVI. Monadelphia.

XVII. Diadelphia.

Lathyrus pratensis. Only about the firths of 60°.

Vicia cracca. Only in the vicinity of Cape Farewell.

XVIII. Polyadelphia.

XIX. Syngenesia.

Leontodon taraxacum. L. The young roots are eaten by the natives raw, and the young leaves as sallad with train oil.

Hieracium alpinum. L.
murorum. L.

Artemisia. *Nova species.*
An engraving of this species will soon be published in the *Flora Danica.*

Gnaphalium alpinum. L.
sylvaticum, fuscatum. Wahlenberg.

Erigeron uniflorum. L.

Pyrethrum inodorum. Wildenow.

Arnica alpina. L.
angustifolia. Vahlii.

Achillea millefolium. L. Used by the Greenlanders as a remedy for old sores.

Viola canina. L.
palustris. L. } Both of these are found only about the firths of 60° and 61°.

XX. Gynandria.

Orchis albida. Swartz.
groenlandica. *Species Nova.* (Vide *Flora Danica.*)

XXI. Monœcia.

Carex dioica. L.
atrata.
bracteata.
cæspitosa.
stricta.

Xanthium strumarium. L. Only found in the garden of the Moravian Brethren at Lichtenau, in the firth Agluitsok, near Cape Farewell, in the 60°, probably sent from Europe amongst other seeds.

Betula alba. L.
nana.
alnus pumila.

XXII. Diœcia.

Salix myrsinites. L.
glauca. B. Lapponum. L.
herbacea. L.
reticulata. L.
lanata. L.
lapponica. L.
livida. Wahlenberg.
affinis versifoliæ, Wahlenberg.

Empetrum nigrum. The fruit eagerly eaten by the natives.

Rhodiola rosea. L. It only reaches the 65° of latitude. Both the root and the leaves are eaten by the natives, the former raw, the latter with train oil.

Juniperus communis. L. It only reaches the 66° of latitude.

XXIII. Polygamia.

Holcus alpinus. Wahlenberg.

XXIV. Cryptogamia.

1. *Filices.* (Ferns.)

Equisetum arvense. L.
sylvaticum. L.
reptans. Wahlenberg. *Nova Species.* (*Flora Danica.*)

Osmunda lunaria. L.
spicant. L.

Aspidium filix mas. L.
filix femina. L.
dilatatum.
fragile. Swartz.
varietas fragilis. Swartz.
spinulosum. Wildenow.
lonchitis. L.

Cyathea dentata. Smith.

Woodsia Brownii, (vid. *Linn. Trans.*)
groenlandica. (*Nova Species.*)

Asplenium septentrionale.

Lycopodium selago. L.
selaginoides.
alpinum. L.
annotinum. L.

Polypodium vulgare. L.
ilvense. Swartz.
phegopteris.
lonchitis. L.

2. *Musci.*

a. Frondosi.

Sphagnum squarrosum.
obtusifolium.

Gymnostomum æstivum.
truncatulum.

Dicranum purpureum.
scoparium.
flexuosum.
undulatum.
tenue. (*Nova Species* examined by Dr Taylor, at Dublin.)
groenlandicum. (*Nova Species* examined by Dr Taylor, at Dublin.)

Didymodon capillaceum.

Grimmia maritima. (Very common on the whole coast.)

Grimmia apocarpa.

Trichostomum canescens.
lanuginosum.

Splachnum urceolatum.
rubrum.
vasculosum.
mnioides.

Syntrichia ruralis.
subulata.

Polytrichum piliforme.
juniperinum.
alpinum.
septentrionale.
subrotundum.

Orthotrichum striatum.
anomalum.

Mnium turgidum. Vulgatissimum, locis paludosis.

Bryum nutans.
pseudotriquetrum.
crudum.
cæspititium.
argenteum.
turbinatum.

Bryum ? straminifolium.
fructus deerat. T.

Bryum ? epidendrum.
fructus deerat. T.

Leskea incurvata.

Hypnum nitens.
aduncum.
uncinatum.
rutabulum.
rugosum.
schreberi.
cupressiforme.
fluitans.
stramineum.
molle.
loreum.
splendens.
cuspidatum.
filicinum.
cordifolium.
scorpioides.
palustre.

Hypnum ? cochlearifolium. T.

Bartramia fontana.
ithyphylla.

Fontinalis squamosa.

Funaria hygrometrica.

Buxbaumia foliosa.

b. Musci hepatici.

Jungermannia pulcherrima.
excisa.
dilatata.
tamarisci.
ciliaris.
pinguis.

Marchantia hemispherica.

Blasia pusilla.

3. *Lichenes.*

Lecidea sanguinaria.
fusco-lutea.
pustulata.

Lepraria botryoides.
jolithus.

Gyrophora hyperborea. (Lichen proboscideus. L.)

Greenland. Flora Groenlandica.

Gyrophora erosa.
cylindrica.
hirsuta.
Endocarpon tephroides.
Isidium defraudans.
Urceolaria calcarea.
Parmelia tartarea.
candelaria.
brunnea.
subfusca.
gelida.
stellaris.
saxatilis.
omphalodes.
parietina.
fraxinea.
farinacea.
jubata.
capillaris.
nigrescens.
ciliaris.
ochroleuca.
Peltidia horizontalis.
venosa.
resupinata.
canina.
saccata.
crocea.
Cetraria islandica.
groenlandica nigra.
groenlandica viridis.
nivalis.
pulmonaria.
juniperina.
Cornicularia lanata.
tristis.
pubescens.
Stereocaulon paschale.
globulare.
Bœomices cocciferus.
pyxidatus.
cornucopioides.
fimbriatus.
gracilis.
digitatus.
radiatus.
cristatus.
foliaceus.
rangiferinus.
uncialis.
subulatus.
radiatus.
Bœomices fragilis. Coralloid. fragil. Hoffm.

4. *Fuci.*

Algæ aquaticæ.

Fucus vesiculosus.
divaricatus.
inflatus.
ceranoides.
spiralis.
canaliculatus.
serratus. Eaten by the natives.
soboliferus.
coccineus.
plumosus.
lycopodioides.
confervoides.
nodosus.
siliquosus. (Angustifolius.) Alga marina. Seba.
loreus.
aculeatus.
clathrus.
laceratus.
laciniatus.
flagelliformis. (Fucus filum.)
palmatus. Eaten by the Greenlanders.
edulis. Editur ab Groenlandis fame coactis.
cordatus. Lubentissime editur, aukpadlartok dictus.
esculentus. Fimbriatus. Sutluitsok Greenlandis, delicatula illis esca incocta.
cartilagineus. Urgente hyeme cocta editur, haud lubenter.
ramentaceus. Ulva sobolifera.
saccharinus. Suavis esca nativis.
alatus.
bulbosus.
digitatus. Fucus hyperboreus.
giganticus.
plicatus.
albus.
corneus.
fungosus.
clavellosus.
Fucus vittatus.
viridis.
coronopifolius.
norvegicus.
perforatus. *Nova Species.*

Ulvæ.

Ulva umbilicalis.
plicata.
intestinalis.
spongiformis.
incrassata.
clavata.
latissima.
lanceolata.
flavescens.
compressa.

Tremellæ.

Tremella granulata.
verrucosa.
hemispherica.
nostoc.
agaricoides.
rubra.
adnata.
pituitosa.

Confervæ.

Conferva rivularis.
fontinalis.
dichotoma.
canalicularis.
distorta.
reticulata.
linum.
nitida.
pennatula.
rupestris.
floccosa.
diaphana.

5. *Fungi.*

Agaricus campanulatus.
fimetarius. D. ædib. Groenland.
Boletus luteus.
Helvella atra.
Peziza scutellata.
zonalis.
Clavaria muscoides. Rarissime.
Lycoperdon bovista. Vulneribus applicatur a Groenlandis sanguinis flux. imped. causa.
Mucor mucedo.

Zoology.

ZOOLOGY.—The character of the man who inhabits these latitudes, is given in a former part of the article: it will therefore only be necessary to enumerate the animals which can bear the hardships of this climate.

Mammalia.

Mammalia.—There are only four different land quadrupeds, which are found in every season on the coast of Greenland, viz. the dog, the isatis, the arctic hare, and the reindeer. The arctic, or white bear, is a migrating animal: It comes from the eastern and north-eastern polar regions, in the beginning of the winter, with the floating ice, to the western coast of Greenland, and leaves it again about the end of June.

The dog.

The *dog* is the faithful companion of man in this as in every other country, and would undoubtedly be so in a higher degree, if the Greenlanders treated this poor animal in a more humane manner. The dogs are in general large, and have the size and appearance of wolves. Their colour is very various, generally greyish brown, greyish white, mixed with yellow and black: they bark very seldom, but set up a dreadful howl. They sleep on the roofs of the houses of their masters, or lodge themselves in the snow, lying with only their noses out. They swim very well. The Greenlanders use them in place of horses: they harness them to their sledges, side by side, by means of thongs cut out of the *Phoca barbata*, or great seal: These thongs are ten yards long, the common distance between the dogs and the sledge; and in this manner they visit their friends in winter, or draw home the seals which they have killed over the ice of the frozen sea. They will travél sixty English miles in a day with sledges or sliders of whalebone, loaded with their two masters and five or six seals, Greenland. and 100 miles if they have no load. In the most northern parts they use the dogs also in the chace of the white bear. The Greenlandish dogs are very ferocious, and often fight among themselves till one of them is killed. Canine madness is unknown in Greenland. These dogs are very prolific, having frequently nine and ten whelps twice in a year: some of the bitches eat their whelps. The Greenlanders put their dogs generally on uninhabited islands during the summer, the season in which they are useless, where these poor animals are obliged to provide for themselves, and very often perish by famine. The Greenlanders use the skins for shirts, stockings, and gloves: they make strings of the guts: they are very fond of their flesh as food, and reckon a very fat dog a great delicacy. The dog skins having a very unpleasant smell, do not form an article of trade.

Isatis or Arctic fox. The *isatis* (*canis lagopus*) generally called the arctic fox, or blue and white fox, is only found in the arctic regions, a few degrees within and without the polar circle. It inhabits the whole coast of Greenland, but lives always in the neighbourhood of the sea, in cliffs and cavities, or holes formed accidentally from fragments of rocks, and having many outlets. Their food is small birds and their eggs, eggs of sea fowls, shell-fish, and, when compelled by want, they eat grass, and all that the sea throws up. The arctic fox is of a bluish grey colour: one variety is entirely snow white both in summer and winter. The hair is very thick; thicker in winter than in summer; and very soft and silky. The blue variety changes its colour in summer. and acquires a spotted skin of grey, blue and white, The isatis is undoubtedly the hardiest of quadrupeds. It sets out for prey to the houses of the Greenlanders, during the severity of winter. It couples twice a year, like the dog, and, when with young, the female retires to her kennel. It swims uncommonly well from one island to another, to the distance of four and five miles, in search of prey. It is very harmless, and, when young, is very easily tamed. Its skin is highly prized, and very much thought of in China. It is generally caught by the natives in traps made of stones, like small huts, with a broad flat stone of hornblende slate, or mica slate, hanging perpendicularly by way of a door, which falls down by means of a string baited on the inside with the *salmo arcticus*, a small fish, which the isatis is very fond of. It is also taken by the European settlers in pitfalls, and in springes of iron. The flesh is not eaten by the Greenlanders, unless when they are in the greatest want of food.

White hare. The *white hare, arctic hare*, or *varying hare*, is in Greenland of a snow white colour, both in summer and winter, and lives in great numbers amidst the snowy mountains. It is usually fat, and feeds in summer on grass, and in winter on cryptogamic plants, particularly on lichen islandicus and nivalis (*Cetraria islandica* and *nivalis.*) Its hair is very thick and soft, but very loose. The Greenlanders are not very fond of its flesh, but they like very much to eat the raw contents of the intestines, together with the stomach. They make use of the skins, which are not an article of trade, to clothe their children.

Rein-deer. The *rein-deer*, (*Cervus tarandus*), though very useful to the Laplanders, is only considered as an object of chace by the Greenlanders, and of no utility until deprived of life. They kill every summer more in the interior than they can carry to the shores, and their number is rapidly diminishing every year. Besides this, these thoughtless people neglect the time of their best fish and seal game for this sport. They eat the flesh, which is tender and well-tasted, raw, boiled, and dried. The hunters drink the warm blood, dressed with some berries; the contents of the stomach, called *nerrikak*, is a delicate dish. They are also very fond of the fat of the animal. The skin forms a part of their clothing, particularly of that of the women; and the inhabitant of this dreadful climate is obliged to procure a couple of fine rein-deer skins during the summer, if he wishes to be agreeable to his wife. The sinews, when split, are very good threads, with which the women sew their clothes. The horns are employed for utensils and instruments. The greatest number of rein-deers is found in the vicinity of Baal's river, near to the continental ice, from the 63d to the 66th degree. They occur very seldom in more southern or more northern latitudes.

White bear. The *white bear, polar bear, or arctic bear*, (*Ursus maritimus*, or *Ursus arcticus*), is a migrating animal. It is never seen after the large or black whale (*Balæna mysticetus*) leaves the coast of West Greenland. Their size is stated by some authors to be from 13 to 23 feet, but this is probably too much exaggerated. The largest white bear which was met with on the west coast of Greenland, measured 9 feet and 4 inches from the snout to the tail, the skull of which is now in the museum of the Dublin Society. Another, caught by the celebrated navigator, Captain Phipps, (Lord Mulgrave) at Spitzbergen, measured 7 feet from the snout to the tail. The white bear seems the only animal, that, by being placed in the coldest climate, grows larger than those that live in the temperate zones. Its flesh is not so good as that of the other kinds of bear; it has an oily taste, and a fishy flavour; the liver is very unwholesome, and causes vomiting. The usual food of this animal is fish, seals, and the carcases of whales. On land, which it seldom approaches, it preys on rein-deer, hares, foxes, and birds. It lies in ambush on the flakes of the floating ice, and lurks there after seals and other marine-animals; it also attacks the morse, or walrus, with which it is in constant enmity. The walrus, by reason of its large teeth, has generally the superiority, but frequently both the combatants perish in the conflict. In winter, when hungry, it sometimes attempts to break into the houses of the Greenlanders, allured by the scent of the flesh of seals, but it is very easily driven away with fire-arms and dogs. The female has only one young one, and lodges it in the snow of the floating ice, or on the shores. The affection between the parents and their young is so great, that they will sooner die than desert one another. The Greenlanders kill them with fire-arms, generally assisted by dogs; and both the man and dog, feed on the flesh and fat. The skin is used for boots, and some other domestic purposes; it is also a valuable article of trade, a good skin being generally sold for three or four pounds.

Walrus. The pinnated quadrupeds, or quadrupeds with fin-like feet, are, the *morse*, or *walrus*, (*Trichechus rosmarus*). It is sometimes found of the length of 18 feet, and the circumference in the thickest part is ten or twelve feet. Its weight is from 600 to 1500 pounds. It has very short legs, and five toes on each foot, joined together by webs, with a small roundish blunt nail to each. Its skin is generally an inch thick, thicker on the neck, and very much wrinkled about the joints; it is very thinly beset with grey and reddish grey hair, sometimes mouse-coloured. It has two large teeth or tusks in the upper-jaw, from a foot to two feet long, and four grinders, flat at the top, above and below, the surfaces of them generally being very much worn. It is found of the largest size in the Icy Sea. The animals feed both upon seagrass and small marine animals, Greenland. viz. shells and small fishes. It sleeps upon the floating flat ice, or on the surface of the sea, and when attacked by men, will endeavour to overset the boat, or to make holes in it with their teeth; but it is very clumsy when out of the water upon the ice, where it may be killed with little difficulty. When a walrus or morse is struck with the harpoon, the Greenlanders let it run till it is wearied, and then draw in the line to kill it with the lances. The Greenlanders very seldom kill them in their small canoes; but if they do, they are always in company with three or four men. They are no more seen in large flocks on the coast of West Greenland as formerly, having been diminished by the whale fishers, who killed a great number of them. A flat island on the southern coast of Disko island, called Saitok, situated in the mouth of Disko firth, consists of alluvial land, which is covered with numberless bones and skulls of the walrus. The Greenlanders feed on their flesh, which is of a dark red colour; they use the oil in their houses, cut thongs out of the skin, and employ the tusks for their utensils and instruments.

Walrus.

Trichechus manatus, which is called *auvekœjak* by the Greenlanders, is very seldom seen on the coast, according to their own accounts; and it appears more towards Bhering Straits, and the sea in the vicinity of Kamtschatka.

Seals.

The *seals* may be called the flocks of the Greenlanders. They supply them with flesh, the most desirable food of this nation. The blubber furnishes them with oil for their lamps, and for their chamber and kitchen fire; the fibres of the sinews of the seal furnish thread for their clothes; of the skins of the intestines they make their windows, and their curtains for the tents; the stomach is used as a train oil vessel, and the bladder is employed for the javelins. The blood, mixed with flesh, is eaten as soup. But the most valuable thing is the skin: it covers their boats and their tents; it furnishes clothes, boots, stockings, gloves, and coverings for their bedsteads.

There are different species of seals, partly migrating, partly living on the coast of Greenland. One of the most remarkable is,

Hooded seal.

The *hooded seal*, *Klappmutze* of the Germans, *Klapmyds* of the Danes, *Neitsersoak* of the Greenlanders, *Phoca cristata* of Gmelin. It is so called from a thick folded skin on the forehead of the male, which it can draw over the eyes like a cap, to defend them against its enemies. Its hair is of a double kind, the longest silver white, the shortest black and woolly, which gives it a very beautiful appearance. It grows to the length of ten and twelve feet. The Greenlanders value the skin of the young ones very high. It is uncommonly fierce when wounded, and often attacks the canoe. These seals fight very stoutly among themselves, from jealousy, as the natives suppose. They live in flocks; are found in great numbers round Cape Farewell, and go very seldom to the northern parts of the coast. It is falsely called *Phoca leonina* by some zoologists, this being a very different animal.

Common seal.

The *common seal*, called *Spragled Sael* by the Danes, *Kobbe* by the Norwegians, *Meerkalb* by the Germans, and *Kassigiak* by the Greenlanders, (*Phoca vitulina* of Gmelin) is found sometimes in very large flocks on the coast of Greenland. It is one of the smaller animals of the family, but its skin is the finest of them all, and is of great value among the Greenlanders. It is principally employed for female dresses. The common seal is very cautious, and therefore caught with difficulty.

Harp seal.

The *harp seal*, or *half-moon*, (*Phoca groenlandica*,) called *Svartside* by the Danes, *Robbe* by the Germans, and *Atarsoak* by the natives. It is nine feet long when full grown, and gives the best blubber. Its skin is of a yellowish-white and greyish-white colour, with two large black spots on the opposite sides of its body, in the form of two half-moons, the horns of which are turned in an uniform direction towards one another, and therefore called Half-moon. It becomes like the black spots in its fourth year when full grown. Its skin is the most durable, and therefore used to cover the canoes and the tents. It is incautious, and very easily taken. It never ascends the fixed ice. It is a migrating animal; comes with its young from Spitzbergen to Davis Strait about the end of March, returns in May to Spitzbergen, and comes back again in July. Three or four of them afford a barrel of blubber. It comes in great flocks, and visits the firths of Davis' Strait.

Rough seal.

The *rough seal*, (*Phoca hispida* and *Phoca fœtida*,) called *Neitsek* by the Greenlanders, is the smallest of the generally known species, very seldom exceeding four feet in length. It never frequents the high seas, but keeps always in the vicinity of the fixed ice, generally in high latitudes, and is very seldom seen southward from Disco Bay. Many thousand are killed every winter in Omenak's firth or Cornelius bay, in the 72° of latitude. The male emits an insupportable smell in its coupling time, nevertheless it is eaten with great avidity by the northern Greenlanders.

Great seal.

The *great seal*, (*Phoca barbata*,) called by the Greenlanders *Urksuk*, is of the largest kind, but is very seldom met with on the coast of West Greenland. It measures sometimes ten feet in length, has a thick skin, with very thin brown hairs; and on its upper lip very long white pellucid whiskers, which are curled at their points. Its flesh is white and very good. The Greenlanders cut out of the skin thongs and lines for their seal game, whips, and other domestic articles.

The Greenlanders mention some other species of seals, which very seldom occur, viz.

Siguktok, having a very long snout; in its body it is similar to the *Phoca groenlandica*. Perhaps it is the *Phoca ursina*.

Imab-ukallia, of a snow-white colour, the eye presenting a fire-red iris, probably the *Phoca leporina*.

Atarpiak or *atarpek*, the smallest species of seal, not exceeding the size of the hand, of a whitish colour, with a black spot of the form of a half-moon on each side of the body.

Kongeseteriak has, according to the description given by the natives, some resemblance to the sea-ape, which is described by Mr Heller.

Sea unicorn or narwhal.

The *Sea-unicorn* or *narwhal*, (*Monodon monoceros*,) called *Kernertak* by the Greenlanders, is a migrating animal. It is generally from seventeen to twenty feet long, has a smooth black skin, and a small mouth in proportion to its body. It has no teeth, but a horn, wreathed or twisted on its surface, and from eight to ten feet long, runs from the left point or end of the upper jaw. It is white, has the solidity of the hardest bone, and far surpasses ivory in all its qualities. The animal uses the horn to get at its food the sea-grass, and also as a weapon against its enemies. It has two nostrils in the skull, but they emerge in one aperture through the skin. It swims with wonderful velocity, and can only be killed when there is a great number of them together. They are always seen in flocks, in the severest winter, amidst the fissures of the fixed ice, in the bays from 70° of N. Lat. to the most northern regions. They never occur in more southern latitudes. The Greenlanders drive with their sledges to the fissures of the ice, where the animals generally come up to take air, and kill them there with their harpoons, or with guns. They eat both their flesh and skin, raw, dried, or boiled; use the blubber for their lamps; and the horns, which are highly valued, as an article of trade. Most of them are killed in Disco bay, in the 70°; in Omenak's firth, or Cornelius bay, in the 72°; and at Upernavik, in the 73°.

White fish.

The *white-fish*, *beluga* of the Russians, and *kelleluak* of the Greenlanders, is likewise a migrating animal, and visits the coast of West Greenland regularly every year about the end of November. It is, next to the seal, the most useful animal to the Greenlanders, and it comes at a season when their provisions fall very short. It arrives in flocks, in very stormy weather, when the wind blows from the south-west. It has a short, roundish, very fleshy head, but the skull is longish and flat; the eyes and the mouth are small; in each jaw of each side are nine teeth; the pectoral fins are nearly of an oval form; and beneath their skin may be felt the bones of five fingers, which terminate in five very distinct projections. The body is round, oblong, and well proportioned; and its tail is divided into two lobes, which lie horizontally. Its length is from twelve to seventeen feet. In swimming it makes great use of the lobes of its tail, bending them under the body, and working it with such force as to dart along with the velocity of an arrow. One of the large size yields five barrels of good blubber. Its flesh is somewhat similar to that of beef, though oily; its skin is eaten raw, dried and boiled. Its oil is of the best, whitest, and finest quality. The intestines are used for windows, and the curtains of tents. The sinews, when split, give the best sort of strong thread. The female white-fish has two nipples, and yields a yellowish-white milk, but it produces only a single young one, which is of a fine pearl-grey colour, but it afterwards grows white. The pearl-grey young is called *utak* by the natives. The full grown are the most beautiful animals; they are not shy, and sometimes follow, tumbling themselves round the boats. They are killed with harpoons, and also caught in large strong nets, which are set in narrow sounds between the islands.

The *porpoise*, or *Delphinus delphis;* the *nise*, or *Delphinus phocœna;* and *the sword-fish*, or *Delphinus orca*, are frequently seen on the coast, but very rarely caught.

Whales.

Whales.—There are different species of whales which visit the coast of West Greenland, viz. *Balæna physalus*, or fin-fish, called *tunnolik* by the Greenlanders; *Balæna musculus*, or *northcaper*, (Green. *keporkarnak*); *Balæna rostrata*, (Green. *tigagulik*); *Balæna boops*, (Green. *keporknak*), and *Balæna mysticetus*, or the Greenland whale, called *arbek* by the natives. The *Balæna boops*, or *butskopf*, comes regularly to the coast in the neigbourhood of Fredrikshaab about the end of July, when the Greenlanders, both men and women, go out in their canoes. The men in their small canoes follow the whale, and continue to throw a great number of harpoons and lances into the animal, until it dies from loss of blood. They afterwards join their canoes, fasten their spoil to them, and carry the booty to their houses, where it is divided.

Balæna boops.

The *Balæna boops* is a smaller kind of whale, its length being from twenty to twenty-five feet. It has a fin on its back, and also a protuberance which grows towards the tail. It has long rugged wrinkles under its neck, that are white inside, and greyish-black on their elevation. A great number of the shells called *Lepas balænaris*, or *Lepas diadema*, are found near its fins. Its body is longer, and sharper behind and before, than that of the other whales. Its back is of a black, and its belly of a greyish-white colour; the whalebones of this species rarely exceed the length of one foot. Its blubber is thin, and not very oily. This whale follows always along the coast farther to the north, and it is also caught by the Greenlanders in Disco Bay.

Balæna mysticetus.

Balæna mysticetus, the great or Greenland whale, is the most valuable and lucrative species of this genus, on account of its bigness, and the great quantity of fat, which affords much oil; it is also the most tame, and the easiest to be caught, on account of its unwieldy size. It has no back-fin. The head of it forms one-third part of the whole body. Its eyes are very small in proportion, not much bigger than those of an ox, and black, with a white iris; they lie deep, and are placed above the junction of both lips. Instead of ears, a hole appears on each side of its head, so small that it is scarcely discernible, not admitting any thing thicker than a goose-quill; but within the flesh there is a larger orifice, formed like an ear, which enables it, as has been noticed, to hear very distinctly. The two holes, or pipes, on the top of its head, are crooked, and very similar to the holes in the belly of a violin. They are for receiving air, as well as for discharging the water which it swallows by its mouth. This is forced upwards through these holes in very large quantities, and to a considerable height, (of some fathoms) with such a noise, that it roars like a hollow wind, and may be heard at three miles distance. When wounded, it blows more fiercely than ever, the water frequently being mixed with blood. Its throat is uncommonly narrow, not exceeding the width of one inch and a half. Its tongue is eighteen feet long, when the animal measures fifty-six or sixty feet; it is then ten feet broad, is very fibrous, floats on the water, and affords four to six barrels of oil; its weight is to 600 or 800 pounds. The tongue is inclosed in long pieces of a corneous substance, generally called whalebones; and these are covered on their interior side with a kind of fibre, or straight hair of the same substance, similar to coarse horse hair. On each side of the tongue are commonly found 250 of different lengths; the longest are about the middle, and decrease towards the snout and the throat; they are attached to the upper jaw. The under jaw forms with the jaw bones an oblong triangular deep bason, of a tendinous and cartilaginous substance, which is as deep as to cover the longest whalebones in their perpendicular shape, when the mouth is closed; this receptacle is, of course, deepest towards its middle part. The broad ends of the whalebones, where they are joined to the palate, are generally one foot broad; they terminate very pointed, and have the form of a curved sword; they would wound the tongue, which is very delicate, if they were not covered with hair on their inside. There are no other teeth in the mouth. This whale is very thick from the head to the middle, but thinner and sharper towards the tail; its fins and its tail stand horizontally.

Dimensions of the Greenland whale.

In the spring of 1813, a whale was killed at Godhavn, of the length of 67 feet. The dimensions of a whale, killed in the year 1811 at Godhavn, was, from the centre of the mouth to the point of the tail, 56 feet. From the point of the under lip to the root of the fins 23½ feet. From the fins to the point between the two lobes or wings of the tail 33 feet. The length of the head was 18 feet. From the middle point of the upper lip to the blow-holes 16½ feet. The length of one of the fins 8 feet 4 inches. The thickness of a fin, on its thickest part, 1 foot 9 inches. The breadth of the tail from one extremity of its wings to the other, 22 feet 7 inches. The length of one of the blow-holes 11 inches. There were 13 ribs on each side, and in all 26 ribs. The animal was a female. The fins serve this large animal for rudders, to turn in the water, and to give a direction to the velocity impressed by the tail. The tail serves for an oar, to ad-

Greenland.

vance itself in the water; wherewith it swims with incredible force and celerity. When swimming a little under the surface of the water it leaves a track in the sea like a great ship, and this is called its wake, by which it often is followed. The female makes use also of the fins, when pursued, to bear the young one, placing it on its back, and supporting it by the fins on each side, from falling. They are also seen sometimes having their young upon the tail.

The skin of the whale is of a different nature. The epidermis resting upon the skin is not thicker than parchment; but when this is removed, the real skin appears, which is about an inch thick, of a bluish-black colour, fibrous and spongy; it is called by the Greenlanders *maktak*; it is very much wrinkled in the old whales, and smooth in the young ones. Beneath the skin (*maktak*) lies a yellowish white, very tenacious, reticulated fibrous substance, which affords more fritters than oil; it is called *maksak* by the natives: with this substance the real blubber is immediately connected. The blubber is of very unequal thickness, from 10 inches to one foot thick upon the back, and on the under lips two feet thick; but the latter is very cartilaginous, and intermixed with coarse nerves. The head and the back of the whale is bluish-black, the under jaw is white, and sprinkled or spotted with bluish-black, and the tail is greyish black. The skin of the suckers is greyish blue. The Greenlanders state, that the old animals become more and more of a greyish white colour. The blubber of young whales is reddish white and rose red, that of the old is yellowish white; the flesh of the young is dark blood-red, that of the old is dark red-brown. The bones of the whales are very porous, and afford, when sawed in pieces, the finest oil. The female whale has two breasts, with teats like a cow, and has one young one, very seldom two. When it suckles the young it lies on its side, on the surface of the sea, and the young one attaches itself to the teat. The food of the whales is the *clio arctica*, the *argonauta arctica*, *cancer pedatus*, and *cancer oculatus*, none of them exceeding the size of a common wasp. Sometimes also *oniscus pulex*, and other species of oniscus are found in its stomach. It takes its food under water; these small insects become entangled by the hair of the whalebones, and the water is emitted partly on the sides of the mouth, partly through the blow-holes. The whale cannot remain longer than from 15 to 20 minutes under water. It sleeps on the surface of the sea, and is often caught asleep.

Settlements for the Danish whale fisheries.

The settlements or colonies, which are established and supported by the Danish government on the coast of West Greenland, for the purpose of the whale-fishery, are Holsteinsburg in 67° 10′, Egedesminde and Wester-island on the southern point of Disko bay, Hunde Island, and Crown-prince-island in Disko bay, Christianshaab, Claushavn and Jacobshavn on the continent of Disko bay, Godhavn on Disko island, and Klokkerhuck on Arve-Prince-Island, situated on the entrance of the Waygat. The fishery is carried on in boats, by natives and settlers, on the account of the Danish government. The fishery was not very successful during the last ten years. The English and Scotch whale-fishers visit Disko bay every year about the end of April, and leave it again in June. The Dutch whale-fishers, who formerly also came there every year, were prevented from fishing at all during the late war. It is only the balæna mysticetus, which is caught there at that season. It comes to the coast about the end of December, and leaves it again in June.

The spermaceti whale, or cachalot, (*Physeter macrocephalus*) the enemy of the balæna mysticetus, is seldom seen on the coast of West Greenland.

Birds. Land birds.

Birds.—West Greenland presents very few land birds. The largest of them is the *vultur albicilla*, the cinereous eagle, called *nektoralik* by the natives; it feeds on seals, fishes, and all kind of birds; is of a greyish brown colour, and inhabits Greenland the whole year, sitting on the rocks with flagging wings, and flies slowly. It is eaten by the Greenlanders, and the skin employed for clothing.

The *falco rusticatus*, the *falco islandus*, and the *falco fuscus*, or Greenland falcon, called by the natives *Kirksoviarsuk kernertok*, inhabit the most remote parts of the firths; they feed on birds. The latter is of a very fine appearance. Its colour is marbled of white grey and brown. It is only eaten by the natives when compelled by hunger. All falcons inhabit Greenland the whole year.

The *beautiful snowy owl*, or *stryx nyctea*, called *orpik* by the Greenlanders, is found in the interior of the continent, in the vicinity of the glaciers. It preys on every kind of bird day and night.

The *raven*, (*Corvus corax*,) (Green. *Tulugak*,) occurs in great number, and frequents the huts of the natives, who abhor its flesh.

The *white partridge*, (*Tetrâo lagopus*), called in North Greenland *ageiksek*, and in South Greenland, *kauio*, inhabits in summer the mountains for the sake of crowberries, (*Empetrum nigrum*). In winter it descends to the valleys near the shores. It is brownish in summer, and changes its colour in winter into a snow white. The Greenlanders like very much to eat its intestines raw.

Of small land birds, which all leave this country in the beginning of winter, are only seen the *fringilla lapponica*, (Green. *Narksamiutak*), the *fringilla linaria*, (Green. *Orpingmiutak*), the *motacilla oenanthe*, (Green. *Kusseklak*), and the *emberiza nivalis*, (Green. *Kopanauarsuk*). The arrival of the latter about the end of May announces the approach of spring. In autumn, in the beginning of September, it collects again in great flocks, in order to migrate.

Water birds.

Of water birds, there occur on the coast,—

1. *Anas bernicla*, bernacle. Green. *Nerdlek*.
2. *Anas clangula*, golden-eye. Green. *Kærtlutorpiarsuk*.
3. *Anas histrionica*, harlequin. Green. *Tornaviarsuk*.
4. *Anas boschas*, mallard. Green. *Kertluctok*.
5. *Anas glacialis seu hyemalis*, long tailed duck. Green. *Aglek*.
6. *Anas spectabilis*, king-duck. Green. *Siorakitsok*.
7. *Anas mollissima*, eider-duck. Green. *Mitek*.

Eider duck.

The *Anas mollissima*, or eider-duck, visits the coast as soon as the grass begins to grow, and plucks the finest down from its breast to form its nest. The down taken from the nest, is the finest and most elastic. It is customary to take away the first eggs, which occasions a second laying, and a second deplumation. They lay their eggs on uninhabited islands among the grass growing near the shores. They brave the severest winter of the arctic regions, and their breeding-places are the most northern. They come constantly every spring to the same spot again if not disturbed. The Greenlanders kill them with darts and guns, watching their course (when they dive) by the air-bubbles, and strike them when they ascend. The flesh is valued as food. The skin of this duck is the most valuable of all as a garment placed next to the skin. The down forms a very considerable article of trade. The colony Egedesminde produced in the year 1808, 1000 pounds weight of that article. One pound sterling is paid for one pound weight of the best sort of down.

enland. Of *Merganseres* occur,—1. *Mergus serrator.* Green. *Paik.*

2. *Mergus merganser*, goosander. Green. *Pararsuk*

ks. Of *Auks.*—1. *Alca impennis*, great auk. Green. *Isarokitsok.*

2. *Alca torda*, razor-bill. Green. *Akpardluk.*

3. *Alca pica*, black-billed auk. Green. *Akpa.*

4. *Alca arctica*, puffin. Green. *Killangak.*

5. *Alca alle*, little auk. Green. *Akpalliarsuk.*

The *alca pica* vies with the eider-duck in point of utility to the Greenlanders. The skins are used for clothing, and the flesh is eaten. They only approach the coast when the cold becomes very severe, and breed in summer in the clefts of the remotest rocks. They are killed in canoes with darts, and give food to the Greenlanders in the months of February and March, when they want every other supply from the sea. It appears that the words *alca*, *auk*, and *akpa* are formed from the note or sound which the bird emits when flying or swimming in large flocks.

els. Of *Petrels*, or *Procellariæ*, are seen,—

1. The *Procellaria glacialis*, fulmar. Green. *Kakordluk* ; and,

2. The *Procellaria puffinus*, shear-water. Green. *Kakordlungoak.*

The prey of these birds being the blubber of the whale, they are only found in the vicinity of the whale-fisheries. They are, from the nature of their food, extremely fetid; and so stupid and voracious, as to be killed with rods in their attempt to obtain prey. They are rarely eaten.

lemots. Of *Guillemots.*—1. *Colymbus grylle*, black guillemot. Green. *Sergvak.*

2. *Colymbus glacialis*, northern guillemot. Green. *Tudlik.*

3. *Colymbus septentrionalis*, red-throated guillemot. Green *Karkfak.*

Their skins are very excellent for clothing, in consequence of their durability.

Tns. Of *Terns.*—*Sterna hirundo*, great tern. Green. *Imerkoteilak.*

Their eggs are the most delicate of all water-birds. They come latest in summer, that is, in the beginning of June, and leave the coast earliest, that is, in the beginning of September, under great noise.

Gs. Of *Gulls.*—1. *Larus marinus*, black-backed gull. Green. *Nayardluk.*

2. *Larus tridactylus*, kittiwake. Green. *Tattarak.*

3. *Larus candidus*, ivory gull. Green. *Nayauarsuk.*

4. *Larus arcticus, cataracta parasitica*, arctic gull. Green. *Meriarsairsok.*

5. *Larus glaucus*, glaucous gull. Green. *Naya.*

ans. Of *Pelicans.*—1. *Pelicanus carbo*, corvorant. Green. *Okaitsok.*

2. *Pelicanus cristatus*, crested corvorant. Green. *Tingmik.*

3. *Pelicanus bassanus*, gannet. Green. *Kuksuk.*

All these birds are used as food; the skins for clothing.

pax. Of *Scolopax.*—1. *Scolopax gallinago*, common snipe. Green. *Sigrektok.*

2. *Scolopax jardreka*, jardreka. Green. *Sargvarsursoak.*

Tga. Of *Tringa.*—1. *Tringa striata*, striated sandpiper. Green. *Sirksariarsungoak.*

2. *Tringa interpres*, Hebridal sandpiper. Green. *Telligvak.*

3. *Tringa lobata.* Green. *Nelloumirsortok.*

4. *Tringa fulicaria.* Green. *Kajok.*

5. *Tringa alpina*, dunlin. Green. *Tojuk.*

Plers. Of *Charadrius*, or *plover.*—1. *Charadrius apricarius*, alvargrim. Green. *Najoiroveck*

Greenland. 2. *Charadrius hiaticula*, ringed plover. Green. *Tukagvajok.*

Fishes. Fishes.—Greenland cannot boast of valuable fisheries. The natives attend only to their seal-game, and neglect entirely every other branch of industry. The few Europeans residing there are occupied with trade. There can be no doubt, however, that such an extensive coast would afford numerous and profitable banks. Some have already been discovered at Tunugliarbik, Guannersoak, Fredrikshaab, Fishfiord, Sukkertop, Amertlok, where *different species of cod fish* are caught, for instance, *Gadus æglefinus*, (Green. *Misokarnak*); *gadus callarias*, (Green. *Sarolik*); *gadus morrhua*, (Green. *Saraudlirsoak*); and *gadus barbatus*, (Green. *Ogak*). In the north of Greenland, in the 70, 72, and 73d degrees, were discovered very extensive *flounder banks.* The *pleuronectes hippoglossus*, holibut, (Green. *Netarnak*), sometimes of a weight of more than 100 pounds, is found in abundance in the neighbourhood of the colonies Godthaab and Sukkertop. Extensive banks of the *pleuronectes cynoglossus*, (Green. *Kaleraglik*), were lately discovered at Jacobs-havn in Disko bay, and at Omenak in Cornelius bay. Different species of *salmo*, viz. the *salmo carpio*, (Green. *Ekalluk*), the *salmo alpinus*, (Green. *Iviksarsok*), and the *salmo rivalis*, visit every year the friths and inlets of the continent. But the most remarkable of all the fishes is the *salmo arcticus*, called *Angmarsæt*, the Greenlanders deriving their daily food from them. It forms their bread, and makes also a sort of dessert after their most delicate repasts. The *Angmarsæt* live at sea most part of the year; but, at the end of May, they come in immense numbers into the bays and friths. They are taken in nets, in all kinds of vessels, and even with the hands, in great multitudes. The whole bottom of the sea seems covered with them. They are dried on the rocks, put into sacks, and preserved for the winter under heaps of stones. They are generally eaten dried instead of bread, but many are dressed fresh as soon as they are taken. They seldom exceed seven inches in length. They have a very strong sharp smell when they are dry; and are, on the whole coast of Norway, in bad credit, as a very noxious fish, a calumny which they do not deserve. The impression of this fish occurs frequently in an indurated grey sandy marl on the end of the bays. Next to *angmarsæt*, the Greenlanders eat most of the *ulkes*, a kind of *cottus*, particularly *cottus scorpius*. They eat the fishes dried, or boiled in sea water, but the heads of *pleuronectes* are eaten putrid. Salmo arcticus.

Insects.—The Greenlanders are tormented with very troublesome insects. The *culex pipiens*, a kind of musquitoes, appears in the months of June, July, and August in myriads. But a great number of other insects increase, from the incredible filthiness of the natives. Insects.

The insects, which contribute to the comforts of life, are, *Cancer phalangium*, a species, which has some resemblance to *cancer longimanus*, the cancer *squilla*, and cancer *homaroides*. The minute species of *Cancer pedatus* and *Cancer oculatus* afford food to the whale, and their existence is therefore of great importance to the natives. Numerous species of *oniscus* are found partly in the sea, and partly attached to the bodies of several marine animals.

Vermes.—Numerous species of *gordius* and *lumbricus* are found, and the intestines of the arctic quadrupeds, birds, and fishes, swarm with different species of *ascarides*. Of the interesting family of *Nereis* occur 10 species. Worms.

Shells.—The coast of Greenland cannot boast of numerous varieties of beautiful shells, of which the seas Shells.

Greenland. Shells.

of the warm climates abound. Of *Asterias* occur the *asterias rubens*, with 6 rays; the *spongiosa*, with 5 conical rays; the *papposa*, with 12 and 13 rays; the *minuta*, with 6 rays, and the *ophiura*, with 5 rays. In Discofiord is found the *asterias caput medusæ*. Of *Echinus* exists only the *saxatilis*; 12 species of *Serpula*; 3 species of *Chiton*, one of which is new, and not yet described; its testæ are marbled of a yellow and red colour. Of *Lepas* occurs on the shores, *lepas balanus*, and *balanoides*; and on the skin of the Balæna boops, the *lepas balænaris*, or *diadema*.

Of Bivalvia are found the *mya* arenaria, arctica, truncata and byssifera, the latter a new species; only one *Cardium*, viz. ciliare; three *Veneres*, the islandica, minuta, and fragilis. The *pecten* islandicus. The *mytilus* edulis, discors and faba. The myæ and mytili are eaten by the natives; and the shells used as spoons.

Univalvia are: some *patellæ*, *argonauta arctica*, the favourite food of the balæna mysticetus; the *helix* pellucida, nitida and haliotoides; the *trochus* cinerarius, divaricatus and helycinus; the *tritonium* undatum, despectum, antiquum, glaciale, lapillus, fornicatum, clathratum, craticulatum, and ciliatum; the two latter are new species. Of *Nerita*, the littorea only is found.

In the friths and inlets are found various *tubiporæ madreporæ*, *milleporæ*, and *celleporæ*, but all very minute. *Flustræ* and *sertulariæ* grow on the whole coast in great numbers; *alcyonia* and *spongia* occur very seldom.

Catalogue of books respecting Greenland.

It will no doubt be interesting to our readers to have a catalogue of works concerning Greenland, which have been published at different times.

The oldest accounts of Greenland will be found in *Kongs-speilet*, or *Speculum regale*. More in Whitfeldt's *Chronica*, and in Lychsander's *Chronike*. Copenhagen, 1602. Part of it is translated into English, and published in Purchas' *Pilgrims*.

Jens Munks *Navigatio Septentrionalis*, in Danish, was published at Copenhagen, 1624, 8vo. It contains his voyage for discovering a north-western passage, and some account of Greenland.

Isaac de la Pereyre wrote a *Relation de la Groenlande*. Paris, 1613, 8vo. It was translated into the Danish and German language.

From this time to the year 1721, some curious critical pamphlets were written concerning East and West Greenland, viz.

Rudolph Cappel, *Orbis Arcticus*. Hamburgi, 1675, 4to.

Arngrimi Jonæ, *Groenlandia*, (in Latin.) Hafniæ, 1688, 8vo.

Thormodi Torfæi, *Historia Vinlandiæ Antiquæ*. Havniæ, 1705, 8vo.

Thormodi Torfæi *Groenlandia antiqua*. Havniæ, 1706, 8vo. and 1708, 8vo. *cum tabulis geographicis*.

Pierre de Mesange, *les aventures et les voyages de Groenlandt avec une relation de l'origine, de l'histoire, des mœurs, et du paradis des habitants du pole arctique*, à Amsterdam, 1720, 2 vols. 8vo.

Zorgdrager *oud en nieuwe Groenlandish Walvischery*, 4to. Amst. translated into German, Hamb. 1724, 4to.

Hans Egede, the celebrated Danish missionary, went to Greenland in the year 1721, and published, in the year 1729, at Copenhagen, in 4to. *Den gamle Groenlands nye perlustration*. It was soon translated into English, German, Dutch, and French.

Afterwards he published, in the year 1738, at Copenhagen, in 4to. *Omstændelig og udforlig Relation angoende den Gronlandske Missions Begyndelse og Fortsættelse*, (containing his Journal).

Paul Egede, his son, the second Danish missionary, published soon afterwards, continuation of *Relationerne betreffende den Gronlandske Missions Tilstand* from 1734 to 1740.

Greenland ‖ Greenock. Catalogue of books respecting Greenland.

In the year 1788 he published his last work, *Efterretningerne om Groenland, uddragne af en Journal holden fra Aarene*, 1721 till 1788. Copenhagen, 8vo. with plates.

Nils Egede, his brother, who was a merchant in Greenland, published a continuation of *De Gronlandske Relationer*, from 1739—1743.

In the year 1761 David Crantz, of the German Unitas Fratrum, visited their settlements on the coast of West Greenland, and remained there till August 1762. In the year 1765 he published, *Historie von Gronland*. 2. Bande, 8vo. with plates. Barby; and in the year 1770, Fortsezzung (continuation) *Der Historie von Gronland*. His account was translated into English, Dutch, and Swedish.

The Rev. Otto Fabricius, who was a missionary in Greenland during five years, published his *Fauna Groenlandica* at Copenhagen, in 1780, in 8vo.

The first Greenlandish Grammar was published by Paul Egede in the Danish and Latin language at Copenhagen in 1760, in 8vo.

The first Dictionary in Greenlandish, Danish, and Latin, was published by Paul Egede, in 1750, in 8vo.

Both works were very much improved by Otto Fabricius, the Grammar in 1791, and in a second edition in 1801, and the Dictionary in the year 1804, 8vo.

Paul Egede was also the first who translated the New Testament into the Greenlandish language. It was reprinted in the year 1803, and very much improved by Otto Fabricius.

Besides this, partly by the Danish Society for the furtherance of the missions, partly by the Unitas Fratrum, psalm-books, prayer-books, and other religious books, have been printed, and distributed gratis amongst the Greenlanders.

GREENLAW, is a small town of Scotland in Berwickshire, and is situated on a plain, watered by the Blackadder, nearly in the centre of the county. There are here the remains of two religious houses, which were dependent on the priory of Kelso. Marchmont house, the seat of the family of Marchmont, is about 2 miles from the town. Greenlaw is the county town of Berwickshire. Its population is about 600.

GREENOCK, is a sea-port town in Scotland, situated on the Frith of Clyde, about 22 miles below Glasgow, and 46 above Ayr. It contains many neat and well-built houses, but its streets are irregular and narrow; and its general appearance is far from being elegant. Of late years, it has extended very much to the west, and there, as might have been expected from the opulence and taste of the inhabitants, a great improvement has taken place both in the general plan and in the structure of individual edifices. The principal public buildings of Greenock, consist of the infirmary, which was erected in the year 1808 at an expence of nearly £2400, and contains good accommodation for a considerable number of patients; the theatre, erected the same year, at an expence of £2500; a bridewell, erected in 1809, at an expence of £1340; and a tontine inn, erected in 1802, at an expence of £10,000. There are three established churches, viz. the West Church, which serves the country part of the parish, is very old, and very uncomfortable; the New Church, built in 1762, a large commodious place of worship in the centre of the town, and having a steeple attached to it 146 feet high; and the East Church, originally built in 1774 as a chapel of ease, but erected into a parish church in 1809. There is also a Chapel of Ease for the Gaelic population, built in 1791 at an expence of £ 1700, and containing 1600 people. Besides these, there are various dissenting meetings: the Burgher meeting, erected in 1791 at an expence of £ 1300, and containing 1000 sitters; the Antiburgher, erected in 1803 at an expence of £ 1122; the Relief, erected in 1808 at an expence of £ 2200, and containing 1700 sitters. There is also a Tabernacle, a Methodist meeting, and a Roman Catholic chapel. A Unitarian preaches in the theatre on Sunday evenings. There are public schools for all the various branches of literature and science. A free school, established in 1790, is under excellent management, and gives useful and religious education to hundreds of poor boys and girls, at an expence of 6s. 8d. per annum for each child. In 1812, a society was instituted in Greenock and Port Glasgow for the encouragement of arts and sciences. About 150 subscribers, at 5s. each per annum, were obtained, and the whole funds are distributed in prizes to persons of genius and merit. For some years, there has been connected with this an exhibition of paintings. Since 1793, there has existed an institution, under the title of the Greenock and Innerkip Farmer and Agricultural Society. There are several subscription and circulating libraries, with extensive collections of books. One newspaper, the Greenock Advertiser, is published thrice a week. The poor, who are very numerous, are supported partly by the public collections, partly by voluntary assessments, and partly by the interest of sums, which from time to time have been bequeathed to them by the charitable. There are various societies established by particular trades and professions, whose principal object is to afford relief to their decayed members: Such as the Ship-carpenters Society, instituted in 1732; Master Wrights Society, instituted in 1734; Shoemakers Society, instituted in 1754; Journeymen Coopers Society, instituted in 1792; Widows Society, instituted in 1796, &c. The Merchants House Society was instituted in 1787; five guineas are paid on admission, and 5s. annually for the support of those families or individuals belonging to it, who have grown indigent. There was formerly in Greenock a society, designed the Clyde Marine Society; but in 1786, it was incorporated by act of parliament with the Glasgow Marine Society. This institution is very rich, and very useful. There are several banks and branches of banks established at Greenock, which do a great deal of business.

The old harbour of Greenock, begun to be built in 1707, contains about 10 acres. These are inclosed within two circular quays, in the middle of which is another quay built in 1712, projecting like a tongue. The original cost was 10,000 merks Scots, or £ 5625 sterling, which was to be defrayed by a malt duty, and was liquidated in 1740, leaving a surplus of £ 1500. In 1801 and 1803, acts of parliament were obtained for enlarging and improving the harbour; and when all the plans are executed, the accommodation for shipping, &c. in this port will be of a very complete and superior kind. The new harbour will contain about 8 acres of ground, which were obtained from Sir John Shaw Stuart and Lord Cathcart at 5 guineas per fall, and a shilling per fall of feu duty. During the last ten years, £ 85,000 have been expended in extending the harbours, by building new quays, sheds, &c. and an additional sum of £ 25,000 will be required to finish the work, including the expence of building a new graving dock.

The expence of erecting the present sheds, and keeping them in repair, has cost the trustees of the harbour £ 9868, and those yet to be erected will not cost less than £ 3132, making together £ 13,000.

The revenue received from them for the year ending September 1812, was £ 1201
Do. 1813, 1472
Do. 1814, 2052
Do. 1815, 2053

And the yearly rent on an average for five years ending in April last, is £ 1609.

The anchorage or ring money for the year ending September 1813, was £ 175 13
Do. 1814, 181 17
Do. 1815, 218 12

making the yearly rent on an average for three years £ 192.

Ship-building is not so much followed as might have been expected at such a port as that of Greenock. On an average, there are about 10 or 12 vessels built annually. As to quality and construction, these vessels are equal to any in the united kingdom. There is a graving dock, which was erected by share holders in 1783. The building yard of Messrs John Scott & Co. containing a graving dock, a basin, boat and mast sheds, blacksmith's shop, &c. is, in point of size and convenience, superior to any private establishment of this kind in the kingdom. Mr Steele also has excellent premises for building and repairing ships.

There are four large rope works, and several smaller ones. They employ from 200 to 300 hands, and manufacture annually about 1000 tons of cordage, which is sold for the use of the shipping of the port, and for exportation to the colonies. There is one rope-work for making patent cordage. Sailcloth is also manufactured here to a considerable extent. There are two manufactories for this article. Greenock contains two soap and candle manufactories, which are carried on to a large extent, principally for supplying our North American and West India colonies with these articles. One of them is an old establishment, having existed since the year 1772. There are also two extensive breweries, both of which export large quantities, solid and in bottles. While the French West India islands were in our possession, the supply of this article was very great, particularly light coloured table beer. There are two iron and brass founderies; one large hat manufactory, and several smaller ones; a green glass and a flint glass work; three tan works; a pottery; and a lamp-black manufactory. All these depend greatly on the export trade, and the demand for the shipping.

An account of the number of ships and vessels, with their tonnage, and number of men and boys usually employed, registered and belonging to the port of Greenock for the years ending 30th Sept. 1814 and 1815:

	Ships.	Tons.	Men.
Year ending 30th Sept. 1814,	360	34,159	3325
Do. 30th Sept. 1815,	336	35,210	3220

At present there are 379 ships, brigs, sloops, &c. registered at the custom-house, admeasuring 47,268 tons, and navigated by 3457 men.

An account of the number and tonnage of ships and vessels, which were of, and belonging to, the port of Greenock, with their number of men, that have traded to and from foreign parts, or coastwise, or been employed in fishing, in the years ending 5th January 1815 and 1816, accounting each vessel but once in the year.

Years ending	*Foreign Trade.*			*Coasting.*			*Fishing.*		
	Ships.	Tons.	Men.	Ships.	Tons.	Men.	Ships.	Tons.	Men.
Jan. 5. 1815,	187	37,694	2428	103	7590	409	60	2721	368
Jan. 5. 1816,	187	35,205	2318	100	7410	441	71	3199	511

An account of the total number of ships, with their tonnage and men, including their repeated voyages, that have entered inwards and cleared outwards at this port, from and to foreign parts in the years ending 5th January 1815 and 1816, distinguishing British ships from foreign, but omitting such ships as have entered or cleared before at any other port in England or Scotland.

	Inwards.						Outwards.					
	British.			Foreign.			British.			Foreign.		
	Ships.	Tons.	Men.	Ships	Tons.	Men.	Ships.	Tons.	Men	Ships.	Tons.	Men.
Year ending 5th Jan. 1815,	327	55,229	3392	5	999	60	354	59,490	4149	5	1007	69
Do. 5th Jan. 1816,	347	55,337	3309	30	8155	396	350	55,524	3615	28	7087	376

An account of all vessels entered inwards and cleared outwards coastwise at this port, in the years ending 5th January 1815 and 1816.

	Inwards.			Outwards.		
	Ships.	Tons.	Men.	Ships.	Tons.	Men.
Years ending Jan. 5. 1815,	562	27,386	1894	557	28,061	1883
Do. 1816,	513	27,128	1813	545	28,591	1904

The herring fishery has been long an object of importance to the town of Greenock. So far back as the year 1688, it was carried on to a considerable extent. Since that period, it has experienced frequent vicissitudes. The following statement will shew its present situation:

In the year ending the 5th of April 1815, there cleared out for the herring fishery 177 vessels, 6896 tons, manned with 958 men. Carried out 688,171 square yards of netting, 68,205½ bushels of British salt, and 36,861½ barrels.

Entered inwards from do. 174 vessels, 6612½ tons. Carried in 24,503½ bushels salt, 11,394¼ barrels (not filled) with herrings, and 23,603½ barrels of herrings.

Exported to Ireland, 5828 barrels; to the north of Europe 350; to the West Indies 24,203. Total exported 30,381 barrels.

In the year ending the 5th of April 1816, there cleared out for the fishery 149 vessels, 5623 tons, manned with 814 men. Carried out 547,167 square yards of netting, 53,434½ bushels of salt, 30,172 barrels.

Entered inwards from the fishery 157 vessels, 5975 tons. Carried in 15,382 bushels salt, 6941 empty barrels, and 24,275½ barrels of herrings.

Herrings exported to Ireland, 4478 barrels; to the north of Europe 859; and to the West Indies 23,368. Total exported 28,705 barrels.

An account of the amount of duties received at the port of Greenock, for the two years ending 5th January 1815 and 1816.

Year ending 5th January 1815,	£376,713	15 10½
Do. 5th January 1816,	403,176	6 8

Account of the amount of drawbacks and bounties paid for the same period.

	Drawbacks.	Bounties.
Year ending Jan. 5. 1815,	£41,120 5 7¼	£67,978 8 3¾
Do. Jan. 5. 1816,	32,924 2 3¾	81,617 19 1¾

The excise duties and drawbacks are not included in the above.

The total receipt of the duties of customs at the port of Greenock, year ending 5th January 1816, was £403,176, 6s. 8d. principally under the following heads:

Upon general goods imported	£115,717 13 11¾
Upon sugar, rum, coffee, tobacco, wine, &c. for home consumption	275,111 10 2¼
And upon general goods exported	12,347 2 6
	£403,176 6 8

And there was paid during said year for bounties, on linen, sail cloth, silk, sugar, and cordage exported, £81,617, 19s. 2¼d.

Vessels entered and cleared at the custom-house 1815, and paid harbour dues in and out.

	Harbour Dues.
1638 vessels, 177,906 tons, ...	£4811 13 4
150 lighters employed on the river .	214 18 3
From steam boats	312 0 0
Anchorage revenue	350 0 0
	£5688 11 7

The slaughter of cattle, &c. for the years ending September 1813, 1814, and 1815.

Year.	Cows.	Calves.	Sheep.	Lambs.	Goats.	Hogs.	Revenue.
1813	1721	1777	13,363	7003	1	224	£223 8 9
1814	1972	1904	13,911	7692	12	488	246 2 6
1815	2391	1996	15,105	8500	—	285	272 6 3

Making an average per year for three years of £247, 5s. 10d.

In 1757, the population of Greenock was 3900. In 1781, it was 12,000. In 1792, it was 14,299. In 1797, it was 15,000. In 1802, it was 17,458, the number of houses being 1029; of males 8194, and of females 9262. In 1804, it was 20,000. And in 1811, it was, exclusive of those at sea, 19,042, having increased in the preceding 20 years 4743, or 1212 males, and 3531 females. Greenock is a burgh of barony. It was erected in 1757, by Sir John Shaw Stuart the superior, and is governed by a council of 9 feuers, 2 of whom are annually elected to the office of bailies, with corresponding powers. In 1795, the rental of the parish, comprising 5065 Scots acres, was £3500 sterling, its valued rent being £2285 Scots. In 1810, the rental was 10,000 sterling. (τ)

GREENWICH, is a market town of England, in the hundred of Blackheath, and county of Kent. It is delightfully situated on the south bank of the Thames, where the river is from 320 to 360 yards broad at low water, and is principally celebrated for its splendid naval hospital, and for the Royal Observatory. The kings of England had a royal residence at Greenwich since the reign of Edward I. A.D. 1300. After the restoration of Charles I. when the buildings had fallen almost

Greenwich. into ruin, this monarch ordered them to be taken down, and a magnificent palace of freestone to be erected on the spot, from the designs of Webb, the son-in-law of Inigo Jones. Only one wing of this edifice was completed at the expence of £36,000. Charles occasionally resided in it; but it was not till the reign of William III. that any farther progress was made in the building. The government having resolved, on the suggestion of the queen, to provide an asylum for old and disabled seamen, Sir Christopher Wren recommended that the unfinished palace should be devoted to this purpose. A grant of the palace and adjoining lands was made in 1699 to commissioners. The foundation stone was laid on the 3d June 1696, and was gradually enlarged and improved till it reached its present state of splendour and magnificence.

The following account of Greenwich Hospital has been abridged from a very full and excellent description of it in the *Beauties of England and Wales*.

Greenwich Hospital. Greenwich Hospital is principally built with Portland stone, and consists of four distinct quadrangular masses of buildings, distinguished by the names of the respective sovereigns, in whose reigns they were founded or built. The grand front opens on a terrace, skirting the southern bank of the Thames, and extends 865 feet in length, in the centre of which is a descent to the river, by a double flight of steps. The ground plan of the whole edifice forms nearly a square, of which King Charles's building occupies the north-west angle; Queen Anne's, the north-east; King William's, the south-west; and Queen Mary's, the south-east. The interval between the two former buildings forms a square 270 feet wide, in the middle of which is a statue of George II. sculptured by Rysbrach, out of a single block of white marble, which weighed 11 tons, and was taken from the French by Admiral Rooke: this statue was given to the hospital by Sir John Jennings, who was governor from 1720 to 1744. The inscriptions on the pedestal were by Mr Haugan. The space between the two latter buildings which include the hall and chapel, with their elegant domes, and the two colonnades, forms a lesser square. The two squares are intersected by a spacious avenue, leading from the town through the hospital. The buildings which immediately front the Thames have a general correspondence in style and arrangement. The north and south fronts of each exhibit the appearance of a double pavilion, conjoined above by the continuation of an Attic order, with a balustrade, which surmounts the whole, but is separated below by an open portal. The centre of each pavilion displays an elegant pediment, supported by four Corinthian columns, and the sides a double pilaster of the same order. King Charles's building contains the apartments of the governor and lieutenant-governor, the council-room, and anti-chamber; with 14 wards, wherein 300 pensioners may be accommodated. In the council-room are several portraits: in the anti-chamber two large sea-pieces, given to the hospital by Philip Harman, Esq.; and a series of six small pieces, representing the loss of the Luxemburgh galley, in 1727. Queen Anne's building, which was erected between 1698 and 1728, contains several apartments for inferior officers, with 24 wards for 437 pensioners. King William's building stands to the south-west of the great square, and comprises the great hall, vestibule, and dome, designed and erected by Sir Christopher Wren, between the years 1698 and 1703. To the inner side of each range is attached a colonnade 347 feet in length, supported by Doric columns, and pilasters 20 feet in height. The great hall, or saloon, is 106 feet in length, 56 in width, and 50 high: the ceiling and sides are covered with portraits and emblematical figures, executed by Sir James Thornhill, for which he was paid at the rate of L.3 per square yard for the ceiling, and L.1 for the sides, amounting in the whole to L.6685. The west front of King William's building, which is of brick, was finished about 1725 by Sir John Vanbrugh: the building contains 11 wards, wherein are 551 beds. The foundation of the eastern colonnade, which is similar to that on the west side, was laid in 1699; but the chapel, and the other parts of Queen Mary's building which adjoin to it, were not finished till 1752. It corresponds with King William's, and is furnished with 1092 beds, in 13 wards. The chapel which forms part of Queen Mary's building, is one of the most elegant specimens of Grecian architecture in this kingdom, and was erected from the classical designs of the late James Stuart, Esq. It is 111 feet in length, and 52 in width, and is capable of accommodating 1000 pensioners, nurses, and boys, exclusive of the seats for the directors and other officers. The entrance portal consists of an architrave, frieze, and cornice, of statuary marble: the folding-doors are of mahogany, highly enriched by carving. The interior is finished in an elegant style, and is adorned with many appropriate paintings, the most distinguished of which is the altar-piece, executed by West, and representing the preservation of St Paul on the island of Melita. There is a double range of windows on each side of the chapel. Without the walls of the hospital stands the infirmary, erected in 1763, after a design by Stuart: it forms an oblong quadrangle, 198 feet long and 175 broad, consists of two stories, and is divided into two principal parts, appropriated respectively to those whose cases require surgical aid, and to those who need only medical assistance. It contains sixty-four rooms, and each is fitted up for the accommodation of four patients. It also includes a chapel, hall, kitchen, and apartments for the physician, surgeon, and apothecary; with hot and cold baths, and other necessary offices. Near the hospital is the school, where 200 poor children are educated. The school-house was erected in 1783, by Stuart. It is 146 feet long, 42 broad, exclusive of a Tuscan colonnade in front 180 feet long, and 20 broad, for the boys to play in during bad weather. The pensioners, who are the objects of this noble charity, must be seamen disabled by age, or maimed, either in the king's service, or in the merchant service, if the wounds were received in defending or taking any ship, or in fight against a pirate. Foreigners who have served two years in the British navy, become entitled to the benefits of this institution in the same manner as natives. The widows of seamen are provided for, having the exclusive privilege of being nurses in the hospital. The number of pensioners is upwards of 2400, (of whom at an average 203 die annually,) who are furnished with clothes, diet, and lodging, with a small allowance of pocket-money. The nurses are 144, each of whom receives eight pounds per annum as wages, with every necessary of life. The commissioners of the hospital are about 100, and consist of all the great officers of state, the archbishops, the lord chancellor, the judges, the master and five senior brethren of Trinity-house, the lord mayor, and three senior aldermen of London, with some of the principal officers of the hospital. The annual average expence of each pen-

Greenwich.

sioner, according to the report of the commissioners of naval enquiry, was estimated at L.27 : 10 : 9 per man; and of the nurses, L.29, 15s. each, the total annual expence being L. 69,206, 5s. The funds of the establishment are principally derived from a duty of sixpence per month, paid by every mariner, either in the king's or merchant's service; the forfeited estates of the Earl of Derwentwater, containing many valuable lead and other mines; various benefactions from different sovereigns, from parliament, and from private persons, from fines for offences committed on the Thames, from the half-pay of such of its officers as have regular salaries, and from other sources of less importance.

Greenwich park.

Greenwich park, which is vested in the crown, was encircled with a wall by James I. and contains 188 acres. It is planted chiefly with elms and Spanish chesnuts, some of which are of a very large size. In one part of the park are the remains of many ancient barrows, in some of which were found human bones, spear heads, &c. The upper part of the park is considerably elevated above the Thames; and on one of the eminences stands the Royal Observatory, which was built by Charles II. in 1675, on the site of the ancient tower erected by Duke Humphrey in the reign of Henry VI. It is built of brick, and is by no means an elegant structure; but it contains excellent apartments for the Astronomer Royal, and commodious rooms for the admirable instruments, with which it is now furnished. Flamstead, the first Astronomer Royal, died in December 1719, and was succeeded by Dr Halley. Dr Bradley succeeded upon the death of Halley in 1742, and died in 1762. Dr Bliss held the office for two years, and was succeeded in 1764 by Dr Maskelyne. Mr Pond, the present Astronomer Royal, suceeded Dr Maskelyne in 1811, and, by means of the fine mural circle constructed by Troughton, has already made a series of the most valuable observations, decidedly the most accurate that have been made in any of the other observatories of Europe.

Royal observatory.

A farther account of the institution, and of the instruments it contains, will be found in our history of ASTRONOMY, and in the articles CIRCLE and OBSERVATORY.

The church of Greenwich is an elegant stone building, and was erected in 1718. Greenwich contains two hospitals for poor people, and several schools for the education of the poor, and some excellent boarding schools.

The following is the population abstract for 1811, for the town of Greenwich:

Number of houses	2,315
Number of families	3,276
Ditto employed in agriculture	96
Ditto in trade and manufactures	1,002
Males	8,723
Females	8,224
Total population	16,947

Gregorian || Gregory James

GREGORIAN CALENDAR. See CHRONOLOGY.

GREGORIAN TELESCOPE. See OPTICS.

GREGORY, ST VINCENT. See GEOMETRY.

GREGORY, JAMES, an eminent Scotch mathematician and natural philosopher, was born at Aberdeen in the month of November 1638. He was a son of the Rev. Mr John Gregory of Drumoak, in Aberdeenshire,* who was married to the daughter of Mr David Anderson of Finshaugh, the brother of Alexander Anderson, who was professor of mathematics at Paris: (See ANDERSON). Having lost his father in the 13th year of his age, the charge of his education devolved upon his elder brother David Gregory, who put into his hand the Elements of Euclid, and stimulated the ardour which he had begun to show for mathematical learning. After having completed his philosophical studies at the Marischal College of Aberdeen, James Gregory directed his particular attention to the subject of optics, and he published the results of his labours in a work entitled

* The following quotations, relative to the Rev. John Gregory of Drumoak, are taken from Spalding's *History of the Troubles in Scotland*, from 1624 to 1645:

"Upon the second day of June 1640, Mr John Gregory, minister at Drumoak, was brought into Monro by a party of soldiers: He was taken out of his naked bed upon the night, and his house pitifully plundered. He was closely keeped in Skipper Anderson's house, having five musketeers watching him night and day, and sustained upon his own expences. No not his own wife could have private conference with him, so strictly was he there watched. At last he is fined to pay Major-General Monro 1100 merks, for his outstanding against the covenant, and syne got liberty to go; but in the General Assembly holden in July, he was nevertheless simpliciter deprived, because he would not subscribe the covenant; and when all was done, he is forced to come in and yield to subscribe the covenant.

"Next, Mr John Gregory having been summoned to appear before the General Assembly (1640), by and attour his being fined in 1000 merks, as ye have before, was deposed from the ministry of Drumoak. The Laird of Drum deals for him, being his own pastor, and upon swearing and subscribing the covenant, and teaching penitentially, with great difficulty he was again restored (1641) to his own parish kirk.

"Upon Thursday, the 15th of April 1641, being a presbytery day, Mr John Gregory, of whom ye heard before, teached a penitential sermon in New Aberdeen. It was not found satisfactory by Mr James Hervie, Moderator, and the remanent members of the Presbytery, and he was ordained to put the same in write. The brethren advised the same with the next Provincial Assembly, who found it not satisfactory, and therefore they ordained him to preach penitentially at certain kirks, till he gave content to the next ensuing General Assembly; which he obeyed. He was received and reinstated in his kirk (1641).

"Upon Tuesday, the 6th of September 1642, Mr John Gregory, at the visitation of the kirk of New Aberdeen, teached most learnedly upon the fourth verse of the second chapter of the Colossians, and reprehended the order of our kirk, and new brought in points. Mr Andrew Cant, sitting beside the reader, as his use was, offended at this doctrine, quickly closed the reader's book, and laid down the glass before it was run, thinking the minister should the sooner make an end; but he beheld and preached half an hour longer than the time. Sermon being ended, the brethren conveen to their visitation, where Mr Andrew Cant impugned this doctrine, desiring the said Mr John to put the same in write. He answered, he would not only write, but print his preaching, if need so required, and abide by all that he had teached as orthodox doctrine. The brethren heard all, and had their own opinions, but without any more censure they dissolved, somewhat peturbed with Cant's curiosity.

"Upon Thursday he railed out in his sermon against the said Mr John Gregory's doctrine, and on Sunday likewise. At last, by mediation of the town's baillies, at a cup of wine, they two were agreed, and settled, with small credit to Cant's business."

Mr Gregory of Drumoak was one of the first persons in Scotland who understood the use of the barometer as an instrument for predicting the weather. Having one day observed that the mercury was falling rapidly, he advised his parishioners to remove the sheaves of corn from the low grounds on the banks of the river Dee. They immediately followed his advice, and when they found his prediction verified by an unusual rise of the river, they were naturally led to regard him as a being of a superior order. Mr Gregory died about the year 1652.

Optica promota seu abdita radiorum reflexorum et refractorum mysteria, geometrice enucleata, cui subnectitur Appendix subtilissimorum astronomiæ problematum resolutionem exhibens, Lond. 1663. It was dedicated to Charles II. and was completed with the assistance and encouragement of his brother David, after he had been stopped a long time at the twenty-sixth problem.* This work is remarkable, as containing the description of a new reflecting telescope, and the deduction of the true law of refraction. The method in which he has investigated this law, is remarkable for its elegance and originality; and, in his experimental demonstration of it, we are furnished with a striking proof of the accuracy of his observations. In comparing the refractions calculated by the law, with the experiments of Vitellio on the refractions of water and glass, the greatest error amounts to 61′ in water, and 94′ in refractions from glass into water. When compared with the experiments of Athanasius Kircher, the greatest error in water is 89′, in wine 110′, in oil 104′, and in glass 93′; but in comparing them with his own observations, the greatest error is only 15′; and it is remarkable, that he made the index of refraction for water 1.3347, differing only 0.0018 from 1.3358 the most accurate measure, whereas Vitellio made it 1.306. Before the publication of the *Optica Promota*, Gregory was informed, that he was anticipated in the discovery of the law of refraction by Descartes, and he thus alludes to it in his preface:—*Et ex analogiis in prima hujus tractatuli propositione declaratis, inveni primam hujus opticæ partem, de genuina refractionum hypothesi et mensura nescius scilicet (propter inopiam novorum librorum Mathematicorum in alias inclyta Bibliotheca Abredonensi) hæc eadem a Cartesio fuisse inventa.*

The invention of the reflecting telescope formed an epoch in optics and astronomy. Gregory was not acquainted with the errors in dioptric instruments, arising from the unequal refrangibility of the rays of light; and his principal object in proposing this new instrument, was to avoid the error arising from the spherical figure of the lenses. It consisted of a parabolic concave mirror, near whose focus is placed a small concave elliptic speculum, having a common focus with the parabolic one. This instrument gave rise to the Newtonian telescope, in which the small mirror is plane, and reflects the image to the side of the tube where the eye-glass is placed; and also to the Cassegrainian telescope, which differs only from that of Gregory, in having the small speculum convex instead of concave. The Gregorian principle has been almost universally used for telescopes of a moderate size. The Newtonian form has been adopted in the magnificent instruments used by Dr Herschel; but it is extremely probable, that the Cassegrainian telescope, in which the rays never cross each other at a focus, † will hereafter be considered as the most valuable of the reflecting telescopes. The *Optica Promota* is terminated by a collection of astronomical problems. The object of one of these, is to determine the parallaxes of two planets from their conjunction; and, in a scholium to this problem, he points out the great use of the transits of Venus and Mercury, in determining the sun's parallax. ‡ This happy idea, which has since been of such service to astronomy, has always been ascribed to Dr Halley.

Mr Gregory went to London about the year 1664 or 1665, and was introduced to Mr Collins, the secretary to the Royal Society, who introduced him to some of the best practical opticians, for the purpose of having his reflecting telescope executed. A Mr Rives was employed for this purpose, but he could not polish the speculum upon the tool, and was therefore obliged to do it with a cloth and putty. The success of this trial was so little, that Gregory was discouraged from making any farther attempts, and a tube was never even made to hold the mirrors. He afterwards, however, made some trials with a little concave and convex speculum; but, to use his own words, "they wer but rude, seeing I had but transient views of the object; being so possessed with the fancie of the defective figure, that I wold not be at the pains to fix every thing in its due distance."

After these unsuccessful attempts to construct a reflecting telescope, Gregory left England, and fixed his residence at Padua, which was then in high repute as a seat of mathematical learning. Here he published, in 1667, 1668, his work, entitled, *Vera Circuli et Hyperbolæ Quadratura in propria sua proportionis specie inventa, et demonstrata*, which contains his discovery of an infinitely converging series for the areas of the circle, ellipsis, and hyperbola. A copy of this work was laid before the Royal Society by his friend Mr Collins, and was honoured with the approbation of Lord Brouncker and Mr Wallis. In the following year he reprinted it at Venice, and added a new work, entitled, *Geometricæ pars universalis quantitatum curvarum transmutationi et mensuræ, inserviens*, which contains a new method for the transmutation of curves. This work had previously appeared at Padua in 1668; and, upon its arrival in England, was read by Mr Collins to the Royal Society.

In the year 1670, Mr Gregory received, in a letter from Mr Collins, a series for the area of the zone of a circle, and being informed that Newton had invented an universal method by which he could square all curves geometrical and mechanical by infinite series of that kind, Gregory applied himself to the investigation of the subject, and discovered an universal method of series, which he communicated to Newton, and the other English mathematicians, by a letter to Collins, dated February 1671. His brother David urged him to publish this method without delay; but he declined this from the most honourable motives; for Newton having been the first inventor, he thought himself bound to wait till his method should be published.

Upon Mr Gregory's return to London, we believe in-

* "Ubi diu hæsi omni spe progrediendi orbatus; sed continuis hortatibus et auxiliis fratris mei Davidis Gregorii in mathematicis non parum versati (cui siquid in hisce scientiis prestitero, me illud debere non inficias ibo) animatus tandem incidi in seriam imaginis considerationem, &c." *Pref. ad Optic. Promot.*

† The effect of the collision of the rays in the focus was first noticed by Dr Brewster, in the most perfect achromatic telescopes: (See *Treatise on New Philosophical Instruments*, p. 44 and 193.) It was afterwards observed in reflecting telescopes by Mr Kater, who has examined the subject with much attention and success: (See *Phil. Trans.* 1813, 1814.) We have found from experiment, that the heat of a burning lens, as well as the light, is more intense within than without the focus, and that radiant heat is also most intense within the focus. Mr Leslie had long before obtained the same result with regard to radiant heat. It is therefore certain, that this diminution of effect must arise from the collision of the luminous as well as of the calorific rays. We may therefore lay it down as a principle in the construction of optical instruments, that the rays should, if possible, never be brought to a positive focus.

‡ "Hoc Problema pulcherrimum habet usum, sed forsan laboriosum in observationibus Veneris vel Mercurii particulam solis obscurantis: ex talibus enim solis parallaxis investigari poterit." *Optic. Promot.* schol. prop. 87.

1668, he was elected a fellow of the Royal Society, and laid before them an account of a dispute in Italy relative to the Earth's motion, which Riccioli and his followers had denied. About this time also he engaged in a dispute with the celebrated Huygens through the medium of the *Philosophical Transactions.* Huygens published in the *Journal des Sçavans,* July 2d 1668, some animadversions on Gregory's quadrature of the circle, and particularly objected to the proposition which stated, the impossibility of expressing perfectly the area of a circle in any known algebraical form besides that of an infinite converging series. Gregory defended himself in the 37th Number of the *Philosophical Transactions,* and the dispute was carried on with considerable warmth by both parties. The whole of the controversy will be found in Huygens' *Opera Varia,* vol. ii. p. 463.

In 1668, Gregory published in London his *Exercitationes Geometricæ,* a small work of twenty-six pages, which contains the following subjects:

Appendicula ad verum Circuli et Hyperbolæ Quadraturam.

N. Mercatoris Quadratura Hyperbolæ Geometrice demonstrata.

Analogia inter Lineam Meridianam Planispherii Nautici et Tangentes Artificales Geometrice demonstrata; seu quod secantium Naturalium additio efficiat Tangentes Artificiales.

Item, Quod Tangentium Naturalium additio efficit Secantes Artificiales.

Quadratura Conchoidis.

Quadratura Cissoidis.

Methodus Facilis et Accurata componendi Secantes et Tangentes Artificiales.

The preface to this work, and the introduction to the *Appendicula,* &c. are remarkably interesting, in so far as they throw considerable light on the dispositions of our author. He speaks with great severity of the jealousy and injustice of his contemporaries, and alludes to the treatment which he had received from Huygens. In the introduction to the *Appendicula,* he resumes this subject with more keenness. He declares, that Huygens had accused him of ignorance and plagiarism; and after arguing against Huygens' claim to the discovery, he concludes with this remarkable passage: "At parum refert quis sit ejus primus inventor, satis enim constat me primum esse publicatorem; neque mihi esset difficile affirmare (si modo mentiri vellem) me ante 20 annos illam cognovisse: utcunque sit, conabor hic circuli et hyperbolæ quadraturam ad talem perfectionem promovere, ut Hugenius prolem suam vix cognoscat."

Mr Gregory was about this time elected professor of mathematics in the university of St Andrew's. In 1669, he married the daughter of George Jamieson, the celebrated Scottish painter, by whom he had a son, James, the father of Dr John Gregory, (the subject of a succeeding article,) and two daughters. In August 1672, he began a correspondence with his friend Mr Collins, relative to the comparative merits of his own telescope, and that of Sir Isaac Newton. The sentiments of the two philosophers were communicated to each other by their respective friends, and the dispute was thus carried on in the most amicable manner. The correspondence has been published by Dr Desaguliers, at the end of his edition of Dr David Gregory's Catoptrics, and Dioptrics.

In the year 1669, a work was published at Rotterdam, by Mr George Sinclair, professor of philosophy in the university of Glasgow, entitled *Ars nova et Magna Gravitatis et Levitatis*; and another work on hydrostatics, by the same author, appeared at Edinburgh in 1672. Mr Sinclair had been dismissed from his professorship soon after the restoration, on account of his political principles, and had given offence to the Royal Society of London, by charging them with negligence and injustice. He appears also to have acted improperly towards one of Mr Gregory's colleagues, and thus to have incurred the displeasure of that mathematician. In the year 1672, Gregory, under the assumed name of Patrick Mathers, archbedal to the university of St Andrew's, attacked Sinclair in a tract, entitled *The great and new art of weighing Vanity, or a discovery of the Ignorance and Arrogance of the great and new Artist, in his Pseudo-philosophical writings.* To this work is annexed *Tentamina de motu penduli et projectorum.*

In 1674, Gregory was called to the mathematical chair in the university of Edinburgh, a situation which he did not live long to enjoy. In the month of October 1675, when he was walking home from supper, he was struck suddenly blind, and expired a few days afterwards, in the 36th year of his age.

The following is a list of the inventions and discoveries of James Gregory, as given by Dr Hutton. The reflecting telescope; burning mirror;* quadrature of the circle, ellipse, and hyperbola; method for the transmutation of curves; geometrical demonstration of Lord Brouncker's series for squaring the hyperbola; demonstration that the meridian line is analogous to a scale of logarithmic tangents, of the half complements of the latitude; a simple converging series for making logarithms; solution of the famous Keplerian problem, by an infinite series; method of drawing tangents to curves geometrically, without previous calculation; a rule for the direct and inverse method of tangents, depending on the principle of exhaustions; a series for the length of the arc of a circle from the tangent, and *vice versa,* and also for the secant and logarithmic tangent, and secant and *vice versa*; and serieses for the length of the elliptic and hyperbolic curves. See Hutton's *Mathematical Dictionary,* 2d edition, p. 601, &c. and the other works quoted in the article.

GREGORY, David, Dr, a celebrated astronomer and mathematician, was the nephew of the subject of the preceding article, and the eldest son of David Gregory of Kinnairdie. He was born at Aberdeen in the year 1661, and after receiving his education at the grammar school of that town, he went to Edinburgh for the purpose of completing his studies. In 1684, when he was only 23 years of age, he was appointed professor of mathematics in the university of Edinburgh, and in the same year he published his work, entitled, *Exercitatio Geometrica de Dimensione Figurarum sive specimen methodi generalis Dimetiendi quasvis figuras.* Mr Gregory having found among his uncle's papers particular examples of infinite series, without any of the methods, proposes in this treatise to explain a method which may suit the examples given by his uncle; and he does this by applying the principles of indivisibles, and the arithmetic of infinites, to particular cases in hyperbolas, parabolas, ellipses, spirals, cycloids, conchoids, and cissoids. He also explains several methods of reducing compound quantities into infinite series, so that

* See our article Burning Instruments, vol. v. p. 131.

the method of infinites may be conveniently applied to them.

Dr Gregory seems to have been one of the earliest supporters of the Newtonian philosophy in Britain; and while the doctrines of Descartes were in the highest esteem at Cambridge, the true system of the universe was publicly taught in the university of Edinburgh.

In consequence of a report that Dr Bernard proposed to resign the Savilian professorship of astronomy at Oxford, Gregory went to London in 1691, and, in spite of the brilliant talents of his competitor Dr Halley, he was appointed to succeed Dr Bernard, through the friendship and influence of Sir Isaac Newton and Mr Flamstead. Halley, who lost this appointment in consequence of his attachment to infidelity, became afterwards the colleague of Dr Gregory, when, in 1703, he succeeded to Dr Wallis as Savilian professor of geometry. During Mr Gregory's residence in London, he was elected a fellow of the Royal Society, and before his appointment to the mathematical chair, the university of Oxford had conferred upon him the degree of doctor of physic.

In the year 1692, Viviani, one of the disciples of Galileo, had proposed to mathematicians the Florentine problem of the quadrable dome. Leibnitz and Bernoulli had resolved this problem on the very day on which they had received it, and the Marquis L'Hospital had also given a solution. Dr Wallis and Dr Gregory were equally successful, and the latter published his solution in the *Philosophical Transactions* for 1693, under the title of *Solution of the Florentine Problem, concerning the Testudo veliformis Quadrabilis.* In 1694, he published another paper in the *Transactions*, containing a vindication of his uncle from a charge preferred by the Abbot Galloise, * that James Gregory and Dr Barrow had stolen from Roberval their general propositions concerning the transformation of curves. Galloise replied in the *Memoirs of the Academy* for 1703; and Dr Gregory put an end to the controversy by a very sharp answer, which appeared in the *Philosophical Transactions* for 1716, and which was the last of his communications to that learned body.

In 1695, Mr Gregory published at Oxford his *Catoptricæ et Dioptricæ Sphericæ Elementa*, a work which formed the substance of lectures which he delivered in 1684, in the university of Edinburgh, and which require no higher mathematical knowledge than the elements of Euclid. This work was republished and translated by Dr William Browne, with several important additions; and a third edition of it by Dr Desaguliers, appeared in 1735. In this work it is stated, that in the construction of telescopes, "it would perhaps be of service to make the object lens of a different medium, as we see done in the fabric of the eye, where the crystalline humour (whose powers of refracting the rays of light differs very little from that of glass) is by nature, who never does any thing in vain, joined with the aqueous and vitreous humours, (not differing from water as to their power of refraction,) in order that the image may be painted as distinct as possible on the bottom of the eye." We cannot agree with the biographers of Dr Gregory, in considering this suggestion as any thing like an anticipation of the principle of the achromatic telescope; for it was impossible to form an idea of the construction of that instrument, till it was discovered that bodies possess different dispersive powers. This remarkable property of light, even the penetrating mind of Newton failed to discover; and we must not allow ourselves to diminish the well-earned reputation of Dollond, by giving to another any portion of the praise which is so exclusively due to himself. In the year 1747, more than 50 years after this conjecture of Dr David Gregory was published, the celebrated Euler suggested the human eye as the model of an achromatic telescope, and several ignorant foreigners have ventured to claim a share of Dollond's merit for this illustrious mathematician. Whatever credit therefore may be given to Euler, must now be claimed for our countryman David Gregory.

In the year 1697, our author published, in the *Phil. Transactions*, a long paper *On the properties of the catenaria or curve line, formed by a heavy and flexible chain, hanging freely from two points of suspension.* The leading properties contained in this communication, had been previously discovered and published by Huygens, Leibnitz, and Bernoulli, but without demonstrations; and Mr Gregory proposed to himself to demonstrate these properties. An anonymous writer in the Leipsic Acts for February 1691, attacked this paper as destitute of originality. Dr Gregory replied to this attack in the *Phil. Trans.* for 1699, and claimed as his own discovery the property of the catenaria as being the true geometrical figure of an equilibrated arch. This discovery, however, had been previously made by Dr Hooke. †

The greatest of Dr Gregory's works, and that on which his fame must rest, appeared at Oxford in 1702, entitled *Astronomiæ Physicæ et Geometricæ Elementa*, Fol. In this valuable work, all the physical explanations are founded on the principles of the Newtonian philosophy; and the geometrical parts are either proved by reference to the writings of standard authors, or demonstrated by lemmas inserted in their proper places. A very admirable analysis of this work was given, apparently by Dr Halley, in the *Phil. Trans.* for 1703. Newton himself considered these elements as an excellent defence and exposition of his philosophy.

This work was followed, in 1703, with an edition of Euclid, entitled *Euclidis quæ supersunt omnia, Gr. et Lat. ex recensione Davidis Gregorii*, M. D. &c. It was published in prosecution of a plan of Sir Henry Saville to print the works of the ancient mathematicians. It contains the Elements; the Data; two musical tracts; the Optics and Catoptrics; the tract *De Divisionibus*; and a fragment, *De Levi et Ponderoso.*

In the year 1704, Dr Gregory published, in the *Philosophical Transactions*, a paper on *Cassini's Orbit of the Planets*, in which he shewed that the hypothetical curve proposed by that astronomer, is not consistent with the received doctrines of astronomy.

After Dr Halley had been appointed to the Savilian professorship of Geometry in 1703, he embarked with Dr Gregory in the prosecution of Sir Henry Saville's plan, and had begun the publication of the Conics of Apollonius; but after having proceeded a short way in this undertaking, he was seized with an illness of which he died, at Maidenhead in Berkshire, on the 10th of October 1710, in the 49th year of his age.

He left behind him four sons by his wife Elizabeth,

* See *Hist. Acad. Par.* 1693.

† See Robison's *System of Mechanical Philosophy*, Vol. I.

daughter of Mr Oliphant of Langtown, to whom he was married in 1695. Among his manuscripts were found *A Short Treatise of the Nature and Arithmetic of Logarithms*, which was afterwards published in Dr Keill's translation of Commandine's Euclid; a *Treatise of Practical Geometry*, which was translated and published by Mr Maclaurin in 1745; and a commentary on the *Principia*, which Newton kept by him many years after the author's death. Sir Isaac had entrusted Gregory with a manuscript copy of the *Principia* for this purpose, and he availed himself of the annotations of his friend in the second edition of that immortal work. A complete copy of these observations was presented, by the present Dr James Gregory, to the library of the University of Edinburgh, where it is carefully preserved. There are some paragraphs in this manuscript in the handwriting of Huygens, concerning his theory of light.

His wife, who survived him, erected an elegant monument to his memory in the church of St Mary, Oxford, with the following inscription:—

P. M.
Davidis Gregorii, M. D.
Qui Aberdoniæ natus, Jun. 24, 1661,
In Academia Edinburgensi
Matheseos prælector publicus,
Deinde Oxonii
Astronomiæ Professor Savillianus,
Obiit Oct. 10. A. D. 1710;
Ætatem illi heu brevem Natura concessit,
Sibi ipsi longam prorogavit
Scriptor illustris.
Desideratissimo viro
Elizabetha Uxor.

David Gregory, of Kinnairdie, the brother of the celebrated James Gregory, was born in 1627, and served an apprenticeship to a mercantile house in Holland; but having a great passion for knowledge, he returned to Scotland in 1655, when he was 28 years old, and having succeeded to the estate of Kinnairdie, by the death of an elder brother, he devoted his time to mathematics and philosophy. He appears to have been the first person in the country who had a barometer, and he had the honour of corresponding, upon meteorological subjects, with the celebrated Mariotte. "About the beginning of the last century," says Dr Reid, "he removed with his family to Aberdeen, and, in the time of Queen Anne's war, employed his thoughts upon an improvement in artillery, in order to make the shot of great guns destructive to the enemy, and executed a model of the engine he had conceived. After making some experiments with this model which satisfied him, the old gentleman was so sanguine in the hope of being useful to the allies in the war against France, that he set about preparing a field equipage with a view to make a campaign in Flanders, and in the mean time sent his model to his son, the Savilian Professor, that he might have his and Sir Isaac Newton's opinion of it. His son shewed it to Newton, without letting him know that his own father was the inventor. Sir Isaac was much displeased with it, saying, that if it tended as much to the preservation of mankind as to their destruction, the inventor would have deserved a great reward; but as it was contrived solely for destruction, and would soon be known by the enemy, he rather deserved to be punished, and urged the professor very strongly to destroy it, and if possible to suppress the invention. It is probable the professor followed this advice; for at his death, which happened soon after, the model was not to be found.

When the rebellion broke out in 1715, the old gentleman went over a second time to Holland, and returned when it was over to Aberdeen, where he died, about 1720, in the 93d year of his age. He left behind him a historical manuscript of the transactions of his own time and country."

Mr Gregory had twenty-nine children by two wives, and he had the good fortune to see three of his sons professors of mathematics at the same time, viz. David Gregory at Oxford, James at Edinburgh, and Charles at St Andrews. James was first a professor of philosophy at St Andrews, and succeeded David when he removed to Oxford. Charles was created professor of mathematics at St Andrews in 1707, and in 1739 he resigned that office in favour of his son Professor David Gregory, who died in 1763, and left behind him a good compendium of arithmetic and algebra, with the title, *Arithmeticæ et Algebræ compendium, in usum Juventutis Academicæ*, Edin. 1736. His son David was master of an East India ship. David Gregory, the eldest son of the Savilian professor, was appointed Regius Professor of Modern History, at Oxford, and died in 1767, after having filled, for many years, the situation of dean of Christ's church. The celebrated James Gregory, the inventor of the reflecting telescope, had only one son, James, born in 1674, who was professor of medicine in King's College, Aberdeen. His youngest son was Dr John Gregory (the subject of the next article), and the father of the present Dr James Gregory, professor of the practice of medicine in the university of Edinburgh.

GREGORY, John, Dr, an eminent physician, was born at Aberdeen on the 3d of June 1724, and was the youngest child of Dr James Gregory, professor of medicine in King's College, Aberdeen, by his second wife, Anne Chalmers, the only daughter of the Rev. Principal Chalmers of King's College.

In consequence of the death of his father when he was only seven years old, the charge of his education devolved upon Principal Chalmers, his elder brother Dr James Gregory, who had succeeded his father as professor of medicine, and his cousin the late celebrated Dr Reid. After receiving the first rudiments of his education at the grammar school of Aberdeen, he entered King's College, and made rapid progress in the knowledge of ethics, mathematics, and natural philosophy.

In 1742, he went to Edinburgh, accompanied by his mother; and having resolved to pursue the study of medicine, he attended the different medical lectures, and became a member of the Medical Society, at a time when his friend, the celebrated Dr Akenside, was a member of the same institution. In the year 1745, Mr Gregory went to Leyden, to complete his professional studies, under the care of Albinus, Gaubius, and Van Royen, who were at that time the ornaments of the university. Here he became acquainted with the famous John Wilkes and the Hon. Charles Townshend, two of the greatest wits of the age; and before he left this university, he received from King's College, Aberdeen, an unsolicited degree of doctor of medicine. Upon his return from Holland, he was chosen professor of philosophy in the same college; and during the years 1747, 1748, and 1749, he read lectures in mathematics, experimental philosophy, and moral philosophy.

Having resolved, however, to establish himself as a physician at Aberdeen, he resigned his professorship in the end of 1749, and went for a few months to the continent.

After he returned to Scotland, he married, in 1752, Elizabeth, daughter of William Lord Forbes, who brought him a handsome addition to his fortune. This accomplished and amiable woman, who possessed the rare combination of great beauty and great intelligence, lived only nine years after her marriage, and left her husband and six children to lament their premature loss.

Perceiving little prospect of succeeding in Aberdeen to the full extent of his wishes, Dr Gregory resolved to settle in London, where he arrived in 1754. He was chosen a Fellow of the Royal Society in the same year; and, from the influence and attachment of his friends, as well as from his own professional talents, he had the best prospects of an extensive practice. The death of his elder brother, however, occasioned a vacancy in the professorship of physic in King's College, Aberdeen; and being solicited to accept of this situation, he returned to his native country in 1756, and began to discharge the duties of his new office.

Among the eminent young men who at that time adorned the university, were Reid, Campbell, Beattie, Gerard, John Stewart, professor of mathematics in Marischal College, and David Skene, a correspondent of the celebrated Linnæus. These young men established a literary society or club, which met weekly at a tavern. A short essay was read by each member in rotation, and a literary or philosophical question was proposed every night as a subject of discussion at the following meeting. The proposer of the question was obliged not only to open the discussion, but to digest the opinions of the different members in the form of an essay, which was engrossed in the album of the society. Several of those composed by Dr Gregory on philosophical, moral, and political questions, still exist, and contain some of his favourite opinions. Some of the separate essays which Dr Gregory contributed were afterwards corrected, and published in 1765, under the title of *A Comparative View of the State and Faculties of Man with those of the Animal World*. It was considerably enlarged by the author in a second edition, and has passed through other editions since his death.

About the end of the year 1764, Dr Gregory removed from Aberdeen to Edinburgh. In 1766, he was appointed professor of the practice of physic, on the resignation of Dr Rutherford; and in the same year, he succeeded Dr Whytt as first physician to his Majesty for Scotland. His lectures on the practice of physic were delivered in the years 1767, 1768, and 1769; but, in consequence of an arrangement with Dr Cullen, professor of the theory of physic, these celebrated individuals gave alternate courses of the theory and practice of medicine. The lectures of Dr Gregory were never committed to writing. Having made himself fully master of his subject by previous meditation, he required no other aid than a few notes containing the heads of his lecture. The introductory lectures, however, were carefully composed, and related principally to the duties and qualifications of a physician. Many copies of these lectures having been taken by his pupils, one of them was offered for sale to a bookseller. It therefore became necessary to anticipate this fraudulent design, by the publication of a correct copy, which appeared in 1770, and afterwards in a more enlarged and perfect form, in 1772. In the same year, Dr Gregory published *Elements of the Practice of Physic, for the use of Students*, a work intended as a text-book for the use of his pupils. He proposed to embrace all the diseases of which he treated in his lectures; but he did not live to bring the work farther down than to the end of the class of febrile diseases.

After the death of his wife in 1761, Dr Gregory occupied his solitary hours in the composition of a *Father's Legacy to his Daughters*. This admirable work, which every mother should study, and every daughter read, was written under the impression of an early death. It is marked by a deep knowledge of the world and of human character, and abounds with the finest lessons of piety and virtue.

From the eighteenth year of his age, Dr Gregory had been, at irregular intervals, attacked with the gout; a disease which he inherited from his mother, who died suddenly, in 1770, while sitting at table. Dr Gregory anticipated a similar event for himself, and often mentioned this impression to his friends. In January 1773, when conversing with his son, the present Dr Gregory, the latter remarked, that having had no attack for the three preceding years, he might expect a pretty severe fit of it that season. His father was displeased with the prediction, which was unfortunately too correct; for he was found dead on the morning of the 10th of February, although he had gone to bed in his usual health.

"Dr Gregory," says his friend and biographer Mr Tytler, "was in person considerably above the middle size. His frame of body was constructed with symmetry, but not with elegance. His limbs were not active; he stooped somewhat in his gait; and his countenance, from a fulness of feature, and a heaviness of eye, gave no external indication of superior powers of mind or abilities. It was otherwise when engaged in conversation. His features then became animated, and his eye most expressive. He had a warmth of tone and of gesture, which gave a pleasing interest to every thing which he uttered. But, united with this animation, there was in him a gentleness and simplicity of manner, which, with little attention to the exterior and regulated forms of politeness, was more engaging than the most finished address. His conversation flowed with ease; and when in company with literary men, without affecting a display of knowledge, he was liberal of the stores of his mind.

He possessed a large share of the social and benevolent affections, and which, in the exercise of his profession, manifested themselves in many nameless, but important, attentions to those under his care; attentions which, proceeding in him from an extended principle of humanity, were not squared to the circumstances or rank of the patient, but ever bestowed most liberally where they were most requisite. In the care of his pupils, he was not satisfied with a faithful discharge of his public duties. To many of these, strangers in the country, and far removed from all who had a natural interest in their concerns, it was a matter of no small importance to enjoy the acquaintance and countenance of one so universally respected and esteemed."

Dr Gregory left behind him three sons and two daughters, the eldest of whom is Dr James Gregory, professor of the practice of medicine in the university of Edinburgh, who fully inherits the virtues and talents of his ancestors. The works of Dr John Gregory were published at Edinburgh in 1788, in 4 vols. duodecimo, and were enriched with a well written life of the author, by the late Mr Tytler, Lord Woodhouselee, to which we have been indebted for the preceding facts.

GRENADA, the most southerly of the Caribbee islands, in the West Indies, is situated between 12° 20′ Description.

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and 11° 58′ North Lat. and between 61° 20′ and 61° 35′ West Long. It is twenty leagues north-west of Tobago, and the same distance from the nearest point of the American continent. It is about twenty-five miles in length, from north to south, and fifteen at its greatest breadth, contracting gradually towards both extremities. A chain of mountains traverse the whole island from north to south, and give rise to a great number of small rivers; and in the highest ground is a circular lake, called Grand Etang, from which several of these streams derive their source. There is a bay on the north-west coast, (which has been recently fortified at great expence,) so capacious and secure, that sixty men of war may ride in it safely almost without casting anchor. The air is salubrious, and the soil fruitful in the productions of the climate.

History.

Grenada was discovered by Columbus in 1498, and was at that time inhabited by a warlike people called Charaibes or Caribbees. The Spaniards do not appear to have made any attempt to form a settlement on the coast, and the natives remained free and undisturbed till the year 1650. At this period, the French governor of Martinico, Du Parquet, landed on the island with 200 adventurers, who seem to have been resolved upon a wanton destruction of the unoffending inhabitants, and an unwarrantable possession of the country; but, being hospitably received by the unsuspecting objects of his unjustifiable attack, they pretended to make a purchase of the island for a few knives and hatchets, a quantity of glass beads, and a barrel of brandy to the chief. Immediately assuming the sovereignty, and having roused the natives to resistance by their tyrannical proceedings, they took measures to extirpate the whole race as lawless rebels. This they are said to have speedily accomplished by a course of atrocious massacres; and a few wretched survivors of their butcheries having thrown themselves headlong from a steep rock, rather than fall into the hands of such merciless enemies, the French settlers, with characteristic levity, gave to the spot the name of *Le Morne des Sauteur*, the Hill of the Leapers. The perpetrators of these enormities soon began to quarrel among themselves, and to suffer, in their turn, the oppressions of tyrannical governors. By a succession of calamities and revolutions, the narration of which would interest few readers, the prosperity of the settlement was so much impaired, that, in the year 1700, more than twenty years after the sovereignty had been vested in the crown of France, there were found on the whole island only 151 white inhabitants, 53 free negroes or mulattoes, 525 slaves, 64 horses, 569 horned cattle, 3 plantations of sugar, and 52 of indigo. Above fourteen years afterwards, however, an active commercial intercourse was opened with the island of Martinique, cultivation was rapidly extended, and, notwithstanding the interruption which these improvements sustained by the war in 1744, Grenada was found, in 1753, to contain 1262 white inhabitants, 175 free negroes, 11,991 slaves, 2298 horses or mules, 2456 horned cattle, 3278 sheep, 902 goats, 331 hogs, 83 sugar plantations, &c.; and in 1762, when it surrendered to the British arms, it is said to have yielded annually, together with its dependencies the Grenadines, a quantity of clayed and muscovado sugar, equal to 11,000 hogsheads of 15 cwt. each, and 27,000 lbs. of indigo. Having been finally ceded to Great Britain by the treaty of peace in 1763, a duty of 4½ per cent. upon all exported produce was ordered to be levied in place of all customs and duties formerly paid to the French king; a measure which gave rise to a great constitutional question, in which, after a long and elaborate law discussion, judgment was given by Lord Mansfield against the crown, and the duty was abolished in Grenada and the other ceded islands. Great commotions and divisions also were excited in the island, respecting the election of Roman Catholic inhabitants as members of assembly. By these party-contentions, the colony continued to be disturbed till its recapture by the French in 1779; and they were again renewed with additional violence, after its restoration to Great Britain in the general pacification which took place in 1783.

Division and tow[ns]

The island of Grenada is divided into six parishes, viz. St George's, St David's, St Andrew's, St Patrick's, St Mark's, and St John's; and, since its restoration to Great Britain in 1783, a Protestant clergy have been established by law. Four clergymen are allotted to the whole, and each is provided with an annual stipend of £330 currency,* £60 for house rent, and a considerable portion of the valuable glebe lands which had formerly been appropriated to the support of the Romish clergy, for whose benefit a part of the amount is still reserved. The capital of Grenada, formerly named Fort Royal, but now St George, is situated close to the spacious bay on the west coast, already described, and is divided by a ridge into two towns; the Bay-town, in which is a handsome square and market-place; and the Carenage-town, where the principal merchants reside. On the ridge, between the two towns, stands the church; and on the promontory above it is an old fort built of stone, and capable of accommodating an entire regiment. The other towns are only villages or hamlets, which are generally situated at the bays or shipping places.

Government.

The governor of the island is also chancellor ordinary and vice-admiral, and his salary is £3200 currency per annum, which is raised by a poll-tax on all slaves. The council consists of twelve members, and the assembly of twenty-six. A freehold or life estate of fifty acres in the country, and of fifty pounds house rent in the capital, qualifies for a representative. An estate of ten acres in fee, or for life, or a rent of ten pounds in any of the country towns, and a rent of twenty pounds out of any freehold or life estate in the capital, gives a vote in the election of the representatives. The law courts, besides those of chancery and ordinary, in which the governor presides, are the court of grand sessions of the peace, held twice a year, in which the person first named in the commission of peace presides; the court of common pleas, in which a professional judge, with a salary of £600, presides; the court of exchequer, lately fallen into disuse; the court of admiralty, and the court of error, composed of the governor and council, for trying appeals. In all cases the common statute law of England is the rule of justice, unless where particular laws of the island interfere.

Popul[ation].

The white population of Grenada has decreased considerably since it came into the possession of the British. In 1771, their number was above 1600; in 1777, they had diminished to 1300; and in 1791, they were not supposed to exceed 1200. Of these about two-thirds are able to bear arms, and are incorporated into five regiments of militia, with a company of free blacks, or mulattoes, attached to each. There are likewise about 500 regulars from Great Britain, for the defence of the island. The negro slaves, also, which, in 1779, were

* The currency of Grenada, or rate of exchange, is commonly £65 per cent. worse than sterling.

Grenada.

stated at 35,000, including those which were in the smaller islands, were found, in 1785, to have decreased to 23,926. The free people of colour amounted, in 1787, to 1115, whose evidence is received in the courts of law, upon proofs of their freedom being produced; and who are allowed to possess lands or tenements to any amount, provided they are not aliens.

State of cultivation and soil.

There are 80,000 acres of land in the island, but only 50,000 were brought into cultivation in 1791. The face of the country is mountainous, but every where accessible, and well provided with rivulets and springs. On the west side, the soil is a rich black mould, lying on a substratum of yellow clay; on the north and east, it is a brick mould; on the south, and in the interior, it is of a reddish hue, and generally poor. In 1776, the exports from the island and its dependencies were 14,012,157 lbs. of muscovado, and 9,273,607 lbs. of clayed sugar; 818,700 gallons of rum; 1,827,166 lbs. of coffee; 457,719 lbs. of cocoa; 91,943 lbs. of cotton; 27,638 lbs. of indigo, and some smaller articles, the whole of which, at a moderate computation, was worth, at the ports of shipping, £600,000 sterling. The sugar was the produce of 106 plantations, worked by 18,293 negroes, which gives rather more than a hogshead of muscovado sugar of 16 cwt. from the labour of each negro,—a return which Mr Edwards affirms, to be unequalled by any other British island in the West Indies, except St Christopher's. In 1787, the exports were 175,518 cwt. of sugar, 670,390 gallons of rum, 8812 cwt. of coffee, 2,062,427 lbs. of cotton, and 2810 lbs. of indigo. In 1810, the value of the exports amounted to £388,936, and of the imports to £173,366.

The following Table shews the Articles imported into Grenada in the Years 1804, 1805, *and* 1806.

	1804.				1805.				1806.		
Articles imported.	Great Britain.	British Colonies.	United States.	Other Countries.	Great Britain.	British Colonies.	United States.	Other Countries.	Great Britain.	British Colonies.	United States.
Corn	Bushels. 13,558	—	17,626	—	Bushels. 10,414	234	14,987	408	Bushels. 21,285	314	9966
Bread, Flour and Meal	Cwts. 2,860	773	22,456	—	Cwts. 2525	23	21,658	—	Cwts. 3085	609	12,812
Rice	—	—	Barrels. 395	—	—	—	Barrels. 471	—	—	—	Barrels. 436
Beef & Pork	Barrels. 1361	—	1875	—	Barrels. 572	—	2891	—	Barrels. 979	1 33	817
Dry Fish	Bar. Quint. 0 399	0 13,112	228 1575	—	Bar. Qt. 45 542	0 18,181	0 735	—	Bar. Qt. 0 616	0 19,454	0 981
Pickled Fish	Barrels. 2205	184	805	—	Barrels. 822	316	190	—	Barrels. 726	268	9
Butter	Firkins. 3019	16	68	—	Firkins. 818	—	240	—	Firkins. 1769	72	200
Cows & Oxen	—	—	Number. 134	48	—	—	Number. 183	34	—	—	Number. 156
Sheep & Hogs	—	—	Number. 175	7	—	—	Number. 160	49	—	—	Number. 125
Oak & Pine Boards, & Timber	—	Feet. 6000	1,793,641	—	—	Feet. 18,479	2,875,399	—	—	Feet. 2650	2,090,862
Shingles	—	—	Number. 1,328,700	—	—	—	Number. 2,391,200	—	—	Number. 21,000	2,281,400
Staves	—	—	Number. 9000	539,897	—	Number. 15,100	843,000	—	—	Number. 14,880	920,883

Sugar ant.

The sugar plantations in this colony are subject to great ravages, from the carnivorous or sugar ant, an insect which is thought to be common to all the West India islands, but which has been peculiarly destructive in Grenada. It is the *Formica omnivora* of Linnæus, and is described by Sloane as the *Formica fusca minima antennis nis longissimis*. They are of an ordinary size, a slender shape, a dark red colour, remarkable for the quickness of their motions; but are distinguished from every other species, chiefly by the sharp acid taste which they yield when applied to the tongue, and the strong sulphureous smell which they emit when rubbed together between the palms of the hands. Their numbers have often been so immense, as to cover the roads for the space of several miles; and so crowded in many places, that the prints of the horses feet were distinctly marked among them, till filled up by the surrounding multitudes. They were never seen to consume or carry off any vegetable substance whatever, but always laid hold of any dead insect or animal substance that came in their way. Every kind of cold victuals, all species of vermin, particularly rats, live poultry, and even the sores of the Negroes, were exposed to their attacks. But they were chiefly injurious by constructing their nests among the roots of the lime, lemon, orange trees, and sugar canes, and so obstructing their growth, as to render the plants sickly and unproductive. A premium of £20,000 from the public treasury, was offered to the discoverer of any effectual method of destroying them; and the principal means employed were poison and fire. By mixing arsenic and corrosive sublimate with animal substances, myriads were destroyed; and the slightest tasting of the poison rendered them so outrageous as to devour one another.

Grenoble. Lines of red hot charcoal were laid in their way, to which they crowded in such numbers, as to extinguish it with their bodies; and holes full of fire were dug in the cane grounds, which were soon extinguished by heaps of dead. But, while the nests remained undisturbed, new progenies appeared as numerous as ever; and the only effectual check which they received, was from the destructive hurricane of 1780, which, by tearing up altogether, or so loosening the roots where they nestled, as to admit the rain, almost extirpated the whole race, and pointed out the frequent digging up and consuming by fire of those stools and roots in which they take refuge, as the best preventative of their future increase. See Edward's *History of the West Indies*, vol. i.; Abbé Raynal's *History of the Indies*, vol. v.; and Gray's *Letters from Canada*, p. 379. (*q*)

GRENOBLE, a city of France, the capital of the former province of Dauphiny, and, under the late government, the chief town of the arrondissement or district of Grenoble, and of the department of the Isere. This city stands at the confluence of the rivers Drac and Isere, the latter dividing it into two unequal parts; the former, which is crossed by a bridge with a single lofty arch, is liable to overflow its banks, and commit considerable devastation both in the city and its environs. Grenoble is situated at the foot of the Alps, in an agreeable country, abounding in wood and water, but of a climate so variable, that the thermometer sometimes ranges through nearly 30° in a day: the greatest heat is from the 10th of July to the 15th of August, and the greatest cold from the 20th of December to the 20th of January The city stands 900 feet above the level of the sea, and the medium height of the barometer is 27 inches two lines. Nine-tenths of the city are on the left bank of the Isere, constituting the portion chiefly exposed to inundations, several of which have done much damage, and the water has been known to rise three feet deep in the streets.

Grenoble is surrounded by a wall, and is commanded by a citadel; but, unless its fortifications have been lately augmented, it is not considered a strong place. Within the walls, its area occupies about 64,000 square feet. It consists of 1200 or 1300 houses, and is inhabited by 23,500 souls, according to recent computations, for those of older date increase that population above a fifth. The streets are broad, and tolerably regular; and the houses, in general well built, consist of four or five stories. There are several fine public edifices, particularly the Episcopal palace, and that wherein the parliament formerly held its sittings. Among the charitable institutions which sufficiently illustrate the disposition of the citizens, the general hospital is the chief, and is governed by directors selected from the most distinguished of the inhabitants. The building, which is very spacious, is appropriated for incurables; persons insane; the indigent, who commonly amount to 400; and the foundlings of the city, about 150 in number, are also received here. This institution occupies an inclosure to the south-east of the city, and adjoining to it is the military hospital. In the hospital of Providence there are 60 beds, and in the hospital of the Ladies of Charity, for females, there are 20; besides which institutions, there is a poor's house in the suburbs. Grenoble has also a museum of the arts, and a botanical garden well managed. A garrison, consisting of a small body of troops, is kept here.

The principal manufactures of this city, are woollen cloths, muslins, hats, and particularly gloves, the principal towns of France, Spain, Italy, and Britain being supplied with them. Marble cutting is also carried on to some extent, for which purpose there are mills driven by water from the adjoining rivers.

Grenoble Gretna.

Grenoble is the see of a bishop who formerly arrogated the title of Prince of Grenoble, and enjoyed those peculiar privileges, which, in less enlightened ages, were reserved almost exclusively for ecclesiastics. Besides the parish churches, there are several monastic institutions.

Grenoble is celebrated for the complaisance and polished manners of its inhabitants, many of whom have shewn a distinguished taste for letters. Condillac and Mably, well known among the modern literati of France, were both natives of this place. It has also to boast of having given birth to the Chevalier Bayard, characterised by his sovereign Francis I. as one *sans peur et sans reproche*, and who, if we are to credit history, singly defended the narrow pass of a bridge against 200 horsemen. The Baron Adrets, a sanguinary chief of the Huguenots, during the wars for the reformation of religion, was born here, and distinguished himself by his cruelty on the miserable prisoners who fell into his power.

As the site of this city is elevated only 15 feet above the level of the river Isere, an unusual humidity prevails, which is the source of many serious distempers among the inhabitants. Though standing at the edge of a plain, extending over a square league, and surrounded by fertile fields and gardens, these advantages are counteracted by the miasmata emanating from the depositions of the waters. Certain seasons of the year are extremely unhealthy; slow fevers are seldom eradicated; and it has been remarked, that even the children are, in infancy, of smaller size, and longer of attaining the strength and complexion of those in the neighbouring country. "The river Isere," an intelligent physician observes, "has become a kind of domestic enemy to Grenoble, with which it is necessary to live; the constant humidity and the mud deposited by its tranquil waters in the neighbouring marshes, are inconveniences with which beneficent nature has accustomed the inhabitants; but they excite less attention than the tendency of all the prevalent diseases to terminate in dropsy." It has been proposed to counteract the deleterious effects arising from local circumstances, by digging a canal to drain off the stagnant waters, and which, at the same time would prevent the overflowing of the river; as also to deepen the bed of the Isere, in order to give it a stronger current.

Grenoble has subsisted from a very ancient period, and was known by the name of *Cularo*, under which it is designed in a letter from Plancus to Cicero. It is said to have been called *Gratianopolis* from the Roman emperor Gratian; but since the period when it was possessed by the Allobroges, and when it was denominated a city, it repeatedly changed its masters. After various revolutions, Dauphiny came under the dominion of the kings of France, and Louis XI. instituted a parliament in Grenoble, founded on the model of the parliament of Paris, since which time it has remained an integral part of the kingdom. (*c*)

GRETNA, or GRAITNEY GREEN, is the name of a village and parish in Scotland, in the county of Dumfries. The village of Gretna, which is the first stage in going from Longtown in England, to Annan in Scotland, is built on each side of the road, and has, for more than 70 years, been famous as a place for the celebration of the clandestine marriages of English lovers. This ceremony was generally performed by a blacksmith or tobacconist, and the number of marriages have been calculated at 65, which brought in an annual income of about £1000, at the rate of 15 guineas each. The remains of an oval druidical temple, occupying about half an acre of ground, has been discovered at Gretna Mains. The mansion house of Gretna hall has been fitted up by the proprietor the Earl of Hoptoun as an inn. The population of the parish, in 1811, was 1749.

GREW, Nehemiah, a celebrated botanist, was born at Coventry, about the year 1628, and was the son of Dr Obadiah Grew, vicar of St Michaels. At the restoration of Charles II. being a non-conformist, he went abroad, and prosecuted his studies at a foreign university, where he took the degree of Doctor of Medicine. Upon his return to England he settled at Coventry, and, in the year 1664, his attention was first directed to the anatomy of plants; and he was encouraged to proceed in this branch of natural history by his brother-in-law Dr Henry Samson, who pointed out to him a passage in Glisson's work *De Hepate*, in which this subject is represented as an unexplored, but promising line of study. In the year 1670, Dr Sampson, who had seen the first book of Grew's *Anatomy of Plants*, put it into the hands of Oldenburg, who gave it to Dr Wilkins, bishop of Chester, by whom the manuscript was read to the Royal Society, under the title of a *Philosophical History of Plants*. This work was highly approved of, and was printed by that distinguished body in 1671, under the title of the *Anatomy of Vegetables begun, with a general Account of Vegetation founded thereon*. In consequence of the reputation which this work acquired for its author, Grew was invited to settle in London, where he arrived in 1671.; and, upon the recommendation of Dr Wilkins, he was elected a Fellow of the Royal Society, and admitted on the 30th November 1671. At the suggestion of the same learned divine, Grew was appointed curator to the Royal Society for the anatomy of plants, which led him to draw up the 2d, 3d, and 4th Parts of his work, and the various lectures on the same subject, which form a part of his Anatomy of Plants. All these papers were composed between the years 1670 and 1676, and were read at various meetings of the Royal Society. They were afterwards collected in 1682, with 83 plates, and published in a folio volume, under the title of the *Anatomy of Plants*, a work full of the most important facts in vegetable physiology.

In the year 1673, Dr Grew published in the Transactions, a paper, entitled *Observations on Snow*, in which he supposes, that the snowy particles are formed by the drops of rain containing spirituous particles, and meeting in their descent with others of a saline, partly nitrous, but chiefly urinous or acido-salinous nature. In the year 1677, he was appointed secretary to the Royal Society, in which capacity he published the *Phil. Trans.* from January 1678 to February 1679. In the year 1680, he was made an honorary fellow of the College of Physicians, and attained to considerable practice in the medical profession.

Dr Grew drew up a catalogue of the natural and artificial rarities belonging to the Royal Society, and preserved at Gresham College, which was published in 1681 in folio, with the title of *Museum Regalis Societatis*, containing 22 plates. It was accompanied with another work, entitled the *Comparative Anatomy of Stomachs and Guts begun*, being several lectures read before the Royal Society in 1676. The description of the Museum, though by no means free from mistakes, is a work of merit, and is remarkable for an ingenious scheme or disposition of shells.

The other papers which he printed in the Transactions, were

The Description and Use of the Pores in the Skin of the Hands and Feet. Phil. Trans. 1684.

Some Observations on a diseased Spleen, Id. 1691.

Description of the American Tomineius, or Humming Bird, Id. 1693.

On the Food of the Humming Bird, Id. 1693.

A Demonstration of the Number of Acres in England or South Britain, and the use which may be made of it, Id. 1711.

One of the last works of Dr Grew, was his *Cosmographia Sacra*, or *a Discourse of the Universe, as it is the Creature and Kingdom of God*. The principal object of this work, was to demonstrate the truth and excellence of the sacred writings. The works of Dr Grew were translated into French and Latin. He died after a short illness on the 25th of March 1711, about the 83d year of his age.

GRIDIRON Pendulum. See Horology.

GRIES, is a mountain of Switzerland, situated in the Alpine chain which separates Piedmont from the Upper Vallais. The road over this mountain leads from Oberghestelen, in the Vallais, to Domo d'Ossola, in the Val-Maggia, and to Locarno. This road rises to the height of 7336 feet, and traverses a glacier a quarter of a league wide, and blackened by the dust of the mica slate. The distance from Oberghestelen to Formazza, at the southern foot of the Gries, is 7½ leagues. The descent of the Gries is by four different terraces or vallies. The first is called Bettelmatte, celebrated for its fine cheese, and for the small lake from which the Toccia, or Tosa, issues. The second valley is called Morast, and from this the road descends by a very steep path to a third valley, occupied by the hamlet of the Auf der Frout, where the valley of the Toccia, or the Dolgia, commences. Another steep declivity conducts to the south valley, called Froutval, which is celebrated for the cataract of the Tosa, or Toccia, which, excepting the fall of the Rhine, is reckoned the most magnificent in Switzerland. It is about 300 or 400 feet high, and forms a species of pyramid, whose base is extremely wide, while its summit is only 4 or 5 feet in breadth. The rock is inclined about 140° or 150° to the horizon. This cataract is surrounded on all sides with lofty rocks, crowned with wood. The southern side of the Gries is inhabited by Germans as far as the village of Foppiano. The south side of the mountain is composed of gneiss, of veined granite, and of mica slate. In the valley of Egino, there are beds of potstone, which are wrought about a quarter of a league on the east side of the bridge. Slates occur to the south, and lower down the mica slate appears. The first valley is composed of gneiss and calcareous strata. Below the second valley, rocks of argillaceous schistus stretch to the north-east; and, on the other side, are rocks of a ferrugineous aspect. All the rocks from the north to the south, as far as Pommat, lie in strata almost vertical, in the direction from north-east to south-west. See Ebel's *Manuel, &c.*

GRIMALDI, Francis Maria, a learned Italian Jesuit, was born in the year 1619, and cultivated the sciences along with his friend Riccioli. Grimaldi was the first person that observed the lengthening of the solar image when refracted by a prism; and he is principally known for his discovery of the diffraction of light; a subject which was afterwards examined by Sir

Isaac Newton, under the name of the Inflexion of Light. These discoveries of Grimaldi are contained in his work entitled *Physico-Mathesis de Lumine, Coloribus et Iride*, Bononiæ, 1665. The principal object of this work, is to determine whether light be a substance or a quality; and, after occupying 535 quarto pages in this discussion, he concludes, with the Aristotelians, that it is not a *substantial*, but an *accidental* quality. A full account of this work will be found in the *Phil. Trans.* for 1672, No. 79, p. 3069. Grimaldi died in 1663, in the forty-fourth year of his age. The discovery of the solar spots, and the present nomenclature of the lunar spots, have been erroneously ascribed to him. See *Phil. Trans.* abridged, vol. i. p. 675, Note. See also OPTICS.

GRIMSBY, or GREAT GRIMSBY, is a borough and seaport town of England, in Lincolnshire, situated near the mouth of the Humber. The streets are clean, and the houses in general well built. The church, which is called St James, is spacious and handsome, and is built in the form of a cross, with a tower in the centre. The steeple is a fine specimen of English pointed architecture. A part of the choir fell down in 1600, but the steeple has scarcely suffered from the depredations of time. In the upper part of the steeple is the singular inscription, "Pray for the soul of John Empringham." The church contains many ancient monuments. Grimsby had formerly a monastery of Gray Friars, a convent of Benedictines, and a priory of Augustine canons. Grimsby was once a rich and populous town, with a considerable foreign and inland trade. It was a mayoralty in the reign of King John; and in the reign of Edward III. it furnished 11 ships and 170 mariners to assist at the siege of Calais. The harbour, however, was gradually choked up, and a dangerous sand bank having drifted near its mouth, its trade declined, and was transferred to Hull. Of late, the trade of the place has revived; the harbour has been improved, a dock constructed at great expence, and the town enlarged by additional buildings. A small coasting trade is carried on with sloops. Salt and coals are the chief articles of importation. There was once at Grimsby a castle, but it is entirely decayed. There are some very extraordinary fountains near the town, called Blow Wells, which never overflow, though they rise to a level with the surface of the ground. Grimsby is a port town under that of Hull, and has a deputy collector, comptroller, and coast surveyor. The Grimsby canal is a short canal which leads from the Humber to Grimsby wet docks. Population of the burgh and parish, in 1811, 2747. See the *Beauties of England and Wales*, vol. ix. p. 689, &c.

GRIMSEL is the name of a lofty mountain in Switzerland, over which there is a road from the canton of Berne into the Upper Vallais. The distance from Meyringen on the Aar, to the Hospice of Grimsel, is about seven leagues, and from thence to Oberghestelen on the Rhone, is three leagues. This road is bordered in several places with frightful precipices, and it is often necessary to pass over bridges apparently insecure.

After leaving Meyringen, the traveller passes through the forests of Mount Kirchet, by the agreeable valley of Im Grund. The gneiss here appears below the calcareous strata, lying above the primitive rock. The strata of the gneiss are almost vertical, a little inclined to the south. Beyond the forest which occupies the extremity of Grund, the calcareous rocks cease altogether, and the gneiss and micaceous schistus replace it on the side of Guttaner, the southern dip of these rocks being a little increased. In the valley of D'Urbach, the great glacier of D'Urbach or of Gauli descends into the plain; and after passing the Aar by a bridge, a rough and solitary path cut out of the rock leads between the mountains of Urbach, Ritzli, Gauli, and Gouttan, to the hamlet of Im Boden, and thence to the village of Gouttanen, situated 3198 feet above the level of the sea, where there is a tolerably good inn. This village was burnt in 1803, but, in consequence of the liberality of the Swiss, it has been rebuilt. About a quarter of a league above Gouttanen, the granite appears in mass, and extends to the Grimsel. Its stratification is distinctly seen. At first the strata stretch from north-east to south-west, and afterwards from east-north-east to west-south-west. About half a league from Gouttanen, the Aar forms a cascade at the side of the road; and a fine rainbow may be always seen in clear weather between ten and two o'clock. Beyond Goutanen the road passes Mount Stampf, and, after twice crossing the Aar, the traveller reaches the chalet of Handeck in two hours. The glacier and the lake of Ghelmer are distinctly seen from that mountain to the east, and to the south-west appear the glaciers of Erlen and Ritzli, and the Handeckhorn to the south. At a considerable distance below the chalet, the Aar forms one of the finest waterfalls in Switzerland. It should be visited during sunshine, between half-past nine and eleven o'clock, and from the bed of the river, as near the bottom of the fall as possible. From Handeck to the Hospice is a distance of two leagues, over a terrible road, which is three times crossed by frightful though substantial bridges. About half a league from Handeck appear immense rounded surfaces of granite, in which steps have been cut for the feet of the horses and of travellers. After travelling half an hour longer, we cross the fine Alpine pastures of Roderischboden. At the last bridge, not far from the Hospice, the Aar suffers another remarkable fall.

The Hospice, which was built in 1557, is surrounded with frightful rocks, and is situated at a height of 5628 feet above the level of the sea. The keeper of it is allowed to hunt in any of the cantons of Switzerland, and is bound, in return, to feed and lodge all travellers that cross the Grimsel. He remains at the Hospice from March till the beginning of November. He can furnish seven good beds, though there are sometimes more than a hundred candidates for them. Near the Hospice is a small lake called Kleinsee, from thirty-two to sixty-two feet deep. The Sassbach throws itself into the lake in a fine cascade. After leaving the Hospice, the road continues to ascend for three quarters of a league, and at its most elevated point the height is 6570 feet. The height of the Seidelhorn, which is the highest summit of this mountain, is 8580 feet. From the highest part of the road, there is a fine view of the Furca, of the Galenstock, of the peaks of St Gothard, of the Gries, and of the southern chain of the Vallais, as far as Mont Blanc. The descent to Oberghestelen occupies only about two hours.

On the top of the Grimsel a reddish granite occurs; mica slate appears in the southern face; and argillaceous schistus at the southern foot of the mountain. A singular grotto, filled with crystals, was opened on Mount Jochli, upon the Zinkenstock, in 1720. It was the richest ever found in Switzerland: It was 120 feet deep and 18 wide, and contained crystals of which a small number weighed nearly eight quintals, and several four or five quintals. Several thousands of quintals were obtained, of the estimated value of 30,000 florins. One of the largest of these was $3\frac{1}{2}$ feet diameter, 2½ feet long, and one of its six faces 1¼ feet wide. It is now in the museum of Natural History at Paris.

The glaciers of the Aar are generally visited by the travellers that cross the Grimsel. In the month of August 1799, the French ascended the mountain, and, after a severe conflict, drove the Austrians from their position on its summit. See Ebel's *Manuel, &c.*

GRINDELWALD is the name of a village of Switzerland, in the canton of Bern. It is situated in a rich Alpine valley, at the height of 3150 feet above the level of the sea. The direction of the valley is N. E. and S. W. and it is encircled with lofty mountains. The Faulhorn, to the north of Grindelwald, is 8020 feet high; the Wetterhorn, to the east, is 11,433; the Eiger, to the south, is 12,268. The Schreckhorn, to the south-east, is 12,530 feet; and the Jungfrau, to the S. S. W. is 12,840 feet. The valley is shut up at the north-east by the Scheideck, which is 6045 feet high.

This valley is one of the most frequented in Switzerland, both from its proximity to Bern, and from the facility with which its two glaciers may be visited. These glaciers are parallel to each other, and are each about a league distant from the Inn. The smaller glacier forms an arm of the immense valley of ice which is situated between the Schreckhorn, the Viescherhorn, and the two Eigers. In the middle of this glacier there is a rock, almost vertical, on which the snow cannot rest, and which has, therefore, received the name of the *warm rock*. The surface of the glacier is extremely unequal, and is formed into many splendid pyramids of ice. Near it is a wood of elder trees, where excellent strawberries may be gathered almost close to the ice.

The great or upper glacier, almost entirely separated from the small one by the rocks of the Schreckhorn, lies between the Mettenberg and the Wetterhorn. Its ancient limits were formed by a hill of debris, thirty feet high, and covered with pines of considerable height. In 1720, the glacier extended thus far, but it afterwards retired, and the space which it left was covered with trees. A new augmentation, however, which it experienced in 1780, destroyed this wood. The torrent which flows from it is the Black Lutschinen. In this valley the traveller frequently hears the thunders of the glaciers, and experiences the violence of the winds which issue from their crevices.

The road from Grindelwald to Meyringen, in the valley of Hasli, by the Scheideck, is extremely interesting. It is only a distance of seven leagues, and may be performed on horseback without any danger. See Ebel's *Manuel, &c.*

GRINDING OF DRUGS. See DRUG-MILL.

GRINDING AND POLISHING OF PLATE GLASS. See GLASS, Sect. vi. p. 314.

GRINDING OF LENSES AND MIRRORS for optical instruments. See OPTICS.

GRINSTEAD, EAST, is a borough and market town of England, in Sussex. It is pleasantly situated on a hill, near the northern border of the county. The town is irregularly built, but it contains many neat modern houses. The church, which stands on the east side of the main street, is a spacious and handsome structure. It has a lofty and well-proportioned tower, adorned with pinnacles at the corners. Sackville college, a large quadrangular stone building, stands at the east end of the town. It was built in 1616, as a charitable institution for the support of 24 old persons of both sexes. A suite of rooms is set apart for the Duke of Dorset, who gave the use of them to the judges when the assizes were held here. There is here a neat chapel belonging to the college, and also a free school here for 12 boys. Population, in 1811, 2804. See *Beauties of England and Wales*, vol. xiv. p. 150.

GRINDSTONES, from the Latin *Gyrandus*, are circular stones, a few inches thick, which are mounted on a spindle, and turned with a common winch, for the purpose of grinding edge tools. When a great number of these stones are driven by machinery for the purposes of cutlery, they are called *blade mills* or *grind mills*. Grindstones are formed of a gritstone, in which the grains of silex are firmly cemented to each other by a siliceous or other hard cement, the interstices not being filled up as in other kinds of sand stone. The following is a list of the grindstone quarries in England, with their degrees of fineness, drawn up, we believe, by Mr Farey for Dr Rees's *Cyclopædia:*

Ashover, N. W. (hill quarry) Derbyshire, middling.
Beely Moor, E. of the town, Derbyshire, coarse.
Belper, S. E. (Hungerhill) Derbyshire, middling.
Biddulph-Hall, N. W. of Leek, Staffordshire, coarse.
Bilstone, S. E. of Wolverhampton, Staffordshire, middling.
Bolsover, N. W. (nunnery) Derbyshire, middling.
Bredsal Moor, N. of Derby, middling.
Brinclif-edge, S. E. of Sheffield, Yorkshire, fine.
Buxton, N. (Corbar) Derbyshire, fine.
Darley Moor, E. of the town, Derbyshire, coarse.
Gate-head fell, 2¼ miles south from Chester Ward, Durham.
Glossop, Derbyshire, coarse.
Harthill, S. E. Yorkshire, fine.
Hooton-Roberts, near Rotherham, York, middling.
Horsley, N. of Derby, fine.
Lane-top, N. of Sheffield, Yorkshire, whitening.
Little-Eaton, N. of Derby, coarse.
Milford, S. of Belper, Derbyshire, coarse.
Molecopt-hill, S. of Congleton, Cheshire, coarse.
Morley-moor, N. of Derby, fine.
Norton, W. (Hemp-yard lane) Derbyshire, fine.
Overton (Gregory) in Ashover, Derbyshire, coarse.
Polesworth, S. E. of Tamworth, Warwick.
Purton, W. of Wolverhampton, Staffordshire, fine.
Ridgeway (Lum-delph) in Eckington, Derbyshire, fine.
Stanley, N. E. of Derby, fine.
Stanton by Dale, E. of Derbyshire, fine.
Stanton Moor, N. E. of Winster, Derbyshire, coarse.
Therberg, near Rotherham, Yorkshire, fine.
Treton, ditto, ditto, fine.
Warton E. of Tamworth, Warwickshire.
Wickersley, near Rotherham, Yorkshire, middling.
Wokes, near Barnsley, Yorkshire.

The most extensive grindstone quarries are those near Gateshead. They are sent to all quarters of the globe under the name of Newcastle grindstones, and constitute a great branch of the trade of Newcastle and Gateshead.

The explosion of grindstones when in motion is a phenomenon which has frequently happened, and which has been attributed to the effect of the centrifugal force, and to the expansion of the wooden wedges. On the 8th June 1768, a very singular accident of this kind happened to a cutler at Ivry-sur-Seine, near Paris, who was grinding kitchen utensils. The stone flew into the air apparently on fire, and burst into innumerable fragments, with a dreadful noise. One of the fragments, of about three pounds weight, flew over a building 40 feet high, and alighted 108 feet beyond it in the garden, where it broke the branch of a lime tree. Another

Grisons.

fragment, of nearly the same size, grazed the parasol of a young lady who was standing beside the cutler. A part of the stone was found upon the pavement reduced to powder. A similar accident happened to a cutler at Strasburg, who was killed by the explosion.

Our readers will find some curious facts relative to grindstones, and to their sudden explosions while they are at work, in the *Encyclopedie Methodique*, art. Tourneur; *Collection Academique*, tom. xiii. p. 45, 48, 413. and tom. xii. p. 109; *Mem. Acad. Par.* 1762. *Hist.* p. 37; and *Id.* 1768.

GRISONS, the *Upper Rhetia* of the ancients, is the name of a republic which was formerly independent, but since the year 1798 it has formed one of the nineteen cantons of Switzerland. It is bounded on the north by the canton of Glaris, from which it is separated by a chain of mountains, and by the German districts of Schweiz, and the Voralberg, in Suabia; on the east by the Tyrolese; on the south by the Valteline, and the Ticino; and on the west by the canton of Uri.

Boundaries.

Extent.

This canton is the largest in Switzerland. It contains 140 square geographical miles (15 to a degree), and comprehends no fewer than 60 principal and lateral vallies. From its most eastern part at Finstermunz on the Inn, to the Mountain Badus at the source of the anterior Rhine, is 32 leagues; and from its most northern part at the Mountain Seesa Plana, to its most southern part near the Mountain St George, is 23 leagues.

Natural divisions.

The natural divisions of the Grisons form five great vallies, viz. the valley of the posterior Rhine, the valley of the anterior Rhine, the valley of the Inn or the Engadin, the valley of the Albula, and the valley of the Landquart, or the Prettigau.

1. Posterior Rhine.

1. The valley of the Posterior Rhine includes the vallies of Rhinwald, Schams, Via Mala, and Domlesch. The Rhinwald is about eight leagues long, and is surrounded on all sides by lofty mountains. It is accessible only by one road, which passes through the defile called Rofflen, which leads into the valley of Schams. The surrounding mountains, of which the Avicula and the Piz-val-Rhin are 10,280 feet high, are covered with enormous glaciers, and the valley is exposed to frightful avalanches. The winter continues nine months. The grass does not begin to grow till the end of June, and it is necessary that the hay be got in before the beginning of September. This valley is inhabited by Germans of the Suabian colony, which the Emperor Frederick I. sent, at the end of the 12th century, to ensure a passage into Italy over the Splugen. The two principal roads for crossing the Alps pass through the Rhinwald; one of them over the Splugen, and the other over the Bernardin. In taking the road over the Splugen, eighteen hours are necessary to go from Coire to Chiavenna. From the village of Splugen, the road follows the brook Hausle all the way to the inn on the summit of the hill on the Italian side, which is a distance of three leagues. The height of the road is here 6170 feet; but that of Tombo-horn, the neighbouring summit of the mountain, is 9795. The gorge called the Cardinell is truly horrifying and dangerous. The road then follows the impetuous course of the Lira, and the traveller arrives in two hours at Isola. In two hours more, after passing through the valley of St Jacques, and by Campo Dolcino, where the customhouse officers examine all baggage, he reaches Creston, and then Sta Maria, which is only a league from Chiavenna. General Macdonald crossed this mountain in 1800, between the 27th of November and the 1st of December, and lost many men and horses by the avalanches. The northern side of the Splugen is chiefly composed of gneiss and micaceous schistus. Very fine white marble occurs near the summit of the road. It stretches between the micaceous schistus from south-west to north-east. The inhabitants of the village of Splugen make very fine articles of it. There were once two roads over the Bernardin, but the shortest is passable only in summer. The longest is kept in repair by the commune of Hinter-Rhein. At the highest part is a Hospice, which is three hours distant from the village of Hinter-Rhein on the north, and two hours from the village of Bernardin, in the valley of Misox, on the south. The small lake of Muesa, with several islets, is situated on the summit of this mountain. The water that runs from the southern face of the glacier of the Rhine throws itself into this lake, which again forms the brook of Muesa, and after running through the valley of Misox, joins the Tesino at Bellinzone. This mountain is composed of gneiss. It was crossed in 1797, on the 7th March, by the French army under General Lecourbe.

Road over the Splugen.

Road over the Bernardin.

In entering the Rhinwald from the valley of Schams by Rofflen, the road passes the villages of Suvers, Splugen, Medel, Ebi or Planura, Noveina or Noufenen, and Hinter Rhin. The church of Hinter Rhin is 4770 feet above the level of the sea. From the very bottom of this valley, which extends itself with a singularly wild aspect, among the horrible rocks of Avicula and the Piz-val-Rhin, the glacier of Rhinwald and the source of the posterior Rhine may be distinctly seen, and can be reached in three hours from Hinter-rhin. From a station a little way beyond the chalets of Tessini upon Zaport, may be seen the basin formed by the rocks of the Black Muschelhorn, and by a ridge of mountains about two leagues long, from which 13 torrents descend. At the bottom of this basin lies the glacier of Rhinwald. The torrent of the glacier issues from a magnificent vault of ice, and receiving the 13 brooks already mentioned, it forms the true source of the posterior Rhine. On leaving this deep gorge, it receives 16 torrents before reaching Splugen. After this it escapes through the gorge of Rofflen, receives other six brooks from the valley of Schams, throws itself into the abysses of the Via Mala, and, still farther enlarged in the valley of Domlesch by ten tributary streams, particularly the Albula, it joins itself at Reichenau to the anterior Rhine, which is considerably less in size, though enlarged by nearly 30 torrents. The Via Mala is one of the most frightful defiles in Switzerland. It extends two leagues from Tousis to Zilis. See Via Mala.

Valley of Schams.

The valley of Schams, which is two leagues long, contains eight or nine considerable villages, on both sides of the Rhine. It is lower and more fertile than the Rhinwald, and is one of the richest and most populous in Switzerland. See Schams.

Valley of Domlesch.

The valley of Domlesch, or Tomleasca, is formed by the posterior Rhine, after its junction with the Albula, and before it falls into the anterior Rhine. It is about two leagues long and one wide, and is the most temperate in the Grisons. It derives much of its celebrity from the picturesque and cultivated mountain of Henzenberg, about two leagues long, and stretching along the west side of the valley. The northern entrance to the valley is scarcely 100 paces wide; and on the south it is shut up by the Beverin and the Mouttnerhorn, between which the river forces itself with great fury. Soon after it receives the black stream of the Nolla, and half a league lower that of the Albula. The valley of Domlesch contains no fewer than 22 villages, and 12 ruined and inhabited castles, some of which are re-

Grisons.

markable for their antiquity. Excepting at Tonsis, the Romansh is here the general language. The base of the mountains is composed of argillaceous schistus, covered with calcareous schistus. Gypsum appears in vertical beds in the Via Mala, and in the western part of the valley. See TOMILS and TOUSIS.

Anterior Rhine.

2. The anterior Rhine comprehends the valleys of Tavetsch, Medels, Sumvix, Lugnetz, Petersthal, &c. The valley of Tavetsch forms the upper part of the anterior Rhine. Sadrun is the principal place. Ruaras is the highest Grison village in the south-east. Selva and Camot are the only other places of note. The anterior Rhine is formed by three branches, which unite at Camot. The middle branch comes from the mountain Badus, and is called Rhin-de-Camot. It is formed by the glaciers on the eastern side of that hill, which throw their waters into the small lakes of Lac-de-Toma and Lac-Palidulca, and form the branch already mentioned. The second branch, called the Rhin-Cornara, flows out of the valley of the same name, having risen in the mountains of la Sceina de la Reveca. The third branch comes from Kamerthal, and rises at the foot of the Crispalt. The anterior Rhine formed by these branches, receives ten brooks before it falls into the middle Rhine, which flows through the valley of Medels. Badus is 9085 feet above the bottom of the valley. It is accessible from the north, south. and east, and commands a grand view of the distant Alps. From Camot and Selva, this mountain may be ascended and descended in one day. The valley of Tavetsch is peculiarly exposed to avalanches. In 1749, an avalanche came from Crispalt, a mountain two leagues distant, and overwhelmed 100 persons, of whom 80 were taken out of the snow alive. On the night of the 13th December 1808, another descended from Rouenatsch on the village of Selva, and killed 42 persons, and 237 cattle.

Mountain Badus.

Valley of Medels.

The valley of Medels is very narrow and picturesque. It is watered by the middle Rhine, and extends five or six leagues. Wheat, barley, flax, and hemp, are here cultivated; but the care of the cattle is the principal concern of the inhabitants. Very fine cheese is also produced in this valley. Beyond the junction of the middle and anterior Rhine, the valley is for 1½ miles very narrow and dark, owing to the height of the rocks, and the fir trees which cover them. The middle Rhine runs in a very narrow channel, and forms many fine cascades. In leaving this defile, the smiling valley of Medels appears. The village of Kurajla is seen situated above the river; and on the left the lateral valley of Platas, which contains the hamlets of Soliva and Bisquolm. At the Hospice of St Maria, on the Lucmanier, the Val-Kadelina opens, in which the middle Rhine has its origin. See LUCMANIER.

Valley of Sumvix.

The valley of Sumvix opens into the Rhine opposite the village of Sumvix, and has the village of Surhein at its mouth. It is about five leagues long, and stretches between huge mountains covered with glaciers. It is rich in mountain pastures, meadows, and forests. The mountain of Tenija, situated at the upper extremity of the valley, divides it into two branches, viz. Val-vijlots and Val-greina. The torrent which runs through the valley, has its origin in the vast glacier of Medels. Though the valley is more fertile than that of Medels, it has only two chapels, and 121 inhabited houses. There is a sulphureous spring half a league above Surhein. The view of the cascade of the Greina, and the surrounding glacier, is particularly admired.

Valley of Lugnetz.

The valley of Lugnetz opens into the Rhine near Ilantz (See ILANTZ). It is eleven leagues long, and contains many lateral vallies. From Ilantz to the central point where the valley divides is three leagues. To the south-west of this point stretches the valley of Urin, and to the south-east that of St Petersthal. The greater part of the inhabitants are Catholics. See LUGNETZ.

Banks of the Rhine from Dissentis to Coire.

The road from Dissentis to Coire, along the banks of the Rhine, is extremely interesting. The Benedictine abbey of Dissentis is situated above the town of the same name on the northern face of the mountain Vakaraka, whose great forests protect both it and the town. It enjoys a splendid view of the Rhine as far down as Coire. It was founded in 614, by Sigebert, a Scottish Benedictine, who came to preach Christianity to the Rhetians. Placide Toparcha of Trons gave him the ground for this purpose, and became himself a monk. The convent and a part of the town were burned by the French in May 1799, and the inhabitants were put to the sword, in consequence of the women having massacred a company of soldiers without arms in a general insurrection. A collection of books and precious manuscripts, and the mineralogical collections and journals of R. P. Placide a Specha fell a prey to the flames. The convent has been rebuilt, and the Catholic school of the canton has been established here since 1804. The town is the chief place of the district of Dissentis, which is one of the most ancient and populous of the Grey league. From Dissentis to Trons is a distance of 3 leagues. The best wheat in the Grisons grows about Sumvix. The mountains are all primitive to Trons, but to Ilantz they are composed of beds of calcareous stone and schistus. To the north of Trons (See TRONS) opens the wild valley of Puntajlas, indented with glaciers from which issue the torrent of Ferrara. From Trons to Ilantz by Tavenas and Rauvis, is a distance of four leagues through a very narrow valley. The great road recrosses the Rhine below Tavenas, and passes by Rauvis, Schlowis, Sagens, Lax, Flims, Trins, and Tamins to Reichenau. At Rauvis, a league below Ilantz, is a mine of galæna, containing silver. The galæna is in masses of gneiss. At Obersax, a village on the other side of the Rhine, there is a mine of pale red copper, containing much silver. There is also here abundance of borax. These two mines have been wrought since 1806. The road through Schowis, Sagens, and Lax, traverses thick forests of pines, and a wild country, diversified with grain and pastures. At Flims, which is situated on beautiful hills in a pleasant place, and also at Tamins, the houses stand in separate clusters. Flims is remarkable for the beauty of its inhabitants, and for the excellence of its springs of water. The torrent Blaun sometimes commits dreadful ranges. From Flims to Elm in the canton of Glaris, is 7½ hours by the Hunter's road. Reichenau is the key of the anterior Rhine, and is situated at the confluence of the posterior and anterior Rhine. The former has an ash-grey colour, and the latter is a limpid green. See REICHENAU.

Town of Dissentis.

Trons.

Mines.

Flims.

Reichenau.

The road from Reichenau to Coire or Chur by Ems, is a distance of 2 leagues. Between Reichenau and Ems, are 15 or 20 conical hills, covered with oak, and adorned in the most picturesque manner by chapels and ruins. From Ems to Coire is a fine rich valley, bounded on the right by the mountains of Malix, and on the left by the Galanda. This mountain is 6598 feet high, and rises like an enormous pyramid. It is ascended most easily on the side of Coire. It is composed of calcareous rocks, and of calcareous schistus containing much argil. The strata are inclined to the south. Coire is situated on the left

Mountain of Galanda.

Grisons.

Town of Coire.

bank of the Rhine, in a rich plain between 2 or 3 miles wide. The town lies partly in the plain, and partly on the steep side of a rock. It is encircled with ancient brick walls, strengthened with round towers. The streets are narrow and dirty. The bishop's palace and the cathedral, built in the 8th century, stand in the highest part of the town. The convent of St Lucius, is situated above the palace. The library of the town, an institution for the poor, the cantonal school. are the other principal establishments. In 1806, about 200 copper medals of the Roman emperors were found near the anterior gate. The plain around Coire is diversified with corn and pasture, and the sloping hills are covered with vines, which yield a pleasant but not a strong wine. The population of the town is 3000. Rafts carrying from 20 to 50 quintals, descend the Rhine from the bridge over the Albula to the Lake of Constance.

Country from Coire to Luciensteg.

Below Coire, the road passes through the fine villages of Masans, Trimmis, Zitzen, and Ighis, to the chateau of Marschlen, where the Messrs Salis have a fine library, and a superb cabinet of natural history. The Economical Society of the Grisons was established at

Zitzen.

Zitzen in 1778, and had published nine fasciculi in 1803. The road now crosses the Lanquart by the bridge of Zollbrucks, where there is a pontage, and passes

Malantz.

through Malantz, Jennins, and Mayenfield. Malantz is a small handsome town on the side of a hill. Its red and white wines are reckoned the best in the Grisons. There are beds of gypsum near Jennins,

Jennins.

and much blue marl in the neighbourhood. Jennins is half a league from Mayenfield, and three quarters of a league from the defile of Luciensteg. The

Mayenfield.

fine valley of Mayenfield is a league wide, and is surrounded with lofty calcareous mountains. The defile

Luciensteg.

of Luciensteg is situated near the northern frontier of the Grisons, on the side of Suabia, between the Gouscher Alp 5573 feet high, and the Flesch 3114 feet high. A wall 100 toises long, and a rampart of the same length, defends on that side the entrance to the Grisons. The frontier passes near Balzeres, situated

Gouscha.

on that defile. At the village of Gouscha near Luciensteg, the mothers are accustomed to tie their children to a rope of a certain length, when they are obliged to leave them at home, lest they should fall over the precipices.

3. Valley of the Inn.

3. The valley of the Inn or the Engadin, is one of the finest in Switzerland. It has 28 lateral vallies, several of which have two or three ramifications. It stretches from the south-west to the north-east, and is 18 leagues long from the Maloggia to the bridge of St Martin. It is divided into the higher and the lower Engadin. The former is seven leagues long from the mountain Maloggia to that of Casanna, and the latter is 11 leagues long from Brail to the bridge of St Martin. It is subject to frequent earthquakes. A full account of this interesting district will be found in our article Inn.

4. Valley of the Albula.

4. The valley of the Albula comprehends the vallies of Davos and of Oberhalbstein. The principal valley of Davos is five leagues long, and is watered by the Landwasser, which falls into the Albula near Filisour, the end of the valley, where the river runs through a defile 1200

Valley of Davos.

feet deep. The lateral vallies of Davos are those of Flula, Dischma, and the fine valley of Sertig, which is divided into two, and has a sulphureous spring, and another mineral water of a purgative quality. Each of these three vallies is four leagues long. Opposite the gorge of Zughen is the valley of Montstein, which has two branches, each a league in length. The district of Davos contains six lakes; the greatest of these, which is half a league long and a quarter wide, contains great quantities of fish. This district possesses several mines of galæna, copper, lead, and iron. The river Albula issues from a small lake in a mountain of the same name, over which there is a road to the Engadin. It descends into the valley across a dreadful gorge called the rock of Bergun or Bergunerstein, and meets the Landwasser at Filisour. Though the smallest of the two, the united stream is called the Albula. It receives the Rhin-d'Oberhalbstein at Tiefenkasten, and is then lost in the posterior Rhine at Furstenau.

Valley of Oberhalbstein.

The valley of Oberhalbstein lies on the northern face of the mountains Septimer and Julier. It is 8 leagues long, and its river rises in a small lake on Mount Septimer. Savognin is the chief place in the valley. About Tintzen the valley grows very narrow, and the road ascends at the side of a torrent, bounded by horrible rocks. At the end of three-fourths of an hour it enters the meadows of Rofna. Near Molins, the castle of Splondatsch appears at the bottom of a frightful gorge. On the road to Marmels, the ruins of the castle of the ancient lords of Marmels rises on the right, upon the summit of lofty rocks. There is a mine of silver and of tin near Ziteil; and the remains of a copper mine between Ochsenberg and Tintzen.

5. Valley of the Prettigau.

5. The valley of the Lanquhart, or the Prettigau, is 8 leagues long and 4 wide, and has 9 or 10 lateral vallies. An account of it will be given under Prettigau. For still farther topographical information respecting the Grisons, see Misox, and the other articles already referred to.

Political divisions.

The Grisons are divided into three leagues. 1. The League of God's House; 2. The Grey League; and 3. The League of the Ten Jurisdictions.

The League of God's House is divided into 11 districts, and 21 communes, and sends 22 deputies to the general diet. Coire is the capital. The jurisdictions are,

1. Coire.	7. Obervats.
2. Pregalia.	8. Oberhalbstein.
3. Upper Engadin.	9. Puschiavo.
4. Lower Engadin.	10. Munster.
5. Bivio or Stalla.	11. Villages of Zitzen, Ighis, Trimmis, and Unter Vatz.
6. Ortenstein.	

The Grey League is divided into 8 high jurisdictions and 27 communes, and sends 32 members to the general diet. The following are the jurisdictions:

1. Dissentis.	5. Flims.
2. Valley of Lugnetz.	6. Rhinwald and Schams.
3. Grub.	7. Henzenberg and Tousis.
4. Waltensburg.	8. Misox.

Government.

The League of Ten Jurisdictions is composed of 11 communities, and send 14 members to the diet. It comprehends the rest of the Grisons, viz. the vallies of Davos, Prettigau, Mayenfield, &c.

Annual diet.

These three leagues are connected by an annual diet of the congress and of the three chiefs. The diet consists of 63 deputies, who are chosen in the several communities by every male above a certain age. The diet meets about the beginning of September at Ilantz, Coire, and Davos, in rotation, and sits three weeks or a month. The chief of the league, in whose district the diet is held, is president, and has a casting vote. In all affairs of importance, the deputies act according to the instructions of their constituents. A majority of votes decides every thing; but they vote in the following manner: When the communities send instructions, the secretary reads them aloud, and the votes are taken from these instructions. In all resolutions respecting which instructions are not received, the deputies may vote as they please; but these resolutions are subject to the revisal of the communities. For this purpose, a congress is held in February or March at Coire, consisting of the three chiefs and three deputies from each league, for the purpose of receiving the votes of the different communities relative to the questions referred to them at the preceding diet. The three chiefs, and the other members of congress, receive 54 florins, about £4, to defray their expences. The deputies to the general diet receive a salary, which never exceeds five shillings a day.

The three chiefs meet three times in the year at Coire, and send information to the different communities respecting the subjects of discussion at the general diet.

rts of ice. The Roman law, modified by municipal customs, prevails in the three leagues. It appears from the concurring testimony of several travellers, that the administration of justice, both in the civil and criminal courts, is very imperfect. The judges are capable of being bribed; and confessions are obtained by torture.

The public chamber of justice, called the *Strafgericht*, is a court composed of ten judges out of every league, and 20 advocates. It is assembled, by a demand made by the peasants to the general diet, and is paramount to all law. There is no appeal from the decisions of this inquisitorial tribunal. The worst effects resulted from the meeting of this court, but fortunately it is now gone into disuse.

ion. The Catholic and Protestant religions both prevail in the Grisons. The Protestants form about two-thirds of the population. There are 135 Protestant parishes, viz. 53 in the League of God's House, 46 in the Grey League, and 36 in the League of Ten Jurisdictions. The livings are from £6 to £25 per annum. The clergy are here obliged to increase their income by traffic; and their poverty is rendered more oppressive from their dependence, as they are generally chosen by the people. Several of the ministers are, however, very respectable, and well informed. The Protestants are educated at Zurich and Basle; and the Catholics at Milan, Pavia, or Vienna. A Latin school was established at Coire for the children of the burghers; and another in 1763, for those intended for the church.

nues. The expenditure of the government consists merely in the salaries of the deputies, and in the expences incurred at the sitting of the diet. The revenues are drawn from the duties upon merchandize, which passes through the canton of the dependent states, and was farmed at 17,000 florins, or £1259: from fines upon delinquents; from a tribute of 500 Philips, or £125, from the Valteline; and 100 Philips, or £25, from Chiavenna; and from the interest of a small sum, the principal part of which, viz. £4000, was vested in the British funds.

nerce. rts. The commerce of the Grisons is very limited. Its principal exports are cheese and cattle, and some planks, stones, and coal, to Milan. The care of the cattle is the principal employment of the peasantry. The canton possesses 8000 head of great cattle, about 30,000 cows, from 60,000 to 70,000 goats, and nearly 100,000 sheep, which come annually from Italy to feed upon the fine pastures of the Grisons. The cattle of the Prettigau are the finest breed. Vines are cultivated in the vallies on the northern and southern frontiers.

rts. The imports of the Grisons, are grain, rice, salt, and silk stuffs, from Milan; grain from Suabia and the Tyrol; salt from the Tyrol and Bavaria; fine linens and muslins from Switzerland; and English, French, and Silesian fine cloth through Germany. The only manufactory in the country, is that of cotton at Coire. The trade of the Grisons, and the subject provinces, is carried on with Milan across the Lake of Como, by its branch the lake of Lecco, by the river Adda, and by the canals of the Adda and the Trezzo.

Languages. The Italian, German, and Romansh languages, prevail in the Grison territory. The inhabitants of Pregalia and Puschiavo, and of the vallies of Misox and Calanca, speak the Milanese dialect of the Italian tongue. The inhabitants of the Ten Jurisdictions, with the exception of a few villages; those of the League of God's House, at Avers, Coire, and the four villages; those of the Grey League, at Splugen, Cepina, and other villages of the Rhinwald; at Valts, in the valley of St Pedro; at Tousis, Reichenau, Feldsperg, Tamins, Meyerhof, Versam, and Valendros.

The Romansh, or Rhetian language, is the vernacular tongue throughout the greater portion of the Grison territory. It was formerly spoken at Coire, and the adjacent districts, and as far as Inspruck in the Tyrol. It is divided into two principal dialects; the one called Cialover, spoken in the Grey League; and the other Ladin, in that of God's House. These dialects vary both in pronunciation and orthography, and they have a great affinity to the Latin, and other languages derived from the Latin. Planta seems to have proved, that the Romansh of the Grisons is the same with the ancient Romansh, called *Lingua Romana*, the mother of the French tongue. It was the earliest language derived from the colloquial Latin, and was understood in Italy, in the Morea, and at Constantinople, having been universally diffused throughout the south of Europe in the 11th and 12th centuries.

Antiquities. The antiquities in the Grisons are very numerous. There are no fewer than 180 castles and ruins of the middle ages.

Population. Mr Coxe reckons the population of the Grisons at 98,000.

The Grey League contains	54,000 souls.
League of God's House	29,000
League of Ten Jurisdictions	15,000
	98,000

In the year 1806, the population was 73,862, viz.

Protestants	44,982
Catholics	28,880
	73,862

Or they may be divided into

Germans	28,000
Those who speak the ancient Rhetian language	36,065
Italians	9797
Total population	73,862

This number is exclusive of the provinces formerly subject to the Grisons. See Coxe's *Travels in Switzerland*, vol. iii.; Ebel's *Manuel d'un Voyageur en Suisse*, passim; and Planta's *Account of the Romansh Language*, in the Philosophical Transactions for 1776, vol. lxvi. p. 129.

Grodno, Groins.

GRODNO, is a town of Poland, in Lithuania, and, with the exception of Wilna the capital, is the most important place in that province. It is now a frontier town in the Russian division of Poland. It is built upon an eminence which overlooks the river Niemen, which is here a broad, clear, and shallow stream. Grodno is a large and straggling place, and has the appearance of a town in decay. The few houses that are in good repair, form a singular contrast with the wretched habitations, the falling houses, the ruined palaces, and the magnificent gateways, which are every where to be seen. Some remains of the old palace, in which the kings formerly resided during the diets, are still to be seen upon a hill of sand, rising abruptly from the river, and forming part of the bank. The new palace is opposite to this hill. It was built, but never inhabited, by Augustus III. and became the temporary residence of Stanislaus Augustus after his abdication. It contains the apartments for the meeting of the diets. The late King of Poland established at Grodno a royal academy of physic for Lithuania, in which ten students are instructed in medicine, and twenty in surgery, and are lodged, boarded, and taught at the royal expence. The physic garden contained 1500 exotic plants, when Mr Cox passed through the town in 1778. The principal manufactures here, are cloth and camlets, linens and cottons, silk stuffs, embroidery, silk stockings, hats, lace, fire arms, needles, cards, bleaching wax, and carriages. They were chiefly established by the king in 1776, and in 1778 they were carrying on in wooden sheds, built by Augustus III. for stables, which were converted into temporary working looms, and dwelling houses for the workmen. The establishment was subsequently removed to Lossona, a village near Grodno, where convenient buildings were erected at the public expence. The country furnishes a sufficient supply of wool, flax, hemp, beavers' hair, and wax, for the manufactories that require these articles; but the silk, cotton, iron, colours, gold, and silver, for the embroidery, and the fine thread from Brussels, are all articles of import. Three thousand persons are employed in these manufactories, including those in the neighbouring villages who spin linen and worsted. Seventy foreigners direct the different branches, and the rest are natives. Grodno contains nine Catholic churches, and two Greek churches. The population consists of 3000 Christians, exclusive of those engaged in manufactures, and 1000 Jews. See Cox's *Travels in Poland, &c.* vol. i. p. 220, 223.

GROINS. In our article CARPENTRY, Book iii. p. 522, &c. we have already treated the subject of groins at some length. We proposed, under the present head, to have investigated the subject of *Domes*, from which we have made a reference; but we have found it necessary to include this subject under that of ROOFS, to which the reader is referred.

In the article CARPENTRY, we have mentioned the great improvement in the construction of brick groins, rising from rectangular piers, as made by Mr George Tapper. The following account of this improvement has been drawn up for our work, by Mr John Narien.

If a square or rectangular area be covered with two vaults, penetrating each other at right angles, and forming two ridges which cross the area diagonally, and intersect each other at the common summit of the vaults, the arch thus formed is called a groined vault: the penetrating vaults may be either semicircular, or semi-elliptical, or one of them may be semicircular, and the other semi-elliptical. The intersections of the circular or elliptical vaults, forming the ridges or groin angles, will be ellipses, because every oblique section of a cylinder or elliptical prism produces an elliptic curve, and the case will be the same when one of the vaults is circular and the other elliptical; for if horizontal lines were drawn from points in the diameter or chord of the circular vault perpendicularly to that diameter, and cutting in different points a line drawn diagonally across the area, the ordinates drawn up to the ridge or groin angle from these points, will be respectively equal to the ordinates at the corresponding points under the circular vault, and consequently their ends will be in the periphery of an ellipse.

The four vaults or arches forming the groined vault, spring from the angles of four square abutment piers, and if the intended vault is to be built of stone, the courses in each arch respectively, are laid upon the centering in lines parallel to the axis of the arch they compose, in such a manner that the voussoirs of each arch meet the voussoirs of its adjacent arch at the groin angle, where the faces of the angular voussoir in each course are wrought in such a manner as to form the curve of the groin, which springs from the angle of the pier on which the arches stand. The upper surfaces of these angular voussoirs are also wrought, so that on both faces they may coincide with the other stones of the same course, by which means these surfaces meet in a ridge which is always perpendicular to the curve of the groin angle. When the intended vault is to be built of brick, the internal faces of the brick voussoirs in each course are cut away at the groin angle, to receive the wedge-like end of a brick in the adjacent arch in the same course, in order to bind the arches together more firmly: (See Fig. 1.) But as bricks have not, like wrought stones, the form of a frustum of a wedge by which they may sustain themselves when arranged in the shape of an arch, their stability must depend upon the strength of the cement placed between them, which, uniting them into one mass, renders a structure of this kind a sort of vault hewn out of a rock.

PLATE CCLXI. Fig. 1.

From a consideration of the above mentioned mode of constructing groined vaults, it will be evident that the pressures, both vertical and lateral, of all the arches of which they are composed, are resisted and sustained by the mutual intersections of the courses of masonry at the groin angles; these intersections may be considered as squares upon the corners of the piers from which they spring, the side of the square being equal to the thickness of the course of voussoirs, so that the diagonal ribs of the vault form as it were two arches, which are kept in a state of equilibration, by the weight of the spandrils immediately over them, and serve as bases upon which the side arches with their spandrils, and all the superincumbent loading, ultimately rests; hence it will be evident, that if the weight of the arches, with their loading over them, were in a constant ratio to the weight necessary for keeping the ribs in a state of equilibration, the whole vault would be in equilibrio in all its parts. This, however, cannot be attained in practice, because the distances between the ribs at any part are never in proportion to the height of the spandrils over the ribs at those parts, and therefore the groined vaulting will always in some degree be defective in its equilibration; besides the disadvantage arising from the whole of the weight falling entirely upon the ribs, which receive no support from the voussoirs of the contiguous side arches, whose joints are all oblique to the directions of the ribs.

But as groined vaults are absolutely necessary in warehouses, and many other buildings, for the purpose of giving communication throughout the same in every direction, which cannot be obtained where waggon-head vaults are used; and as there is a great saving of materials, resulting from the arches bearing on piers only instead of parallel walls, it follows, that an improvement in their construction, which tends to bring them nearer to an equality in strength with the waggon-head vaulting, must be a great acquisition. This improvement has been lately made by Mr George Tappen, an architect of London, who, instead of the square piers hitherto used, has adopted octangular ones, (by which a considerable saving of room is made,) and has thrown stout ribs diagonally over the vault whose breadths are equal to the sides of the octagons on which they stand. The side arches, which in brick-work are set four inches back from the face of the ribs, in order to save the trouble and expence of cutting the groin angles, are worked into, and rest upon these ribs. By this improved construction, the ribs form a much stronger support for the weight of the incumbent vault, and the loading above, than by the old method, as the following comparison will shew.

Since the force of the superincumbent weight has been found by experience to act chiefly in the direction of the groins, they require the greatest strength that can be given them; at the same time, the side arches should be made to throw as little weight as possible upon them, particularly about the summit of the vault, that their tendency to fracture towards the crown may be diminished as much as the nature of the case will admit. In the groined vaults hitherto constructed, where the groins spring from the extreme corners of the square piers, their section, taken perpendicular to their length, forms a square, (see *a*, Fig. 2.) having one of its angles turned towards the centre of the curve, and its side equal to the thickness of the arches: whereas in the new vault, the section taken in the same manner, forms a rectangle equal in breadth to the side of an octagon inscribed in the square pier, and of a depth which may exceed that of the old groin in any proportion, (see *b*, Fig. 2.) Now, the strength of an arch, in its different points, is measured by the greatest weight which it is able to carry on those points without breaking; that is, it is in a ratio compounded of the triplicate ratio of the secant of the angle of the curve's inclination to the horizon, in its various points, and the reciprocal simple ratio of the radius of curvature in the same points. But since the relative strength of arches is to be determined by comparing them in their weakest parts, (namely the crown,) the strength of any arch at the crown will be reciprocally as the radius of curvature at that point, since the angle of the curve's inclination to the horizon at that point is always 0° 0′; or reciprocally as the span of the arches when the rise of them is the same, their thicknesses being supposed equal. From this it will be evident, that the strength of the diagonal ribs and groins will be directly as the areas of their sections, and distances of the centres of gravity from the place where the fracture would end, and reciprocally as the spans of the arches: that is, if A represent the area of the section, G the distance of its centre of gravity, and S the span of the arch; then the strength of one arch to that of another will be as $\frac{A\,.\,G}{S}$.

Let the side of the square pier be $= a$; then the thickness necessary for the side arches will be $= \frac{a}{4}$, which, consequently, will be the side of the square section of the groins in the old arch; its area, therefore, will be $= \frac{a^2}{16} = A$, and its half diagonal $= \frac{1}{2}\sqrt{\frac{a^2}{8}} = G$. The distance of the piers being $4.5\,a$, the span of the diagonal groins will be $= \sqrt{2 \times (4.5\,a)^2} = 6.364\,a = S$; we have therefore $\frac{A\,.\,G}{S} = \frac{\frac{a}{32}\sqrt{\frac{a^2}{8}}}{6.364}$ for the strength of the old groin.

The side of the square pier remaining still $= a$ in the new arch, the breadth of the rib $= \sqrt{2\,a^2} - a$, which is the side of an octagon inscribed within the pier, the thickness proper for the rib will be $= \frac{a}{3}$: then will $A = \frac{a^2\sqrt{2} - a^2}{3}$; $G = \frac{a}{6}$; and $S = 5.364\,a + \sqrt{2\,a^2}$; consequently $\frac{A\,.\,G}{S} = \frac{a^2\sqrt{2} - a^2}{122.004}$, the strength of the new rib.

If we assume $a = 4$ feet 8 inches, (the dimensions assigned by Mr Alexander to the piers of the groined vaults at the London dock tobacco warehouses,) the strength of the old groins will be to that of the new ribs as 5.44 to 10.64, which is nearly 2 to 1 in favour of the new construction; and this will be the case while the same proportions are preserved, whatever may be the extent of the arch.

If the side arches, with their spandrils, and the loading on the floor above, be cut by parallel vertical planes, (as at S, Fig. 2,) the sections will be to each other as their chords *c d* nearly; which being less in the new vault than in the old, on account of the greater breadth of the ribs, the weight incumbent on those ribs (which always tends to destroy their equilibrium) is just so much less in the former than in the latter, and consequently their tendency to fracture is diminished in the same proportion. Plate CCLXXXIV. Fig. 2.

It may not be improper to observe, that Dr Hutton recommends the stones of the wall, or spandril over the extrados of the voussoirs of an arch, to be bonded into the stones of the pier, and with one another; because the pier will then carry part of their weight, and thereby oppose a greater power of resistance to the thrust of the arch. For the same reason, it would be equally advisable, in the new method of building groined vaults, to carry up at the same time the diagonal ribs, side arches, and spandrils, well bonding the whole together into one solid mass; which will render vaults built in this manner a valuable acquisition in warehouses and other large buildings, where the greatest weights are to be sustained.

GRONINGEN, a town in Holland, and capital of the province of the same name. It is intersected by the river Hunes, which passes through it in a northerly direction to the sea. The town is large, rich, strong, and populous, and is adorned with many excellent buildings. It is nearly round, and is surrounded with good ramparts, a wall, and ditches, and has a citadel. Its university was founded in 1614, and endowed with the revenues of several monasteries The harbour can contain many vessels, which enter it by a canal about nine miles from the sea. It carries on a considerable trade in butter, horses, and horned cattle. There are some breweries in the town.

GROSE, Francis, a celebrated antiquarian, was born in 1731, and was the son of a jeweller at Richmond, who died in the year 1769, and left his son an independent fortune. He entered into the Surrey militia, and was appointed adjntant and paymaster; and such was his love of dissipation, that he soon squandered away the fortune which his father had accumulated. The distress to which he was now reduced, compelled him to have recourse to his talents; and having a fine taste for drawing, he began to collect materials for his *Views of Antiquities in England and Wales*, a work which he began to publish in numbers in 1773, and which was completed in 1776. Other two volumes, including Guernsey and Jersey, were completed in 1787. The success of this work induced him to embark more deeply as an author. In the summer of 1789, he made a tour through Scotland; and in 1790, he began to publish, in numbers, his *Antiquities of Scotland*, which were completed in two volumes 4to. In the year 1791, Mr Grose set out for Ireland, with the view of collecting materials for an account of the antiquities of that country; but soon after his arrival at Dublin, he was seized with an apoplectic fit, of which he died, on the 6th of May 1791, about the 60th year of his age. Mr Grose was remarkable for his good humour, conviviality, and friendship. He was extremely corpulent, and altogether singular in his external appearance. A likeness of him, at full length, is given in his Olio, published after his death.

The following is a list of his works: 1. The Antiquities of England and Wales, 8 vols. 4to. and 8vo. 2. The Antiquities of Scotland, 2 vols. 4to. and 8vo. 3. The Antiquities of Ireland, 2 vols. 4to. and 8vo. 4. A Treatise on Ancient Armour and Weapons, 4to, 1785. 5. A Classical Dictionary of the Vulgar Tongue, 8 vols. 1785. 6. Military Antiquities; being a History of the English Army from the Conquest to the present time, 2 vols. 4to, 1786, 1788. 7. The History of Dover Castle, by the Rev. William Daniell, 4to, 1786. 8. A Provincial Glossary, with a Collection of local Proverbs and popular Superstitions, 8vo, 1788. 9. Rules for drawing Caricatures, 8vo, 1788. 10. Supplement to the Treatise on Ancient Armour and Weapons, 4to, 1789. 11. A Guide to Health, Beauty, Honour, and Riches; being a collection of humorous Advertisements, pointing out the means to obtain those blessings; with a suitable introductory Preface, 8vo. 12. The Olio; being a Collection of Essays in 8vo, 1793.

GROTIUS, Hugo, one of the most profound and enlightened scholars, and one of the most remarkable men of his age, was born at Delft in the United Netherlands, on the 10th of April 1583. The name in Dutch is *De Groot* or *the Great*; and as it had for many ages been the patronymick of one branch of his ancestors, the circumstances which led to its adoption are unknown. But few families have better merited such a distinction, if greatness be estimated not by external rank and honour, but by those intellectual and moral endowments, which far surpass in value all the gifts of fortune. The family of Grotius had been illustrious at Delft for four centuries, and he himself in the estimation of his own age and of posterity, pre-eminently merited the surname of *Great* among the *great*. He did not descend, however, in the uninterrupted male line from that family; for it is related, that about the year 1430, Dederic De Groot, burgomaster of Delft, and a highly distinguished member of the family, had an only child, a daughter named Eremgard, whom he left a wealthy heiress. This young lady was sought in marriage by Cornelius Cornetz, who sprung from that branch of the noble family of Cornetz, which, under the Dukes of Burgundy, had emigrated from France into Holland. The lady favoured his addresses, but under this stipulation, that should there be any children of the marriage, they should take the name of her and her ancestors, *De Groot*. The first who, in conformity to this agreement, bore her name, was Hugh, grandson of Dederic, and grandfather of the subject of this article. One of the sons of this Hugh was Cornelius De Groot, born in Delft in 1544. After acquiring much learning at his native place, he prosecuted his studies, literary and mathematical, with great ardour at Louvain and Paris. He delighted in the philosophy of Plato. He then applied himself to the civil law at Orleans, and on his return to Delft, betook himself to the bar, and afterwards filled several important offices. In 1575 he was appointed professor of philosophy in the university of Leyden, which dates its origin from about that time, and which has since been so celebrated in the republic of letters. He afterwards taught the civil law in that seminary, and evinced his preference for the quiet pursuits of learning, by refusing a seat in the great council of the States, though that appointment was repeatedly pressed on his acceptance. He died without issue in 1601. Hugh De Groot had another son, John, who also studied law. He was appointed burgomaster of Delft, and afterwards curator of the university of Leyden. He was an elegant scholar and a poet. But his chief claim to the remembrance of posterity is, that he was the father of our Hugo Grotius, to whom it is now proper to direct our attention.

This illustrious man was born, as we already stated, at Delft in 1583. His mother's name was Alide Overschie, and the family to which she belonged was of some note. Endued by nature with admirable talents, he enjoyed from his infancy the advantage of an excellent education. When he was only seven years of age, he was placed under the tuition of masters, with whom he made such extraordinary progress, that before he had completed his ninth year he composed verses which obtained the approbation of the learned. At twelve he was so great a proficient in the knowledge of the classics, and of *belles lettres*, that he was qualified to pursue his studies at the university. He was accordingly sent in 1595 from Delft to Leyden, where he spent three years in the study of mathematics, philosophy, theology, and law, and excelled in the knowledge of each of these sciences. He was only fifteen years old when he wrote a commentary on a very difficult Latin poet, Marcianus Capella. The celebrated statesman, John Barnevelt, attorney-general of the republic of Holland, having been, in 1598, appointed ambassador to France, the young Grotius accompanied him thither. Henry the Fourth, who then reigned in France, gave him most gratifying marks of his esteem. The monarch presented him with a gold chain, and a portrait of himself; and it is said that he was so highly pleased with such attention, that he caused his own portrait to be engraved, adorned with these tokens of royal favour. While he remained in France, he obtained the degree of Doctor of Law at the early age of sixteen.

On his return to Holland, Grotius, in compliance with his father's desire, entered on the profession of law; and at the age of seventeen, he began to plead with distinguished ability and success. He retained his fondness, however, for classical and literary pursuits, and continued to prosecute his general studies with ardour in those intervals of leisure which his laborious profession allowed, and which supplied the place of recreation, chiefly by affording a change of employment. When he was in his 24th year, he was appointed attorney-general of Holland, Zealand, and West Friezland, and filled his high office with such talents and integrity, that the salary attached to it was augmented.

In 1613 he removed to Rotterdam, to engage in the duty of pensionary, or chief magistrate of that city, as successor of the recently deceased Elias Barnevelt, brother of John, his early patron and friend. At this time, religious controversy ran high in the United Provinces between the Calvinists, or Gomarists as they have been called, from Francis Gomar of Bruges, and the Armenians, especially with respect to grace and predestination. Grotius, amidst the heat of the contending parties, conducted himself with such prudence and moderation, as to retain for a considerable time the respect of both. He was also admitted into the assembly of the states of Holland; and as he had written in defence of the right of the Dutch to trade with India, he was sent to England, to adjust the differences which had arisen between the merchants of the two countries. He succeeded in the object of his mission, and received marks of regard from James I. At his return home, he found the United Provinces divided and distracted by quarrels about religion; and while he had the affliction to see that true patriot and able politician John Barnevelt sacrificed to a faction, under the pretence of treason and heresy, to gratify its own ambitious projects, Grotius himself most narrowly escaped sharing his melancholy fate. Barnevelt was tried by twenty-six commissioners deputed from the Seven Provinces, and, in terms of the sentence of this cruel tribunal, was beheaded in 1619. Grotius, who had been warmly attached to him, and who was suspected, by the bigots of the day, of favouring the Armenians, was involved in his disgrace. He was arrested in August 1618, and in May following was condemned to perpetual imprisonment, and to have all his property confiscated. He was strictly confined in the castle of Louvestein, near Gorcum. "Here he remained," says Dumourier, "without any other consolation than the company of his wife, and of books which his friends were permitted to send to him. A large trunk was usually sent filled with books, which he returned after having devoured them, (*apres les avoir devorés,*) and it was during this imprisonment that he translated Stobœus. But his confinement lasted only about two years, as he was happily delivered from it by the address of his wife, Mary Reygelsberg.* She having remarked, that his guards (tired with frequently searching the great chest filled with linen or books, that passed between the prison and Gorcum) allowed it at length to be transmitted without opening it, advised her husband to place himself in it, after having made holes with a wimble in the part of it over his face, to allow him to breathe. He entered into the scheme, and was thus carried to the house of one of his friends at Gorcum, whence he went to Antwerp by the ordinary conveyance, after having passed through the market-place at Gorcum, disguised as a mason with a rule in his hand. His wife, who had so dexterously managed the affair, pretended that her husband was much indisposed, in order to afford time for his escape; but when she supposed him to be in a place of safety, she told the guards that the bird was flown. It was at first intended to prosecute her, with a view of having her confined in her husband's stead; but she was liberated by a majority of votes, and she was universally praised for having restored her husband to freedom. This took place in March 1621." Dumourier *Memoires de Hollande.* Grotius thus happily delivered, secretly left Antwerp in the following month, and repaired to France, where he experienced powerful protection, and was introduced to Louis XIII. who bestowed on him a pension of 3000 livres, which he enjoyed for about ten years. Prince Maurice, the enemy of Barnevelt, and persecutor of Grotius, died in 1625; and it is a circumstance highly honourable to Grotius, that in his History of the Netherlands, from the departure of Philip II. till 1608, which was not published till after the author's death, he relates the splendid achievements of this prince with the utmost fidelity, and without alluding to the harsh treatment which he had suffered from him. The brother of Maurice, Prince Henry Frederic, entertained the most friendly disposition towards Grotius, and would gladly have recalled him, but was deterred by the jealousy of his political opponents, which still existed with unabated force.

Many attempts were in the mean time made, but, happily for the best interests of learning and humanity, without success, to excite prejudice against him in the breast of his powerful protector Louis. That prince was not to be influenced by such unworthy efforts; but, on the contrary, his respect for Grotius increased, by observing the unabated love which the illustrious exile bore towards his ungrateful country. He employed much of his time while in France in reading and composition, and increased the resentment of his enemies who then prevailed in Holland, by his admirable defence of the deposed magistrates.

In 1631, his pension from the French court was withdrawn, whether from motives of public economy, or from ministerial pique, or from what other cause, cannot be ascertained. He soon after ventured to return to Holland, confiding in the friendship of Prince Henry Frederic. But, through the malice of his enemies, he was condemned anew to perpetual exile. Finding himself cruelly compelled to leave his native land, which he still fondly loved, he repaired to Hamburgh, where he received the most gratifying offers of protection from the kings of Denmark, Poland, and Spain, accompanied with solicitations from each, that he would attach himself to his court. He preferred, however, the patronage of Gustavus Adolphus, king of Sweden, whose death, in 1632, obliged him for some time to remain unemployed in Hamburgh. Queen Christina fulfilled the wishes and intentions of her predecessor; and in 1634, appointed Grotius one of her counsellors. She soon after nominated him to be her ambassador at the court of France. This new diplomatic appointment displeased Cardinal Richelieu, then prime minister of Louis XIII. and he used his influence with Oxenstern, the chancellor of Sweden, to have him recalled. Grotius, who had remained in retirement at St Denis till the ulterior pleasure of the Swedish court should be known, made his formal entry into Paris as Swedish ambassador in March 1635. After having spent eleven years in France, he was, in consequence of his own request, recalled, and having occasion to pass through Holland in his way to Sweden, he was received at Amsterdam with every mark of respect and honour; for many of his enemies had retired, or were dead, and several of his friends were restored to offices of public trust. The account which he gave to the Queen of Sweden of the affairs connected with his embassy, pro-

* Dumourier writes her name Reygelsberg, as in the text; but in a marginal note in Bayle's Dictionary, she is called Reygersbergen.

ved highly satisfactory; and anxious as he was to retire from public life, she would have gladly retained him in her councils; but the jealousies of her courtiers inducing him to persist in his desire, she at length consented. She made him, when on the eve of his departure, a present of twelve thousand rix-dollars. Stress of weather driving the vessel in which he embarked for Holland upon the coast of Pomerania, he was put ashore in a bad state of health, intending to finish his journey by land. He was unable to proceed farther than Rostock. Calumnies, with regard to the soundness of the religious principles of Grotius, and the state of his mind at his death, were officiously published by his enemies; but they are satisfactorily confuted by John Questorpius, professor of theology, and minister of Rostock. This learned and pious man wrote a letter, which is still extant, giving a pleasing account of the chearful resignation and Christian piety by which the close of his valuable life was characterized. He expired at Rostock, on the 28th of August 1645, in the 63d year of his age. The remains of this great and good man were embalmed, and removed to Delft, where they were committed to the sepulchre of his ancestors. His wife appears to have survived him. He left three sons and a daughter. The eldest son Cornelius, who wrote elegant Latin verses, was for some time employed by Oxenstern in Sweden. The second, Dederic, was aide-de-camp to Duke Bernard of Weimar, and was assassinated in a tavern by his valet. The youngest, Peter, was appointed by the Elector Palatine to be his resident with the states general; and, by the favour of the De Wits, he was made pensionary of Amsterdam. After having been employed in different political embassies for Holland, he was tried for alleged offences against the state, and was acquitted. He died in retirement at the age of seventy. Cornelia, the daughter of Grotius, was married to M. de Mouthas, who served with eclat in Holland; but being involved in the fall of the De Wits, he quitted that country in 1672.

The multitude of works which Grotius left behind him on various subjects, prove him to have been an universal and profound scholar, and a man of the most indefatigable industry. It is not without astonishment that we contemplate the literary labours of one, whose private misfortunes and public duties might have been supposed to leave him little inclination, and less leisure, for the calm pursuits of philosophy and science. His mind was amply stored with the treasures of ancient and modern learning, and his excellent memory enabled him to retain and employ, as occasion might require, the knowledge which he derived from his books. It is indeed related of him by Borreman, in proof of his wonderful memory, though we must be permitted to doubt the accuracy of the anecdote, that Grotius having been present at the review of a regiment, recollected the name of every individual belonging to it.

It would be tedious to give a catalogue of the works which are known to have proceeded from his pen, most of which were published during the life of the author, as they amount to seventy-four or seventy-five. As his writings, however, exercised a powerful influence, not only over his contemporaries, but have continued, and still continue, to influence the policy of nations, and the opinions of scholars and philosophers throughout the civilized world, we shall mention the names of some of the most remarkable, and add a few occasional reflections on their value. Considering him, then, as an author, we may, for the sake of arrangement, notice some of those compositions which exhibit him respectively as a scholar and poet, a patriot, a philosopher, a philanthropist, and a theologian. It is to be premised, that his works were generally written in the Latin language, which in his time, and for ages after, formed the chief medium of communication among the learned of all the countries of Europe.

In viewing Grotius as a scholar and a poet, we may mention the following works:

1. *Poemata nonnulla, seu Characteris Pontificis Romani*, &c. &c. 4to, 1599.

2. *Marciani, M. F. Capellæ Satyricon, seu de Nuptiis Philologiæ et Mercurii, libri duo emendati et notis illustrati*, 8vo, 1600. This learned publication, from so young an author as Grotius, was among the first things that brought him into notice, and gave a most auspicious promise of his future greatness.

3. *Mirabilium anni* 1600, *quæ Belgas spectant*, &c.; a poem in 4to.

4. *Adamus Exul*, tragœdia, 8vo, 1601. This work was printed when the author was only eighteen, and about seven years before the birth of Milton. Whether or not this tragedy may have suggested the idea of *Paradise Lost*, or how far he, Milton, may have availed himself of it, we have not at present the means of ascertaining But the choice of this subject by two such eminent contemporaries, is an interesting coincidence in the history of literature

5. *Christus patiens*, tragœdia, 8vo, 1608. This tragedy was translated into English by George Sandys, with notes, in 1640. A German writer used it as a model for the illustration of the rules of tragedy; and Curpzovius, Professor of Poetry at Wittemberg, made it the theme of some of his lectures.

6. *Commendatio Annuli*, (a poem) 4to, 1609 7. *Lucani Pharsalia*, cum notis, 4to, 1614. 8. *Exerpta ex Tragœdiis et Comœdiis Græcis*, &c.

In the biographical sketch, we have had occasion to mention the ardent love of country which characterized Grotius, amidst all the sufferings and varieties of his life; and we noticed two of his works relating to his native land, the one of a historical, the other of a commercial nature. The title of the latter of these, and of the answer to it, are curious, and particularly when we consider them in connection with the political events and speculations which have marked the close of the eighteenth, and the opening of the nineteenth century, both on this and the other side of the Atlantic. It is called *Mare Liberum, seu de jure quod Batavis competit, aut Indica commercia*, 8vo, 1609. It was at first printed anonymously, was then translated into Dutch, and passed through many editions. After the lapse of some years it was answered by John Seldon, in a composition entitled *Mare clausum, seu de dominio maris*, Lond. 1635. To this attack, Grotius, in so far as we have been able to discover, made no reply. Grotius published in 4to, A. D. 1610, his work *De Antiquitate Reipublicæ Batavicæ*. Also, a Discourse pronounced in the Senate of Amsterdam, upon the views of the States of Holland respecting the Reformed Religion. In the Dutch language, 4to, 1616.

But it behoves us now to speak of the great work upon which the fame of Grotius chiefly rests, which exhibits him as a citizen of the world, and which forms the beginning of a great era in the history of political philosophy. The work to which we allude was written in France, at the instigation of his friend Peireskius, and printed at Paris, in 4to, in 1625, entitled *De Jure Belli et Pacis*. The President Jean Jacques de Mesmes gave him the use of his country house Balagni, that he might have leisure and retirement for the composition of this work. The author dedicated it to Louis XIII. and he quickly attained by it a splendid height of popularity and fame. It was revised and improved by Grotius, and translated into many languages. Under this title he has attempted to give a complete system of natural law, and to evolve from the mass of precedents and particular statutes, which constituted the chief study of the lawyers of his time, many of those general maxims which should enter into the principles of legislation, and regulate inter-national transactions, as well as to point out their foundation and sanctions in the nature of man, and in the constitution of human society. His work partakes, in some respects, of the prejudices of the age in which it was written, and, particularly, of an overstrained reverence for the institutions of the Roman law. It is also overloaded with quotations and authorities from classical writers, from the Mosaic law, from other parts of scripture, and from various writers sacred and profane, by which the mind of the reader is often perplexed rather than enlightened; and the diffuseness of the notes forms a curious contrast to the brevity and obscurity of the text. Puffendorff, for whom a professorship was formed at Heidelberg, for the express purpose of extending the knowledge of the doctrines of Grotius, is deemed the most eminent of his disciples and commentators. These doctrines have been since taught almost to our own day, in the most celebrated universities of Europe, and, in the opinion of respectable judges, form the foundation of the ethical and political philosophy of the present times. Bayle has justly remarked, that Grotius must be deemed particularly fortunate as an author; and that, fifty years after his death, this work obtained for him an honour, which was not bestowed upon the ancients till after many ages, namely, that he appeared in it *cum commentariis variorum*.

We have space only farther to mention, that, besides several treatises connected with religion and the controversies of the day, Grotius distinguished himself by a popular and a philosophical work in defence of Christianity. The first of these was entitled, Proofs of the True Religion. It was written in Dutch verse, with the benevolent designs of furnishing innocent and useful employment to the minds of his sea-faring countrymen in long and tedious voyages; and of enabling them to maintain their stedfastness in their own faith, and, as opportunities might occur, to explain and recommend it to the foreigners with whom they might have intercourse. The other work to which we have alluded, is the celebrated treatise *De Veritate Religionis Christianæ*, which was published at Paris in 1639, and dedicated to his friend Bignonius. The plan of this work is comprehensive, the style frequently obscure, and the notes unnecessarily copious and minute. Yet, as it was among the first works of the kind which were published, and as it contained much new and excellent argument and illustration, it has been translated into all the European languages, referred to in most works on the same subject, and preserves its estimation as a standard work on theology at the present day. (*l*)

GROTTO, is a subterraneous fissure or opening in the earth, generally adorned by calcareous incrustations, which produce a brilliant effect when illuminated by torches.

Mountainous and volcanic countries, or those regions which are partitioned into many islands, more frequently exhibit grottos, caverns, or fissures, than low or level grounds. They are also common in places subject to earthquakes, and have the greatest extent and intricacy in countries where huge masses of limestone abound.

The most celebrated grotto for beauty, size, and magnificence, is that of ANTIPAROS, an island of the Mediterranean, already described in the previous part of this work; and that which is reputed next to it is of recent discovery in the island of Skye, among the Hebrides of Scotland. It had been long known to the islanders, that the mouth of a cavern called *Slochd Altriman*, or the *Nursling Cave*, opened among the cliffs overhanging the sea on the south-west shore, and that a particular tradition was annexed to its history. But none ventured to explore its recesses, until, in the year 1808, the masculine intrepidity of a lady, Mrs Gillespie, exposed to more timid adventurers what has been called one of the most remarkable phenomena, which exists in the structure of the earth.

Grotto of Antiparos.

Grotto in the island of Skye.

This cave comes under the particular description of a grotto; for, it may be observed, that a cave and a cavern, between which some authors even make a distinction, properly implies a subterraneous vacuity without incrustations. The land above *Slochd Altriman* is of moderate height; but, from the shore consisting entirely of perpendicular rocks, the entrance can be reached on foot only at low water, and then with particular difficulty. When the tide is up, however, a boat can easily approach it, unless the wind should render such an attempt dangerous from sunken rocks, and dislocations of stony masses from the cliffs. The grand access to the cave is formed by two immense walls of free stone, separated thirty feet asunder, rising above 100 feet in perpendicular height, and stretching out in a straight line from the shore. Here the tide flows in about 400 feet; but, at low water, the bottom is rough, and covered with slippery weeds. These obstructions being surmounted, a magnificent rugged arch, of a Gothic form, is presented to the spectator, and on one side an inferior cave with many lateral crevices. This great aperture is embellished with innumerable dark green stalactites of various sizes; some descending to the ground, and forming pillars overgrown with moss, which, with the intermixture of vivid foliage, brown heath, and wild flowers, produces an interesting combination. Close to the entrance of this grotto, there is, as it were cut out of the stone, a small fountain of pure water, surrounded by rocky pillars, and the water collected in the cistern is derived from the exudation of the rock above. A passage about nine feet broad, and from fifteen to twenty in height, conducts the visitor almost on a perfect level for twenty yards, when a steep ascent for 55 feet leads up a bank of earth, sand, and small broken whinstone, another acclivity now commences, more difficult to overcome, of irregular surface, resembling a solid cascade, or frozen snow, and sparkling with crystallizations. Advancing a few yards, the principal entrance to the interior grotto is gained, eight feet broad, and twelve in height, universally white as marble, and variously decorated with beautiful incrustations. Thousands of icicles of pure white spar are suspended from the roof like the festoons of a curtain, giving the whole a finished appearance. The breadth, on proceeding still farther, enlarges to ten feet, and the height to forty, while the white marble spar continues rough and uneven; and it is only after traversing thirty-five feet of this gallery, that the proper excavation, which has been denominated the *Spar Cave*, is reached. It consists of a circular vacuity about twenty feet in diameter, with a lofty roof, and a pool at the bottom, contained in a marble cistern. But the whole is said to exhibit the most brilliant spectacle which imagination can conceive. The sparry concretions are innumerable, and in every variety of form; while the lights, by which the specta-

Grotto in the island of Skye.

tor examines them, are reflected from a thousand glittering points. Many of the surrounding objects, formed by the calcareous depositions, are compared to animate and inanimate substances of various descriptions. To the right is the resemblance of a monk, as if kneeling on a cushion, with uplifted hands, and large as life. Behind it appear several semblances of busts; and at a distance are seen the images of various animals, together with an exact representation of a fleece. But among the whole, the monk excites the greatest attention. The head is bare, after the monastic fashion; the face is supposed to be distinct; the shoulders are in just proportion; and the drapery of the robe enveloping the body is alike beautiful and correct. Figures of vegetables are every where formed; and numerous columns, some apparently supported by distorted beings, seem to sustain the roof, which resembles a pure white cloud suspended in the air. Portions of it, however, descend in stalactites; which, together with the crystals in the interstices of the columns, emit fine coruscations from the lights below.

Another rugged declivity, similar to that which conducted the spectator to the cave, leads down to the pool, which is sixty-five feet in circuit, five feet deep, and of cooler temperature than the external atmosphere. It resembles a large marble bath of pellucid water, the bottom and sides being of the purest white. It occupies so much of the base of the grotto, that a person cannot walk round it. On its margin the spectator finds himself standing in a magnificent apartment, wholly consisting of the most brilliant spar glittering on all sides, and emitting myriads of rays, which are reflected from the bottom of the pool. In some grottos and caverns of other countries, there is a constant supply of water, which is generally discharged by a stream running towards the entrance; but here there is no visible outlet, and the quantity of water in this reservoir is not observed to decrease. Crossing the pool on a plank, a gallery of great height, but only three feet wide, is found, which leads to farther passages imperfectly explored. Its entrance is formed by two large columns of pure spar; that on the left of rustic conformation, six feet in circumference, and sixteen high; but that on the right rather resembles a work of art. It is of more surprising structure, and more elegant appearance, than any of the figures which the spar of this grotto has assumed. The shaft is twenty feet in length, nearly cylindrical, and its thickness in general about two feet and a half. It stands on a regular circular base rising from the floor, and projecting about twelve inches round its circumference. A series of sections seems to constitute the whole column, each twenty-two inches in length, and divisible into two distinct portions; the upper one being a crystallized mass of stalactites, while, in its general aspect, the under part resembles the foliated carvings of the Corinthian or Composite capital inverted. On more minute inspection, this division is found to display the most methodical arrangement of structure, in the formation and insertion of the foliage of sparry concretion; and the interstices of the leaves are of such dimensions, as to admit of complete inspection of the interior of the column, which proves a combination of the same foliated incrustations as the exterior. Passing by these pillars, the width of the gallery is somewhat enlarged, the sides still exposing elegant and numberless crystals, emitting a dazzling lustre. The floor also is of white marble, but of more singular conformation than in any other part of the cavity. Part of it rising from the rest resembles a piece of lace, and consists of many concretions on one side, while the other is quite smooth, and entirely covered with shining crystallizations, the waved interstices of which are full of water. These beautiful productions abruptly cease at the distance of about 250 feet from the mouth of the cave, and the bare black rock is exposed. Although farther recesses exist, they have not yet been explored.

Several singularities regarding this remarkable grotto being peculiarly interesting, ought not to be overlooked. Its formation is concluded to have resulted from the separation of immense dykes of whinstone, while freestone constitutes both the floor and the roof. Although no considerable stratum of limestone is seen in the neighbourhood, there is a prodigious accumulation of spar entirely calcareous within. The crystallizations are of the most complete kind, free from every imperfection, and white and beautiful. Water is constantly exuding from the whole roof; and it is likewise universally suffused over the incrusted surface of the spar, which is always moist to the touch. But this humidity augments the brilliancy of the coruscations, and is the source of the water contained in the marble cistern. The endless variety in which the sparry incrustations appear, is one of the greatest ornaments of the grotto; and the infinite combinations and modifications of it are alike brilliant and interesting. Sometimes it is disposed in foliage or flowers; sometimes in busts or columns; and the interior, of tubulated stalactites, is studded with innumerable crystals converging towards the centre. It may seem idle to speak of traditions of the ninth century, but we shall only observe in illustration of the name *Slochd Altriman* or the *Nursling Cave*, that it is said to have afforded refuge to a youthful female, who had become the victim of a feud which estranged the parents of her and her lover, the young chief of Colonsay. Separated from him, she was delivered of a son, who was carried to *Slochd Altriman*, whither his mother retired to nurse his infancy; and thence the name of Nursling Cave.

Penpark Hole.

On the 17th of March 1775, the Rev. Mr Newnham, a young clergyman of Bristol cathedral, accompanied by a gentleman and two ladies, went to visit a chasm in the ground called Penpark Hole, about three miles from that city. Wishing to sound its depth with a line, he advanced a short way into the upper part of the opening declivity, which is not steep, in order to give it a freer cast, and, for greater security, held by the twig of a tree, spreading across the chasm. Unhappily, in accomplishing this, his feet slipped, owing to the humidity of the earth, and he was precipitated headlong into a frightful abyss, before the eyes of his terrified companions. An accident so distressing, gave birth to many speculations respecting the caverns where it had happened, particularly as the body of the sufferer was long the object of a fruitless search; but at last some hardy adventurers having resolved on descending, discovered a great accumulation of water at the bottom, and a stone thrown down being interrupted in its fall, disclosed the spot where the body still floated, 39 days after the catastrophe. It is difficult to explain the figure of this, or indeed of any other cavern, without drawings; therefore we shall briefly observe, that the access to Penpark Hole is by two separate chasms in the ground, leading by a declivity to the interior. After passing different lateral vacuities, one of which has a spacious vaulted roof, the adventurer reaches the most extensive recess, branching into an oblong irregular space, 225 feet long, by 123 in width. Below it are other recesses, and the bottom of the whole, which, if we rightly understand the description, is more than 200 feet from the surface of the earth, is covered with water, varying in depth from 6 to 50 feet, but clear, and good, and free from any peculiarities. All the cavities are of extremely irregular formation, in general presenting a rocky surface, or sparry incrustations, and the floor is described as in some places to consist of "a kind of white stone, enamelled with lead ore." The subterraneous communication between the external mouths is extremely narrow, and was first explored by Mr White, a land-surveyor, who, with much hazard and difficulty, forced his way through, by crawling on his belly. But even now, should a stone be displaced in the undertaking, the adventurer would inevitably be buried alive. Penpark Hole was visited in 1669 by Captain Sturmey, and in 1682 by Captain Collins. The former was accompanied by a miner, who, penetrating one of the galleries to a considerable distance, exclaimed that he had found a rich mine; but his joy was suddenly converted to astonishment, for he returned affrighted by the sight, as he said, of an evil spirit. No inducement could prevail on him to revisit the place, and Captain Sturmey himself sickened four days after and died. In consequence of the accident above related, it was more particularly examined by several individuals; but more minutely by Mr Catcott and Mr White, the latter of whom has drawn a section of it.

Derbyshire caverns.

Great Britain abounds with caverns, and especially the county of Derby. Here there are no less than 28 of some celebrity, and some of lesser note. Several have already been alluded to in our notice of that county, as that stupendous recess now converted from a rude and coarse appellation, to the Devil's Cave, or Peak Cavern, Elden Hole, and Poole's Hole, whence we shall restrict our observations to an abstract of Sir Richard Sullivan's adventure in the Three Mile Cavern.

Three Mile cavern.

This is an immense vacuity that has partly been effected by art, and which receives its name from its supposed extent. The descent is accomplished with much difficulty for 420 feet, and introduces the spectator to two or three lofty caverns, beautifully enamelled with spar. "Penetrating still farther," Sir Richard says, "we forced our way with infinite struggles, through a narrow space between two rocks, and thence getting on our hands and knees, were, for the full distance of a mile, obliged to crawl without ever daring to lift up our heads, the passage being both low and craggy; and as it was likewise filled with mud, dirt, and a multitude of bits of rock, our progress was painful indeed; we still, however, hoped for something better. On we accordingly proceeded, till a dreadful noise rumbling along the horrible crevices of the cave, gave us to understand we were near a river. To this then we hurried; but description is inadequate to any thing like a representation of the scene; a vast ocean seemed roaring in upon us; in some places bursting with inconceivable impetuosity; and at others falling through dreadful chasms, burst into shaggy forms to give it vent." It appears that this subterraneous stream is deep, and has a long course; but whether it is absorbed in the earth, or finds a passage to the surface, is not explained. After having underwent many dangers and difficulties, not unattended with personal injury, the author concludes his narrative in these words: "Altogether the depth we had descended was about 140 fathoms, or 980 feet, and the length about three miles, according to the miners calculation. Neither at this distance were we at the end; a passage still continued; but so filled with water, and so full of peril, that the miners themselves were averse to further trial." Possibly the number and size of British grottos and caverns, exceed those within the same bounds of any other country with which we are acquainted; nor are we aware that any spacious recess, (with the exception of the cave in Kentucky,) opening directly from the earth, has been penetrated 2250 feet, as the Devil's Cave of Derbyshire.

Madison's cave.

In the limestone country of Virginia in North America, are several caverns of some extent, among which the most celebrated is Madison's cave on the north side of the Blue Ridge. Its entrance is about two-thirds high in a moderately elevated hill, into which it extends about 300 feet, branching out into subordinate caverns, sometimes ascending a little, but more generally descending, and at length terminates at different places in two basons of water of unknown dimensions, that are never turbid. The vault of this cave is of solid limestone, from 20 to 40 or 50 feet high, through which water perpetually percolates; and trickling down its sides, has incrusted them with elegant drapery, or dripping from the top, generates conical stalactites both above and below.

Great cavern in Kentucky.

Another cave, about 8 or 9 miles long, and with many branches, has lately been discovered in Kentucky. It is covered with stalactites; and a very remarkable mummy was found within it at a considerable distance from its mouth. See KENTUCKY, where we propose to give a full account of this interesting cavern.

Grottos in India.

Besides those curious excavations on the western coast of the Indian peninsula, some interesting caverns occur in that great range of mountains, which, traversing Cochin China, penetrates the neighbouring countries. The inhabitants retreat thither, or conceal their effects in them during the time of war, and they are also kept concealed to avoid the expensive visits of the great men of the country. A naturalist, the late historian of these regions affirms, would here find ample scope for observation: the caverns are full of petrifactions and crystallizations of various colours: immense halls are formed, wherein may be seen the resemblance of altars or thrones; and quantities of fruits appear ready to drop from their trees. One most remarkable grotto traverses a mountain throughout: its entrance and its exit being terminated by two fertile plains. The bottom is covered with water, which may be navigated by vessels; and the roof, which is very lofty in some places, decreases elsewhere to 8 or 10 feet. There is another in the same chain of mountains of vast extent, but abounding in deleterious exhalations; and the water of a canal covering its bottom, is dangerous to be drank. No one has hitherto ventured to explore its most distant extremities.

Grottos in Italy.

In various parts of Italy, we find several famous grottos, though less celebrated for their extent than from some other peculiarities; and although known by the name of grottos, no crystallizations are seen in some of them. In Naples there is a spacious cavity, called *Grotto dei Funaioli*, or the Rope Makers Grotto, because its entrance has long been devoted to this useful purpose. The roof exhibits a rent, said to be the effects of lightning, and in other respects presents a menacing but imposing aspect, though the inhabitants carry on their operations in the most perfect confidence.

The grotto of Pausilippo near Naples, is a great excavation, partly artificial, penetrating the mountain of that name 2316 feet. It is 89 feet high in the most lofty part, 24 where lowest, and about 22 in breadth, traversing volcanic tufa. The date of its formation is

Grouse || Guadalaxara.

unknown; but in modern times, Don John of Arragon, Viceroy of Naples, and Peter of Toledo, under Charles V. brought it to its present state, and now it serves for an ordinary, though disagreeable road from the city, with a glimmering light from two apertures above.

Grotto del Cane.

In the side of a hill, beside the lake Agnano, in Italy, there is an artificial excavation, unskilfully executed, called the *Grotto del Cane.* It is of limited dimensions, being only twelve feet deep, four broad, and nine in height at the entrance, but always decreasing as it recedes. The celebrity of this grotto, which has long been known, is owing to pestilential exhalations arising from the earth; and it receives its name from the animal which is usually selected to demonstrate their presence. If a dog be brought within the sphere of the deleterious vapour, which remains within eighteen inches of the surface, its respiration immediately becomes affected—the abdomen contracts—the eyes are fixed—and the tongue, now of a livid hue, hangs out during the first minute, while, in the next, the animal is totally deprived of motion. Death would inevitably follow, but, on being speedily withdrawn, the lungs resume their play, and the creature gradually recovers its wonted strength and vigour; nevertheless a severe shock is sustained, as the same dog cannot support the experiment above twelve or fifteen times without destruction; in which event it dies in convulsions. The Abbe Nollet, on stooping to inhale the vapour, felt as if he had swallowed boiling water on the first inspiration, yet producing no painful sensations. On lowering his face, a kind of suffocation was experienced; and probably, had the experiment been continued longer, dangerous consequences would have ensued. The vapour is whitish, and possesses some degree of heat: It never rises above eighteen inches from the earth; and a torch immersed in it is extinguished, while the black smoke rolls over its surface without penetrating deeper. See Macleay, *Description of the Spar. Cave in Skye.* Catcott, *Account of a Descent into Penpark Hole.* Lloyd's *Account of Elden Hole,* Phil. Trans. vol. lxi. Leigh's *History of Lancashire.* Pilkington's *View of Derbyshire.* Farey's *Survey of Derbyshire.* Rudder's *History of Gloucestershire.* Hamilton, *Campi Phlagrei. Voyage Pittoresque d'Italie,* tom. ii. *Decouvertes des Savans Voyageurs,* tom. i. p. 133. (c)

GROUSE. See Ornithology *Index.*

GRUYERES, is the name of a small town of Switzerland, in the canton of Friburg. It is situated at the foot of the mountains of this canton. The territory of Gruyeres, is 8 or 10 leagues long and 4 broad; and it is principally celebrated for the excellence of its cheese, which is esteemed the best in Switzerland. The best is made in the pastures of Molesson, and in the mountains of the vallies of Bellegarde and Charmey. It sells at 2½ louis per quintal; and the merchants of the country sell it at 6 batz, or 18 French sous per pound. There are large magazines of this cheese at Bulle, a town about a league from Gruyeres. The view from the summit of the Mollesson, which is near the town, is very grand. It may be ascended in three or four hours.

GRYLLUS. See Entomology.

GUADALAXARA, an intendancy of New Spain, and part of the kingdom of New Gallicia, is situated between 19° and 23° North Latitude. Its greatest breadth, from the port of San Blas to the town of Lagos, is 100 leagues; and its greatest length from south to north 118 leagues. It is traversed from east to west by the Rio de Santiago, a considerable river, which communicates with the lake of Chapala. It contains two cities, six villas, and 322 villages. The principal city Guadalaxara, the residence of the intendant, the bishop, and the high court of justice, is situated on the left bank of the Rio de Santiago, and contains about 20,000 inhabitants. San Blas, a sea port, and the residence of the marine department, is situated at the mouth of the Santiago, and is a very unhealthy place. The eastern part of the province is the Table Land, and western declivity of the Cordilleras of Anahuac. The maritime district, especially towards the great bay of Bayonne, is covered with forests, and supplies excellent timber for ship-building. The interior of the country enjoys a temperate and salubrious climate. The Volcan de Colima, in the northern extremity of the province, is the most western of the volcanoes of New Spain, which are placed in one parallel on the same line. It is estimated to be 10,000 feet in height, but is rarely covered with snow. The lake of Chapala, in the vicinity of Guadalaxara, is nearly 160 square leagues in extent. The superficial extent of the province is 9612 square leagues; and the population in 1803 was 630,500, which gives 66 inhabitants to the square league. The value of its agricultural preduce in 1802, consisting in maize, wheat, cochineal, &c. amounted to £ 568,531 sterling; and the value of its manufacturing industry, composed chiefly of woollen and cotton stuffs, tanned hides, and soap, was estimated at £ 722,351. The revenues of the bishop are 90,000 double piastres. This province abounds in silver mines, and affords excellent pastures. On the coast, in 21° 28′ North Latitude, are the three Marias islands, the most northern of which is about 13 miles in length, and 9 in breadth, surrounded by white rocky cliffs; and another, about 24 miles in circuit, separated from the last by a strait six miles broad, and which Dampean called Prince George's island, abounds in vegetable productions, but is deficient in fresh water. See Humboldt's *Political Essay on the Kingdom of New Spain,* vol. ii. and *Mod. Univ. Hist.* vol. xxxix. (q)

Guadaloupe.

GUADALOUPE, the largest and one of the most valuable of the Caribbee islands, lies between Antigua and Martinique. Its length is between 60 and 70 British miles, and its greatest breadth about 25. The middle of the island is situated in about 16° 20′ North Latitude, and 62° West Longitude. Guadaloupe has somewhat of the form of a crescent, and may be considered rather as consisting of two islands than of one; for it is divided into two parts by a narrow strait called Salt River. For a short distance on each side of this strait, the breadth of the island is not more than four miles. By this remarkable channel, the sea on the north-west communicates with the sea on the south-east. Its breadth varies from about thirty to eighty yards; and it is navigable for vessels not exceeding fifty tons burden. The north-west of the island is divided into Basseterre and Cabesterre; the eastern division of it is named Grandeterre. That portion of the island from which the whole takes its name, is, towards the middle, full of high and rugged rocks, where the climate is so cold, and the soil so barren, that little vegetation is to be seen. Over the summit of these rocks, the mountain called La Souffriere, or the brimstone mountain, rises to a great height. This mountain of sulphur continually sends forth, through various apertures, a thick black smoke, frequently mingled with sparks of fire. It is of a singular form, being divided into two parts by a remarkable channel, navigable by boats. There are many marks of volcanoes in other parts of the island. On a part of the western shore, the sea is so hot at a small distance from the beach, as to boil eggs; and the sand on being stirred, emits a

Description

strong sulphureous odour. The island contains a boiling fountain, and a hot marsh, which is very deceitful, and dangerous to strangers. The islands, of which Guadaloupe is the chief, were discovered by Columbus in his second voyage, when he visited Dominica, Guadaloupe, and Antigua. But they were at that time neglected by the Spaniards in their eager lust of dominion and gold on the larger islands, and on the American continent, the unexplored treasures of which were then opening to their ambition.

History.

No European nation had taken possession of Guadaloupe, when an expedition of five or six hundred Frenchmen, under two adventurous leaders, arrived from Dieppe in June 1635. The new settlers soon commenced a war with the native Caribs, for the purpose of supplying themselves with provisions, of which their own exertions could not yet produce a sufficient quantity for their subsistence. Many of these poor, simple and undisciplined people, unable to maintain a regular struggle with their more skilful invaders, retired to some of the other islands. Others of them concealed themselves in the natural strongholds and recesses of their own, and having previously destroyed their plantations and stores, their superior knowledge of the country enabled them to sally out unexpectedly, and to inflict vengeance on such straggling parties of their oppressors as fell in their way. After a struggle, which was kept up with various success, and which at length produced a terrible famine, a peace was patched up between the contending parties in 1640; and the remnant of Europeans, who had escaped the calamities which they had drawn on themselves, were joined by some discontented sailors and colonists from St Christophers. The superior advantages of Martinique as a sea-port, induced many adventurers to leave Guadaloupe, and pass over to that island; and from this time the French administration bestowed for some years almost exclusive attention on the latter, which became the seat of government of the French islands. For the first sixty years of its occupation by the French, Guadaloupe made little progress; but in the course of the ensuing fifty-five, its improvement was as rapid as it had formerly been slow. In April 1759, the island was conquered by the English. In July 1763, it was restored to its former owners in a highly improved condition. The French government now began to see the value of this settlement, and an independent government was given to it. The island was taken by the British in April 1794, but was retaken by the French under Victor Hughes in February 1795.

Early in 1810, an English expedition, the naval part of which was conducted by vice-admiral Sir A. Cochrane, and the military force by lieutenant-general Sir G. Beckwith, prepared with the design of attacking Guadaloupe and St Eustatius, was ready to commence operations. It was completely successful; and thus the enemy were deprived of the last of their possessions in the Columbian islands.

Guadaloupe continued under the power of the British crown till 1813, when in a treaty dated March 3d, between his Britannic Majesty and the King of Sweden, it is agreed, that this valuable colony should be ceded to the latter, in consideration of an engagement on his part to furnish a force of 30,000 men, in aid of the allied powers against France. Swedish commissioners were accordingly sent, to make arrangements for taking possession of the island; but in consequence of certain political causes not yet fully explained, it was restored to its old possessors the French, at the restoration of Louis XVIII. in terms of the general treaty of peace, signed May 30th 1814. On the return of Bonaparte from Elba in 1815, General Boyer, the governor, hoisted the three-coloured flag. After the second restoration of the Bourbons, he was condemned to death, but the sentence has been commuted into twenty years imprisonment. The sum of one million sterling was the compensation given to Sweden, for our non-fulfilment of the stipulation by which it was to be delivered into her hands. The general astonishment and indignation of the people of Great Britain and Ireland, on finding, that by one of the articles in the treaty with Louis, the slave trade was to be permitted to be carried on by the French for five years, in this island and Martinique, which British generosity had restored, are not easily described. Petitions poured in upon both Houses of Parliament, and addresses to the Prince Regent from every part of the united kingdom. In consequence of these petitions, Lord Castlereagh, the British negociator, was employing all his influence and skill in order to undo what he had done, and to induce the government of Louis to receive these islands under the express condition, that the odious traffic should instantly be definitively and for ever abolished by France. The consideration of this subject was taken up by the congress assembled at Vienna. But there appeared every reason to believe, that our benevolent endeavours would have failed of success, when the irruption of the exiled usurper into France once more transferred this island to the sovereignty of Napoleon Bonaparte. By a stroke of policy, intended at once to show his power, and to conciliate the people of England, he issued a decree as soon as he felt himself replaced on his trembling throne, by which he declared the slave trade to be abolished in the French islands. In doing so indeed, he made no kind of allusion as to the immorality and wickedness of the traffic with Africa. Besides, he knew that while the war should continue, and England ride triumphant on the sea, he could carry on little foreign trade of any kind, and that these islands would probably fall speedily into our hands; so that the sacrifice he appeared to make of interest to duty, was in fact only a nominal one, and as his decree was expressed just as coldly as if he had been prohibiting the importation of flax or grain, he could easily, he well knew, and without any appearance of gross inconsistency, by another of his imperial decrees, restore the trade, on the ground of alleged expediency, whenever he might be able to derive any advantage from the renewal. This decree of Bonaparte, however, though no one could be deceived as to its motive, had a happy effect on the great cause; for when Louis was a second time restored to his throne in summer 1815, and when these islands, once more in the power of England, were to be delivered up to France, the example of Bonaparte himself could be quoted, to shame the new government into accordance with our wishes. Indeed England had now the means and the right to enforce compliance with her request. Accordingly Louis, soon after his return, by a royal decree, declared the French slave trade to be definitively and absolutely abolished.

Commerce.

The unsettled state of this island, may probably have prevented any very accurate estimate either of its trade or population since the French revolution. In the year 1700, the population amounted only to about 382 indigenous inhabitants or Caribs; 325 free negroes; and 6725 slaves.

In 1755, there were

Whites	9643
Slaves	41,140
Sugar houses	334

Guadaloupe || Guam.

Banana trees	2,028,520
Ditches of manioc	32,577,950
Horses	4946
Mules	2924
Asses	125
Beeves	13,916
Sheep and goats	11,162
Swine	2444

In 1767, France received from Guadaloupe,

Fine sugar	140,418 quintals.
Raw sugar	23,603
Coffee	34,205
Cotton	11,955
Cacao	456
Ginger	1884
Campeachy wood	2529
Confections	24 boxes.
Liqueurs	165 boxes.
Potassia	34 casks.
Skins	1202 No.

These articles were sold in the colony for 7,103,838 livres, while the articles imported from France cost 4,523,884 livres, leaving a balance in favour of the colony of 2,579,954 livres.

In 1767, Guadaloupe contained

Whites	12,700
Blacks, or free Negroes	1350
Slaves	100,000
Horses and mules	9220
Horned cattle	15,740
Sheep, swine, and goats,	25,400

It possessed at the same time,

Feet of cacao	449,622
Feet of cotton	11,974,046
Feet of coffee	18,799,680
Sugar houses	388

In the year 1775, eighty-one vessels returned to France loaded with the following produce:

		Value in Europe.
Raw sugar	188,384 quintals.	7,137,930 livres.
Coffee	63,029	2,993,860
Indigo	1438	1,222,529
Cacao	1023	71,651
Cotton	5193	1,298,437
Skins	727	6973

and some other articles of minor importance.

The value of the imports and exports, was in

	Imports.	Exports.
1767	livres 4,523,884	7,103,838
1788	5,362,000	15,053,000

Several of the productions of Guadaloupe were formerly sent to Martinique; and America received some of its liqueurs, and other commodities, and sent in return, wood, cattle, flour, and cod fish.

In 1789, the population of all descriptions was about 104,000. The island is well stored with horned cattle, sheep, horses, &c. and produces a vast abundance of sugar, coffee, rum, ginger, cocoa, logwood, &c.

GUIACUM. See Chemistry, vol. vi. p. 124, Sect. xxiv.

GUAM, or Guahon as it is called by the natives, is an island in the eastern seas, forming one of the group denominated Ladrones, or Marianne islands. According to the computation of the Spaniards, it is about 120 miles in circuit, apparently flat and even from a distance, but the east coast, on nearer approach, is found to be high and shelving, fenced with steep rocks which oppose the perpetual beating of the sea. Here there is no anchorage; but the west side is divided into small low and sandy bays, one of which, called Umata, constitutes a good harbour for a few vessels, and is defended by a battery of twenty guns. The surface of the island gradually rises from the shore to nearly the middle. The rocks are chiefly granitic; and the centre of the pebbles, found on the beach, contains various coloured crystals. Several vallies are interposed between the shore and the inland parts, where vegetation becomes profuse. They appear to have been the bed of so many currents; and their soil consists of sandy earth, mixed with decaying madrepores, from which the sea seems to have withdrawn. The interior, however, is of extreme fertility, abounding with all that can be desired for the use of man. Numerous fountains spring from the rocks, and in their course form transparent pools, shaded by trees, always preserving an agreeable freshness amidst the heats of the climate. But there are no rivers of importance; the other waters being either torrents from among the hills, or inlets of the sea.

Productions.

No portion of the globe is more copiously supplied with vegetables than Guam; and here our celebrated circumnavigator Dampier first discovered the bread-fruit, an invaluable plant, which affords subsistence to so many thousand islanders of the South Pacific Ocean. The forests are full of guavas, bananas, cocoas, oranges, and limes. Capers are produced in abundance from a shrub, indigenous to the soil, of beautiful appearance, flourishing throughout the year, and exhaling a delightful odour. From hence it has been transplanted to the Philippine islands. Two species of banana are thought peculiar to Guam; one of dwarfish size, only three feet in height, but producing a fruit so much superior to all the rest, that its cultivation has been recommended in the European tropical colonies; the other is the wild banana, a large tree, the fruit of which is not eatable. Of the cocoa tree there are three kinds: *first*, the common species, disseminated throughout India, bearing a nut, which is a great article of subsistence; *secondly*, a middle-sized tree, which is lower, the nut having a tender shell and a kernel tasting like an artichoke bottom; *thirdly*, the black cocoa tree, rising at most to eight or ten feet in height, with a nut perfectly round, about three inches in diameter, and very delicate. This last affords oil more abundantly than the others, as also coir for cordage, and the leaves of all the three are equally suitable for thatching huts, and making mats.

Animals.

Fish is plentiful on the shores of the island, though frequently of a poisonous quality, originating, it has been conjectured, either from their feeding on the polypi of madrepores and coral, or other marine animals. It is affirmed, that the very taste of the coral is imparted to them. Turtle are large and numerous; besides which the streams of Guam afford abundance of aquatic tribes peculiar to themselves. But the facility with which subsistence of a different description is obtained, renders that which may be derived from the waters quite of secondary consideration, and it is little sought after.

It has never been explained, what are the birds and quadrupeds which are indigenous to the island. A few cattle, that were carried thither long ago, have multiplied exceedingly, and run wild in the uninhabited districts. They are large, and well fed, and exhibit one remarkable feature common to those resuming their original state, in almost all being white, with black ears. It is known, that in Great Britain the few which remain unmixed from distant ages, and have preserved their pristine ferocity, retain along with it the same peculiarity, which is of much interest to the zoologist. Some years ago, the Spaniards transported a large spe-

Guam. cies of deer from the Philippines to Guam, which undergoes so great a change along with the season as scarcely to be recognizable as the same animal. From December to May, its winter coat is long, thick, and of a grey colour; but from the month of May, the hair is brown, or almost yellow, smooth, and shining, having three black streaks on the back, interspersed with white. It multiplies in the woods, which are also well stocked with wild hogs.

Native inhabitants. Dampier describes the natives of this island as "strong bodied, large limbed, and well shaped. They are copper coloured like other Indians; their hair is black and long; their eyes meanly proportioned; they have pretty high noses; their lips are pretty full; and their teeth indifferent white. They are long visaged, and stern of countenance; yet we found them to be affable and courteous." These people have a great tendency to corpulency, and are very subject to leprosy, or a kind of cutaneous disease, especially in the wet season, or between June and October. They are particularly characterized by mildness and hospitality, which have enabled their invaders to make deeper encroachments on their liberty, than if they had displayed a more repulsive disposition. They are indolent, prone to intoxication, and fond of music, dancing, and cock-fighting. The Spaniards have rendered them acquainted with agriculture; and, to facilitate their labours, they tame the wild cattle, which are trained to carry loads throughout the island. Several are kept for this purpose by most families, becoming perfectly tractable, and as quiet as horses. They are guided by a halter penetrating the septum of the nose, to which they grow accustomed in a fortnight. No part of the industry of the natives of Guam appears to have existed anterior to their conquest; they have either been explicitly taught, or acquired what they practise from example. Some of the mechanical arts are practised by them in carpentry, smith work, brick-making; and they fabricate cloth, cordage, and even cables, for the Acapulco galleons from the wild banana, which are reputed of superior strength to those manufactured of the best European

Canoes. hemp. But there is one branch of the arts in which they have remained stationary since the discovery of their island, namely, the construction of their canoes; and this has arisen less from want of skill to make the alteration, than from their having already adopted the best possible form of which their local situation admitted. Celebrated navigators have repeatedly expressed their admiration of these vessels, which are equally calculated to keep the sea, and to take advantage of the prevalent winds. Some of their canoes are forty feet long, hollowed out of the trunk of a single tree, and very narrow. A piece two inches deep is sewed on as a washing board to raise it higher; "but, what is very singular, one side of the boat is made perpendicular like a wall, while the other side is round, and made just as other vessels are with a pretty full belly." The ends are sharp; each serves for a prow; and the neighbouring islands frequented by the natives lying chiefly north and south, and the wind being almost constantly east, the rounded side is found on the lee. But there is, besides, an outrigger projecting from the side, necessary to steady so narrow a vessel, and at the extremity is a log of wood, in shape resembling another canoe, though much smaller. A single mast stands in the middle, with a triangular sail, which, when taken in, is rolled around a yard at the bottom. No canoes are better adapted for sailing. A French navigator assures us, that, with a fair wind, they go at the rate of nine miles an hour, a distance said to be augmented to fifteen under the most favourable circumstances. Dampier observes, "I did here, for my own satisfaction, try the swiftness of one of them. Sailing by our log, we had 12 knots on our reel, and she run it all out before the half minute glass was half out, which, if it had been no more, is after the rate of 12 miles an hour; but I do believe she would have run 24 miles an hour." He was told of one of them having been sent express to Manilla, and performing the voyage, which is about 400 leagues, in the space of four days. However it is understood, that, although the best sailers known, the canoes of Guam are not safe at sea; but should an accident happen, the natives are so expert at swimming, they are capable of repairing it in the water. The companions of M. Marion observe, that "the form of these embarcations is such, as would do honour to a shipbuilder among people who have made the greatest progress in the knowledge of navigation. This form has been imitated from no model, because it differs from all those which men inhabiting different parts of the world have given to their vessels."

The inhabitants of Guam are dispersed in twenty-one native establishments, chiefly on the coast, and the town of Agana, situated about twelve miles north-east of the harbour. All the Indian families are agricultural, and each has a small portion of land subdivided into fields or gardens; but the interior of the island is still in a state of nature, covered with thick woods, affording excellent timber for the construction of houses or vessels. The town stands on the shore, at the base of some hills of moderate elevation, in a fine district full of springs, and watered by a small rivulet. Its streets are laid out in a straight line; and the houses, built for the most part of wood, stand on posts about three feet above the ground, and are roofed with tiles or palm leaves. But all the public edifices are constructed of brick. There is a fine church here decorated after the Spanish fashion; and two or three convents or colleges occupied by monks, one of which was established for the education of Indians. The religious establishment of Guam was formerly vested in the Jesuits, who, on the suppression of their order, were supplanted by the Augustines; and besides Agana, there are two or three other cures in different parts of the island. The government house is spacious. There is a royal magazine tolerably well stored, and barracks for 500 men. This being the only Spanish colony in the Ladrones, was preserved with considerable care; however, its chief and most important improvements were derived from the governor Tobias, who was at its head about forty years ago. He taught the natives the proper means of cultivating the land; he planted rice, maize, indigo, sugar canes, and cotton, all of which succeeded admirably, and the maize in particular produced an incredible return. To give them a proper example, this paternal governor formed gardens and plantations, where all necessary vegetables were cultivated, along with the most delicious fruits. He established a kind of cotton manufacture, and caused salt pits to be dug. Further, he instituted a school for the gratuitous education of the native children of both sexes, where they were instructed in reading, writing, and arithmetic, as also vocal and instrumental music; whence strangers have been agreeably surprized, in finding practised musicians assisting the celebration of divine worship in a place so remote from the civilized world. Finding it necessary to provide the island with a sufficient force to protect itself, he formed a militia of 200 Indians, among whom were four Spanish captains, while the remainder of the officers were chiefly Mestees, or

Town of Agana.

Guam.

the mixed race of Spaniards and natives from the Philippines. But to preserve these troops from the hazard of idleness, and to procure them ample subsistence, they were occupied in cultivating a tract called the Royal Domain, separate from all other property. By such humane and prudent measures, while the natives are reclaimed to habits of industry, their principles and morals, aided by an innate placid disposition, undergo an absolute alteration; yet this patriotic individual was afterwards persecuted by the clergy of Manilla.

History.

The history of Guam is marked by some singular and interesting features. It was discovered in the year 1521, by Magellan, who ascertained that it belonged to a cluster of nine principal islands, and a number of smaller islets, which he first called *De Velas*, from the sails of the canoes, but afterwards *Ladrones*, from the propensity of the natives to theft. Guam appeared to enjoy a delightful climate; it was covered with fruits, and afforded the means of supporting a colony; therefore the Spaniards having already established themselves in the Eastern Seas, resolved upon making a settlement here. The inhabitants were a wild and savage race; but equally savage with themselves, the Europeans, in usurping their territories, carried fire and sword along with them. In violating the religion of their fathers, they endeavoured to inculcate the principles of Christianity; but instead of adhering to its mild and benevolent doctrines, they practised the most horrible cruelties to enforce belief. While their rude opponents might have been gained by conciliation, a war of extermination was unrelentingly prosecuted, because their demands, alike ungenerous and unjust, were resisted. At this early period, the nine islands of the group were calculated to contain 60,000 inhabitants, of whom 20,000 belonged to Guam. But they gradually fell under the barbarity of their invaders, too well skilled in warfare. After a long interval of suffering, a measure was at length adopted by the natives, which is scarcely to be paralleled in history: They resolved to allow their race to be extinguished in themselves, that posterity might not be able in their misery to reproach them with existence. Thus the women drank deleterious potions to procure abortion at the moment, and to prevent their having any future offspring; and this outrage against nature was so obstinately persisted in, that about 60 years ago, the total population of the group had decreased to 800 or 900 persons. The Spaniards, however, had awakened from their error, and learning the benefit of conciliation, found means to collect the whole in the island of Guam. There it continued to augment during twenty years, to about 1500, since which time we have no further accounts of it; but most probably it is much more considerable, or part may have colonized the neighbouring islands. During these convulsions the invaders did not escape with impunity, and on one occasion when the natives rose upon them, all the missionaries were massacred; but on another, when their numbers were small, they proved unsuccessful, and all except 100 evacuated the island, leaving the Spaniards in peaceable possession of it. Afterwards they became accustomed to the yoke, and a quiet, peaceable, and inoffensive race has now sprung up to promote instead of resist the objects of the settlers.

Guam is of importance as a Spanish establishment, from its position and great fertility: the galleons from Acapulco to Manilla, so much the object of capture to hostile nations, were wont to put in here for refreshments, besides which, a vessel came annually from the Philippines. It is said that the natives of the neighbouring islands have become more warlike of late, and seem disposed to make conquests of other territories; but whether they disturb the European colonies is not explained. In concluding these observations, we may cite the words of a French navigator, who made a short residence in Guam, which will satisfactorily illustrate its properties. "In traversing this island, we discovered how lavish nature has been of picturesque and agreeable places. Enchanting spots were met with in our excursions, where she had bestowed every thing, and where the hand of man had made no arrangements. Ennui was banished: here all was united for the enjoyment of solitude: verdure, shade, coolness, and the perfume of flowers: crystalline fountains were seen springing from the rocks: the song of innumerable birds was heard: and groves appeared of cocoas, bread-fruit, oranges, citrons, and an infinity of fruits interspersed among the foliage of trees, all cultivated by the operation of nature alone. Here, too, they presented a pleasing disorder, which art has never been able to imitate. I could not quit this delightful abode without regret, where life might be passed in satisfaction."

It seems doubtful whether the actual position of Guam is completely ascertained. Dampier, after a very long run, lays it down in Latitude 13° 21′ North, Longitude 125° 11′ West: later navigators place it in 13° 25′ North Latitude, and 155° 10′ East Longitude; and La Perouse, probably from observation, fixes the harbour of Umata in 13° 10′ North Latitude. (*c*)

Guamanga.

GUAMANCA, Guamanga, or Huamanga, is the name of a city and province in Peru. The city was originally founded by Pizarro in 1539, as a middle station for the trade between Lima and Cusco. It was built at first on the site of an Indian village of the same name; but, in memory of a victory gained over the Ynca, was called by the Spaniards San Juan de la Vittoria. It was situated in the vicinity of the Andes, in a barren district; but, after the subjugation of the Peruvians, was removed to its present site, in 13° South Lat. in a more fertile territory, about sixty leagues east-south-east from Lima. It stands upon the declivity of a mountainous ridge, not remarkable for its height; but still so far above the rivers, as to be scantily supplied with water. About twenty noble families reside in the centre of the town, in spacious houses of a considerable height, built partly of stone, and covered with tiles, and surrounded with extensive gardens. It is skirted with suburbs of Indian habitations, which are chiefly built of stone, and, though low in the walls, as is generally the case in the inland towns of South America, yet add considerably to the appearance of the city. It contains a splendid cathedral, and a seminary for the service of the church, under the title of St Christopher; a university, with professors of philosophy, divinity, and law, and endowed with privileges equal to that of Lima; and also several chapels and convents, a hospital, and a college of Jesuits. It is governed by a corregidor, assisted by the principal nobility, who form a corporate body, out of which are chosen the alcaldes, to superintend the several departments of the police of the city, and the jurisdiction of the province.

The province or diocese lying eastward of Lima, is of very considerable extent, and is divided into the following districts:—Guamanga, which contains the capital of the province, is very fertile and populous. Its climate is temperate, and it abounds in various kinds of grain, fruit, and cattle. It contains several mines, but few of them are worked; and its agricultural wealth is fortunately the principal object of attention to the inhabitants. A principal part of its commerce consists in bend leather, for the soles of shoes; and great quan-

Guamanga, Guanaxuato. tities also of conserves and sweetmeats are prepared for exportation.—Guanta, about four leagues north-west of the city of Guamanga, and about thirty leagues in length, is likewise a temperate and fruitful district. It is diversified by numerous heights, woodlands, and broken glens rich in fruits and pastures. Its silver mines, which were formerly very rich, are now almost exhausted; but there are still many of lead; and this metal, together with salt and provisions, are its principal articles of trade.—Vilcas Guaman, about seven leagues south-east of Guamanga, is celebrated for its esculent vegetables and fine pastures, and breeds vast quantities of cattle. The natives are employed in various manufactures, particularly woollen stuffs, which are carried to Cusco and other provinces. There is still remaining in this district one of the old Indian fortifications.—Andaguaylas, to the south of Guamanga, extends about twenty miles eastward, between two branches of the Cordillera, and is watered by a number of small rivers descending from the hills. This extensive valley produces all kinds of fruit and grain, particularly maize and sugar cane. It is one of the most populous districts in the country; and in it many of the wealthier inhabitants of Guamanga have large sugar plantations.—Guanca Velica, or Huanca-Belica, commencing about thirty leagues north of Guamanga, is a bleak, hilly, and barren district. It produces little fruit or grain, and its inhabitants are supplied with provisions from the neighbouring countries. It is chiefly celebrated for an immense and apparently inexhaustible mine of quicksilver, to the working of which the inhabitants owe their chief subsistence. In the mountains are many shells and marine substances; and in a river near the principal town such large petrifactions are formed, that they are frequently used in building houses and other works.—Angares, about twenty leagues west-north-west from Guamanga, and about twenty leagues in extent, is tolerably temperate and fruitful, and yields vast herds of all kinds of cattle.—Castro Virreyna, south-west of Guamanga, is of very various temperature, but in its bleakest parts its greatest wealth is found. This consists in the wool of a species of sheep called Vicunna, which had been improvidently hunted down for the sake of its fleece, and which is now to be found only in the coldest heathy spots.—Parina-Cocha, about twenty leagues south of Guamanga, is fertile in grain, and rich in pastures; and its mountains contain several mines of gold and silver, which yield these metals in great abundance, and supply its principal article of commerce.—Lucanas, about thirty leagues south-south-west of Guamanga, is of a cold temperature, but its vegetable productions are abundant, and its herds of cattle numerous. It abounds in rich mines of silver, and is the centre of a very considerable commerce. See Ulloa's *Voyage to South America*, vol. ii.; and Playfair's *Geography*, vol. vi. (*q*)

GUANAXUATO, an intendancy of New Spain, lies between the 20° 55′ and the 21° 30′ North Lat. and is wholly situated on the ridge of the Cordillera of Anahuac. Its length, from the lake of Chapala to the north-east of San Felipe, is fifty-two leagues, and its breadth, from the Villa de Leon to Celaya, is thirty-one. Its principal cities are, Guanaxuato, or as it is also called Santa Fe de Gonnajoato, in 21° 0′ 9″ North Lat. built by the Spaniards in 1554, surrounded with mines, and containing 70,600 inhabitants; Salamanca, a neat little town situated in a plain; Celaya, in which are several splendid buildings, and particularly a magnificent church of the Carmelites; Villa de Leon, in the midst of a highly fruitful district; and San Miguel el Grande, celebrated for its industrious inhabitants, who are employed in cotton manufactures. The province, which is part of the old kingdom of Mechoacan, was first cultivated by the Europeans in the sixteenth century, who expelled the Indian tribes of hunters and shepherds, and supplied their place with colonies of Mexican or Aztec Indians. During a considerable period agriculture made greater progress than mining, and during the seventeenth and eighteenth centuries, most of the mines were entirely abandoned. But, during the last forty years, the mines of Guanaxuato have yielded a greater metallic produce than Potosi, or any other mine in the two continents; and it is now the first mining district in America. Of the situation and products of its mines, a minute description is given by M. Humboldt, both in the historical account of his travels, and in his *Political Essay on New Spain*, vol. iii. p. 169. One of these mines alone, that of Valentiana, which has been known only for forty years, has sometimes furnished, in one year, as much silver as the whole kingdom of Peru. This fine province also is, relatively, the most populous in New Spain. Its superficial extent is only 911 square leagues, and it contains 517,300 inhabitants, which gives 586 to every square league. The principal natural curiosity in this province, are the hot wells of San Jose de Comangillas, which issue from a basaltic opening, and of which the temperature was found to be 205°.3 of Fahrenheit. See Humboldt's *Political Essay on New Spain.* (*q*)

Guatimala. GUATIMALA, one of the three audiences or kingdoms into which Mexico or New Spain was formerly divided, lies between 7½° and 22° North Lat. extending upwards of 300 leagues along the south coast, and in no place exceeding 160 in breadth. It is in some parts extremely narrow, and on the north coast is deeply indented by the Bay of Honduras. It has been divided into thirteen provinces, according to some accounts, and according to others into eight. The latter of these is here adopted, because it best corresponds with the map given in this work, and also because the limits of the thirteen departments have not hitherto been accurately ascertained.* Veragua, the most southern province, and bordering on Panama, is about fifty leagues from west to east, and from nine to twenty-seven in breadth. It was discovered by Columbus in 1502, and was granted to him and his posterity as a reward of his services. Its coasts are low, and full of brushwood; but the interior parts are hilly, covered with forests very imperfectly explored, but known to abound in rich silver mines. Its principal river Veragua is remarkable for the verdant hue of its waters; and from this circumstance its discoverer gave it the name of Verdes Aquas. Its principal towns are, Conception, considered as the capital of the province, a small place situated near a river of the same name; Santiago al Angel, built in 1521, but frequently destroyed and restored; Santa Fé, a small town and bishop's see in the middle of the province; and Pueblo Nuevo, or New Town, situated in an unhealthy spot at the mouth of a river, about twenty-three leagues south-west of Santa Fé. There are besides upwards of thir-

* The celebrated traveller M. Humboldt has furnished a complete description of the modern division of New Spain into Intendencies; but he has not touched upon the portion comprehended in Guatimala, for which he mentions that he had no data, and which we can therefore describe only under its ancient divisions.

Guatimala.

teen villages inhabited by Indians. Costa Rica, or Rich Coast, north-west of Veragua, is from fifty to sixty leagues in length, and forty in breadth. It consists chiefly of mountainous and woody deserts, and is thinly inhabited and little cultivated. Its mines were formerly productive, but have been abandoned on account of the difficulty of working them; and its chief articles of trade are hides, honey, and wax. Its principal town is Cartago, a small place and Bishop's see in the interior of the province, where the governor resides. Nicaragua, in 12° North Latitude, is about 80 leagues in length, and 50 in breadth, running from north-west to south-east, between Costa Rica and Honduras. It consists for the most part of high woody mountains, in which are some volcanoes, but no mines. There is a large lake, 200 miles in circumference, in the south-west, which communicates with the Atlantic ocean by the river St Juan. Its vallies are well watered, and its principal products are timber of great size, cotton, sugar, honey, wax, cochineal, and fruits. Its chief towns are Leon de Nicaragua, a place of considerable trade, on the north-west border of the lake, several leagues from the south coast; and Granada, a populous and trading town on the west border of the lake, near a rugged volcanic mountain. The eastern coast is surrounded with shoals, and has no proper harbour. Honduras, in 15° North Latitude, extends 180 leagues along the south border of the gulf of that name, and from 25 to 50 from north to south. It is well watered by many streams which run northward into the gulf, and which, overflowing their banks in the rainy season, render the soil extremely fertile. Its bay, which includes a compass of 500 miles, is of dangerous navigation; but celebrated for the excellent logwood, which abounds on its flat and marshy shores. There are several islands along the coast of this bay; one of which particularly, Rattan, about 10 leagues in length, was long the resort of pirates, till the British established a colony upon it, for the protection of the trading vessels. The chief towns of the province are, Valladolid, a bishop's see, a small inland town in a pleasant valley; St Jago, 100 miles east of Valladolid, Truxillo, 125 north-east, and Puerto de Cavallos, about 90 north-west, all formerly places of considerable trade, but now greatly deserted. The British established a settlement in 1730 on the Black river, 26 leagues east of Cape Honduras, and another on a navigable river near Cape Gracias da Dios, where there is a secure and spacious road for ships. Guatimala, in 14° North Latitude, bordered on the south and west by the Pacific Ocean, is a province of considerable importance. Its surface is mountainous, and it is extremely subject to earthquakes; but its vallies are remarkably fruitful, abounding in grain, sugar, cotton, various dyeing drugs, especially indigo of a superior quality, and the richest pastures, stocked with incredible multitudes of cattle. Its capital, St Jago, or Guatimala, a bishop's see and the seat of a university, is a considerable trading town. It formerly stood in a delightful valley, not far from the west coast, but was repeatedly destroyed by tremendous earthquakes and volcanic eruptions; and was at length removed to a beautiful plain about 8 leagues from its former site. Nearly 30 leagues to the south-east is Sansonata, or Trinidad, which is the nearest proper harbour for ships from Panama and Peru trading with St Jago. Vera-paz, or Coban, in 16° North Latitude, at the bottom of the bay of Honduras, and north of Guatimala, is about 35 leagues in length, and 30 in breadth. It is a mountainous country, covered with forests; but a few cultivated tracts yield plentiful crops of maize. Cotton, wool, cocoa, honey, wax, and gums, are its chief articles of trade. It contains no towns of any importance; and Vera-paz, the governor's residence on the bank of a river running south-east to Golfo Dolce, Acarabatlan, a small place to the westward, esteemed for its musk melons, and Robinal, a trading village in the pleasant valley of St Nicolas, are scarcely worthy of being noticed. Chiapa, north-west of Vera-paz, in 16½° North Latitude, is of a triangular form, and each of its sides extends about 65 leagues. It abounds in hills covered with forests, and has two rivers, the Chiapa, running eastward to the bay of Campeachy; and the Samasinta, which traverses the eastern part from south to north. It has no mines of gold or silver; and its riches consist in grain, fruits, and pastures. Its principal town, Cividad Real, a bishop's see, is situated in a valley surrounded by mountains, about 90 leagues north-north-west of Guatimala, and trades in cotton, cocoa, and cochineal. There are several Indian towns in this province, of which the most populous is Chiapa dos Indos, about 12 leagues westward of Cividad Real, situated in a valley watered by the river Tabasco. The natives of this diocese obtained, through the mediation of the Bishop Casas, exemption from slavery, with other signal privileges. Soconusco lies between Chiapa and the Pacific Ocean, and is about 35 leagues in length and 30 in breadth. It is a mountainous country, but has no mines. It is covered with forests, and its vallies produce indigo, cocoa-nuts, fruits, and pastures. The only settlement worthy of notice is Guevitlan, or Soconusco, which is the residence of the Spanish governor, and is situated near the coast of the South Sea, about 40 leagues south of Chiapa. See *Modern Universal History*, vol. xxxix; and Playfair's *Geography*, vol. vi. (q)

GUAXACA, or more properly OAXACA, is the name of a city and intendancy in Mexico, or New Spain. The city, which is the ancient Mexican Huaxyacac, was called Antiquera at the time of the conquest. It is situated in an extensive and populous valley, about 80 leagues south-east of Mexico. It carries on a considerable trade, and is particularly celebrated for it excellent chocolate. It is handsomely built, and contains a very fine cathedral, but is open and unfortified. It is a bishop's see, and in 1792 contained 24,000 inhabitants. The province of Guaxaca lies in 17° North Latitude, reaching from sea to sea, extending about 90 leagues along the south coast, 30 along the Mexican Gulf, and from 30 to 70 in breadth. Its climate presents a perpetual spring, and it is one of the most delightful countries in that quarter of the globe. Its mountainous districts, composed of granite and gneiss, are rich in mines of gold, silver, and lead. Its plains are highly fertile, and yield abundance of sugar, cochineal, fruits, grain, and various useful productions. Its relative population is equal to that of European Russia, and it has been long advancing in civilization. Throughout the whole province, vegetation is extremely vigorous, especially halfway down the declivity, in the temperate region, where the rains are very copious from May to October; and, at a small village, about three leagues from the capital, is an enormous trunk of *Cupressus disticha*, which measures 118 feet in circumference; but upon a narrow inspection is evidently composed of three united stems. Many remains of ancient Mexican structures are to be seen in the province, especially at San Antonio de los Cues, a populous place on the road from Orizaba to Guaxaca, and at a village named Mitla. In this last mentioned place, which was formerly called Miguitlan, Oaxaca. Guayaquil. a word signifying in the Mexican language, a place of sadness, are the ruins of an extensive palace, constructed over the tombs of the kings, and to which the sovereign used to retire for some time on the death of a son, a wife, or a mother. This palace, or rather sepulchre, consists of three edifices placed symmetrically in a very romantic situation. The principal structure, which is in the best preservation, is nearly 131 feet in length, and the distribution of the apartments bears a strong analogy to what has been remarked by the French *savans*, in the monuments of Upper Egypt. A stair, formed in a pit, leads down to a subterraneous apartment, which is 88 feet by 26, and which, as well as the exterior walls of the edifice, is covered with those ornaments generally called *grecques*, such as meanders, labyrinths, &c. some of which are in Mosaic, of small porphyry stones. Several curious paintings have been found in these ruins, representing warlike trophies and sacrifices; but the most striking object is a vast hall, of which the ceiling is supported by six porphyry columns, about 16 feet in height. These columns, the only ones found in the new continent, bear strong marks of the infancy of the art, having neither base nor capital, but simply a contraction of the upper part. Besides the capital, there are several other towns in the province, the principal of which is Tecoantepec, about 40 leagues south of Guaxaca, at the bottom of a bay on the coast of the Pacific Ocean. It is a small town, with a good fishing harbour, and an open road for ships; but the port is impeded by a dangerous bar. It is likely, however, to become a place of greater importance, by the increase of the indigo trade from Guatimala. The family of Hernan Cortez bears the title of Marquis of the valley of Oaxaca, a property containing 4 villas, 49 villages, and 17,700 inhabitants. There are 306 secular ecclesiastics in the province, and 342 regulars. The revenues of the bishop amount to 18,000 double piastres. See Humboldt's *Political Essay on the Kingdom of New Spain*. (*q*)

GUAYAQUIL, a city and province in the kingdom of Quito. The city is the second of Spanish origin in the empire of Peru; and was first built about the year 1535, near the gulf of Charapoto, but, in 1693, it was removed to its present situation, on the west bank of the river Guayaquil, in 2° 11′ 21″ South Latitude, about 63 miles from Quito, and 188 from Lima. It extends along the side of the river nearly half a league, and is divided into an old and new town, both of which contain about 2000 houses, which are built of brick or wood, covered with tiles or thatch, but, on account of the numerous conflagrations by which it has suffered, the latter covering is now prohibited. The ground on which the new town stands, is composed of a spongy chalk, and is every where so level, that, in the rainy season, it becomes utterly impassable either on foot or on horseback, and the communication of the inhabitants is effected chiefly by means of large planks, which soon becoming slippery, afford a very inconvenient path. The place is defended by three forts, two on the river close by the town, and a third behind it guarding the entrance of a ravine. All the churches and convents are built of wood, on account of the softness of the soil, except the church of St Domingo in the old town, which is of stone; and the country supplies timber well adapted for these purposes, being extremely hard, and capable of retaining its solidity either in the mud, or under the water. The city and its jurisdiction are under a corregidor, who is subordinate to the president and audience of Quito, and holds his office during five years; the police is conducted by ordinary Alcaldes; and the ecclesiastical government is lodged in the Bishop of Quito's vicar, who is generally also the priest of the town. It contains a small college of Jesuits, and an hospital without any endowments. The inhabitants of Guyaquil, including the strangers who are drawn thither by commerce, are computed at 20,000; and many of the principal people are Europeans, who have married and settled in the place. All who are capable of bearing arms are enrolled in companies of militia, according to their rank or cast. Though the heat of the climate is equal to that of Panama or Carthagena, yet it is a remarkable circumstance, that the Spanish inhabitants are extremely fresh coloured, and their children universally fair, having light hair and eye-brows. They are accounted the handsomest people in all Peru, and are said to be equally distinguished by the elegance and politeness of their manners. As the river is brackish near the city, good water is extremely scarce, especially during summer, and is brought from a distance of four or five leagues, by means of boats resembling rafts. The fish also in its immediate vicinity is neither good nor plentiful; but great quantities of the most excellent kinds, particularly shell-fish, are brought from the neighbouring coasts, and constitute a principal part of the food of the inhabitants. As wheat is scarce, and the bread from it also badly made, different kinds of roots have been employed as substitutes, particularly unripe plantains cut into slices and roasted. The inhabitants affect great splendour in their formal entertainments; and their dishes are a succession of high-seasoned ragouts snd sweetmeats, always beginning with the latter. Their liquors, on these occasions, are grape-brandy, cordials, and wine. Weak acid punch is much used by both sexes, in the forenoon and evening, as a refreshing and wholesome drink, and as a necessary mode of correcting the disagreeable qualities of the water. Melons and water melons are brought in great abundance to the city during the summer season. From the month of May to December, the air is remarkably serene and delightful; and the cool breezes, which blow from the mountains from mid-day till five or six o'clock next morning, tend greatly to refresh the earth and the atmosphere. But during the other half of the year, the climate is intolerable to strangers, the heat greater than at Carthagena, the rains continual, the country overflowed, the insects and other vermin extremely numerous, and even venomous. They are said to be so abundant in the city, that it is impossible to keep a candle burning except in a lantern, as it would otherwise be extinguished in a few minutes by the multitudes flying around it. Tertian fevers prevail much at this season, which the inhabitants, from a prejudice against the use of the bark, (though originally discovered in the province,) suffer to prey upon their constitutions, till they often become incurable. They are very subject also to cataracts and other distempers of the eyes, which often terminate in total blindness, and which some have ascribed to the aqueous exhalations during winter from the chalky soil. The city carries on a considerable trade, and exports native produce, of which the chief article is cocoa, to the value of 550,000 piastres annually; while the amount of imports is 1,200,000 piastres. The province of Guayaquil extends about 60 leagues from north to south, and about 45 from east to west; and is divided into seven departments or lieutenancies, for each of which the

Guayaquil. corregidor appoints a deputy governor, but whose authority must be confirmed by the audience of Quito. These are Puerto Viejo, a poor and thinly inhabited district, abounding in wood, producing a little cotton, and formerly noted for a considerable pearl fishery in the bay of Manta.—Punta de Santa Elena, a low fertile country, full of salt works, but chiefly remarkable for possessing the purple dye so highly esteemed among the ancients, and which is simply the blood of a species of shell fish growing on the rocks. The threads, after being drawn through this liquor, are tinged at first with a milky hue, which changes into green, and then into a vivid purple, which does not fade by wearing, and is rather improved by washing.—Puna, a low flat island in the mouth of Guayaquil river, about seven leagues square, covered with thickets of mangrove trees.—Yaguache, around the mouth of a river of the same name, which falls into the Guayaquil, has no towns of note, but the country is populous, and produces much excellent wood.—Babahoyo, is a large district, subject to great inundations during winter, but productive in cotton, rice, Guinea pepper, and other fruits, especially in plantations of cacao. Large droves of horses, mules, and black cattle, which are kept in the mountains during the wet season, are brought down when the land is dry, and fattened on the plant called gamalotte, which, resembling barley in its blade, grows in such luxuriance as entirely to cover the plains, even to the height of 7 or 8 feet.—Baba, a very extensive district reaching to the skirts of the Cordillera, abounds chiefly in the cacao tree, which delights in a watery soil, and which here grows frequently to the height of 20 feet. The gathering of its fruit and drying of its seed forms the principal trade of the inhabitants. Daule has many large orchards, and extensive corn fields, plantations of cacao, cotton, and sugar cane, but is chiefly distinguished by the excellence of its tobacco. Throughout the whole province of Guayaquil numbers of cattle are reared, especially where there are mountainous tracts to afford a retreat during the season of the inundations. The woody parts are much infested with insects and noxious animals. The river of Guayaquil, which is the principal channel of the commerce of the country, is navigable for the space of 24 leagues, from the isle of Puna at its mouth to the town of Babahoyo, where all the goods intended for the Cordillera, or proceeding thence, must be entered. This river is frequently swelled by torrents from the mountains; and, as these floods are continually shifting the sand banks, its navigation is uncertain, and requires constant sounding. It is navigated principally by *balzas*, or rafts, which are made of a soft, light wood, and which are of various sizes, but frequently carry 400 or 500 quintals. (See Balza.) The principal articles of the cargoes exported from the province are cacao, timber, salt, and cattle, tobacco, wax, Guinea-pepper, drugs, and ceibo-wool. This last is the product of a high and tufted tree, and bears a greater resemblance to silk than either to cotton or wool. It is chiefly used to fill mattresses, and has this remarkable property, that when compressed by dampness, yet, if laid in the sun, it swells again, and often with such force as to stretch the covering of the mattress. The imports are wine, brandy, oil, and dried fruits from Peru; bays, flour, papas, bacon, hams, cheese, and similar articles, from Quito; iron and cordage from New Spain; and European goods from Panama. But the principal profits of the Guayaquil traders arise from the commercial exchanges between Lima and Quito, which pass in the course of its river, especially in the summer season, when the goods can be conveyed between the mountainous districts and the shipping. The banks of the river are covered with habitations, as the inhabitants thus enjoy the advantages both of fishing and of agriculture. These houses, like the greater part of what are built in the province, are chiefly of timber, and raised upon posts 12 or 15 feet from the ground, on account of the general inundations during winter. In that season, the inhabitants of the level districts pass from house to house by means of canoes, which even the children are able to manage with extraordinary dexterity. The river of Guayaquil supplies the numerous inhabitants of its borders with abundance of fish; and the Indians after harvest set sail in their balzas with their families, and employ several weeks in fishing; moving from one creek to another, according to their success. Besides using harpoons and nets, they employ in the smoother creeks a certain herb called *barbasco*, which they chew, mix with bait, and scatter on the water. The juice of this herb is so powerful, that it often kills the smaller fish when they eat of it; and so stupifies the larger, that they float on the surface, and are taken up without any trouble. The increase of the fish is greatly hindered, by the multitudes of alligators which frequent the river and the adjacent plains; and some of which are fifteen feet in length. They are not ferocious, and uniformly flee at the approach of a man; but they often devour the calves, colts, and even the children when wandering near the river in the dusk; and it is said, that after once tasting human flesh, they become more ravenous, sometimes watching an opportunity to drag the boatmen, while asleep, into the water. The gallinazo, a bird about the size of a pea-hen, and very common in the hot climates of South America, furnishes a useful check to the increase of the alligators by its activity in destroying their eggs. Concealed among the branches of a tree, it silently watches the female alligator till she has laid and covered her eggs in the sand. As soon as she is gone, the bird darts upon the spot, and, assisted by a multitude of its tribe, who readily join the fortunate discoverer, uncovers the nest, and devours the eggs. See Ulloa's *Voyage to South America*, vol. i. (*q*)

GUAYRA. See Caraccas, vol. v. p. 424.

GUERCINO. The original name of this celebrated artist was *Giovanni Francisco Barbieri*. Malvasia relates, that in his infancy he lost the sight of his right eye, and that from this accident he acquired the name by which he is now generally known. He was born at the village of Cento, in the territory of Ferrara; and little doubt remains that he never received any regular instructions in painting but what he derived from two very obscure artists in his own country, namely, Gio. Batista Cremonini, and Benedetto Gennari. It has been affirmed, indeed, that he was taught in the school of the Carracci; but this supposition is rendered improbable by a variety of circumstances, and by none more than the peculiarities of his different styles, all of which are at variance with the principles of that school. It is more than likely, however, that he derived much advantage from studying the magnificent picture of Lodovico Carracci at the Capuchins at Cento; but for the great proficiency which he attained, he must be considered as chiefly indebted to the strength of his own genius, and to the careful study of nature. The tendency of his mind began to shew itself at an early age; and it is recorded of him, that when only ten years old, he painted a picture of the Virgin, in the façade of his

Guercino.

father's house, which would not have disgraced a more mature age, and a more practised hand. When premature talent is found to ripen into great excellence, we too readily give credit to the stories which blind admiration delights to record of childhood already atchieving what belongs to experience and age. And when his biographers relate that this picture of Guercino, at the age of ten, with such a subject as the Virgin, was actually a picture of *extraordinary excellence*; we may safely class it among those innumerable instances of a like nature, in which exaggeration sets not only what is probable, but what is possible also, at defiance.

In the course of his practice, Guercino adopted three different styles, which he followed at different periods. The first is not distinguished either by accuracy or grace of design; and in respect of colouring and effect, is violent, inharmonious, and harsh. It is a bad imitation of Michael Angelo Caravaggio, whose works at that time were held in high estimation. Dissatisfied with his attainments, he visited the celebrated schools of art at Rome, at Venice, and Bologna, and by great study and observation, he changed and improved his manner; and his second stile is free from many of the faults which are observable in his previous works. He still retained that vivid contrast of light and shade which distinguishes the productions of Caravaggio; and, like him, his outlines are generally lost, and blended in the *fondo*, but he now far surpassed him in grandeur of composition, and in dignity of character. His females are remarkable for elegant and fascinating beauty. His men, however, are not always free (even in this his best and most valued manner) from a degree of vulgarity and individuality, which probably arose from too strict an adherence to the mode from which he painted. Among the great performances which he executed at this period, we may reckon the picture of St Petronilla, formerly in St Peter's, and lately removed from the gallery of the Louvre; the Aurora, in the Villa Ludovisi; his St Philip of Neri; his St Glena; and his fine picture of the Resurrection. In a similar style of bold design, and magically forcible effect, both of colouring and of light and shade, he executed his grand undertaking of the Dome at St Piacenza, in which he has carried fresco painting to a high degree of perfection. The late Mr Barry, in a letter dated at Bologna, to Sir Joshua Reynolds, speaks in terms of the highest praise of the pictures by Guercino, at that time in the church of St Gregorio. Speaking of the solemn colouring in the works of Ludovico Carracci, "Guercino," says he, "has much of this manner in his fine pictures at St Gregorio, with this difference, that I observe in Guercino more mellowing and *fuoco* in the colouring;" and he regrets that this great artist should ever have departed from the grave majestic tone which he then practised. Like the great painter to whom he is thus compared, one great excellence of Guercino, is the clearness of his deepest shadows. In his best works, he admitted a very large proportion of shadow; yet, notwithstanding their breadth and deep repose, every object which it envelopes is as distinctly seen as it would be in nature. Nothing is lost, nothing is left ambiguous.

From this style, however, he was at an advanced period of his life tempted to deviate. The manner of colouring which Guido had adopted, remarkable for sweetness, openness, and delicacy, was become the subject of great admiration; and Guercino, in attempting to rival the peculiarities of style so widely different from his own, lost all that stamped him an original genius, and fell into a manner of comparative imbecility. In this last manner, were his pictures of the Annunciation at Forli, the Prodigal in the royal palace at Turin, and the Marriage of the Virgin in St Paterniano, at Faro.

This laborious artist left an incredible number of works. In the list given by Malvasia, he enumerates 106 altar-pieces for the churches, 144 large historical pictures, besides his great fresco works, and his numerous portraits and landscapes in private collections. He left also a vast number of drawings, which are held in great estimation. The etchings which he executed, nine in number, are very spirited. He died in 1666, aged 76. (*l*)

Guericke. Guernsey.

GUERICKE, Otto. See Pneumatics, *History of.*

GUERNSEY, the *Sarnia* of the ancients, is an island belonging to Great Britain. It is one of the Channel islands, lying within the bay of St Michael, and about seven leagues from the coast of Normandy. This island is of a triangular shape. Its extreme length is about $7\frac{1}{2}$ miles, and its greatest breadth about 4 miles. It is about 21 miles in circuit. According to the recent account of it given by Dr Macculloch, it is elevated to the south, and shelves towards the north. The southern coast is bounded by high cliffs, stretching along part of the eastern coast. The rest of the eastern coast, and the northern coast, consist of a number of flat bays, separated by ridges of lofty rocks. Dr Macculloch conceives the island to be divided by an imaginary line, drawn from the town of St Peter's Port to Pezeries. A level tract, broken only by cairns and rocky hillocks, lies to the north of this line. This tract comprehends an inundation of more than 60 years standing, which covers three hundred acres. It was formerly quite dry before the time of low water, but has lately been embanked and drained. Towards the south of the imaginary line, the country forms a higher stratum, everywhere intersected by deep glens and narrow vallies of various directions. With the exception of two or three narrow caves, which form the mouths of small vallies intersecting the high land, the lofty cliffs which bound the southern tract are continuous. There are here few detached rocks, but the northern coast is covered with them. Dr Macculloch observed, that the island is entirely of granitic formation; that the southern division consists wholly of gneiss; and that the rocks which form the northern point, exhibit various kinds of granite, or granitel. At the foot of a rocky steep near Prevolet Point, is a curious cave called *La Cave Mahie*. It is above 200 feet in depth; and from an entrance 9 or 10 feet wide and 6 high, it extends from 50 to 60 feet in height and breadth, ending in granite points.

General structure.

The soil of Guernsey, which is decomposed gneiss, is very fertile, and is well watered by springs and rivulets. Agriculture is carried on with great care. The lands are inclosed with stone fences. The seats of the gentry, and the farm-houses and cottages, which are very handsome, are agreeably situated among orchards and gardens. The ordinary food of the inhabitants, is a soup made of cabbage, pease, flour, and a few slices of green bacon. Their beverage is cyder. The produce of the island is nearly the same as that of the west of England. The fruits are very fine. Pigs are fed in winter on parsnips; and the butter, pork, and veal, are in the highest perfection. Red and grey mullets, mackarel, congor eels, and lobsters, are caught in great abundance round the island. Coals are imported; but the principal fuel of the poorer inhabitants is sea-weed, the ashes of which are used as manure by the farmers.

Soil and agriculture.

The climate of Guernsey is mild and temperate, and

Climate.

Guernsey.

is not subject to excessive heats or colds. The winters and springs are moist, and high winds often prevail.

Religious and political state.

Guernsey is divided into ten parishes, each of which is divided into several vintons, for the better management of affairs. The island is in the diocese of Winchester, and province of Canterbury. The convention of the state, consists of the governor, a bailiff, 12 jurats appointed by the king, who administer the laws, which are quite different from ours. These officers hold their places during pleasure; and they judge in all civil and criminal cases excepting high treason. The governor receives tythes of all kinds of grain. He has under him a lieutenant-governor, who is called the constable of the castle. The prevailing religion is that of the church of England, though the followers of Wesley are numerous. The Catholics are very few in number.

Principal town St Peter's Port.

The only town in the island is St Peter's Port. It originally consisted of a narrow street of high houses, but the buildings have been extended across a ravine over the surrounding heights. The lower streets are narrow, dirty, and irregular. The principal church, built in 1312, is of granite. It has Gothic mouldings, though no pointed arches. Its exterior is handsome. Its porch is remarkable for the depth and extent of its mouldings; and its tower is a great ornament from the pier and road It contains some good modern monuments. The new court-house is handsomely built of granite, and fitted up with suitable offices for the preservation of a few records. The new prison, built after the model of the debtors' gaol at Manchester, is very spacious and commodious. The work-house, or hospital, is supported by an endowment, and by an assessment on lands and houses. The harbour affords sufficient shelter and security to shipping. The keys and the piers are immense masses of rough masonry formed of granite, and extending out into the harbour. These walls are paved, and have parapets, and they inclose a space of several acres. The harbour and the road are exposed to the south-east. Harbours for vessels of light tonnage occur on the north and west sides of the island, at the creeks of Bazon, L'Accousse, Ferminer, St Sampson, and the west passage. The market-house for meat and vegetables, is a large building erected in an open square. Two large and handsome rooms have been fitted up above the market-house, for the public assemblies and entertainments, which are held monthly during the gay season. There is also a small theatre here. An ascent of about 100 steps, leads from the level of the market-place up the side of a ravine to the new town, where there are many good and open streets, one of which, called George Row, contains several elegant houses. The government house, the public walks at L'Hivreur, and the college founded by Queen Elizabeth, are the only other objects of interest.

Ancient castles.

There were formerly four castles in the island, viz. Castle Cornet, the Castle in the Marshes, Vale Castle, and the Castle of Notre Dame. Castle Cornet is situated on a rock of gneiss often approaching to granite, and intersected by veins of quartz, trap, and felspar, curved and mixed in various ways. This rock is about a quarter of a mile from the shore, and near Port St Peter's. It is scarcely accessible but on one side. It is surrounded with an outer wall of great thickness, flanked by several machicolated towers, and the keep has been converted into casemates. Elizabeth enlarged it with a lower line of curtain and bastions; and barracks and accommodation for a numerous garrison have since been formed. It is now defended by a considerable quantity of heavy artillery.

Guernsey, Guiana.

The Castle in the Marshes appears to be very ancient. It is encircled with a double wall of granite, and has an outer and inner ditch, and a keep in the Norman form.

The Vale Castle, which is also ancient, stands upon a commanding eminence, near St Sampson's harbour. It was once reckoned to be strong, but it has now only a surrounding wall, with flanking towers, and a portal. There are barracks for a garrison; and several pieces of cannon on the ramparts, command a passage called the Russel. The castle of Notre Dame, and that of Rocquane, no longer exist.

Manufactures and commerce.

The inhabitants are chiefly employed in agriculture, and in the cultivation of their gardens and orchards, from which great quantities of excellent cyder are made. The only manufacture is that of woollen goods. They are allowed to import 1000 tons of wool annually from England, which is made into stockings, waistcoats and breeches. Lobsters are the only fish which is exported. Guernsey was, before the establishment of the London Docks, the grand depot of all the foreign wines and brandies. Towards the bay of St Sampson's, there is a fine rock of grey or black granite, which is exported in large quantities to London and Portsmouth. It is called the Guernsey or St Sampson's stone, and being hard and tough, it is admirably adapted for building and paving, as it easily breaks into square masses before the hammer. Dr Macculloch could not obtain any physical or historical evidence that emery was a production of this island, as has been generally stated. Every part of the coast of Guernsey is fortified with strong batteries and breast works. The number of houses in St Peter's is about 800, and the population of the island about 15,000.

See Dicey's *History of Guernsey*; Grose's *Antiquities of England and Wales*; and Macculloch's *Account of Guernsey*, in the *Transactions of the Geological Society*, vol. i. p. 7.

Situation and extent.

GUIANA, an extensive country in South America, is bounded by the river Orinoco on the north, by the river of the Amazons on the south, by the Atlantic Ocean on the east and north-east, and by New Granada on the west. It is nearly of a triangular form, and is computed to contain 250,000 square miles. It extends along the coast from the mouth of the Orinoco to that of the Maranon or Amazons river, about 700 miles; and stretches inland from east to west about 1200. The Orinoco is known to communicate by several branch-streams with the Maranon; and one of these, called the Yupura, is considered as the western verge of Guiana. It is therefore completely an insulated tract, and is probably capable of being circumnavigated.

Discovery and history.

The discovery of Guiana has been attributed by some to Columbus in the year 1498, and by others to the Spanish navigator Vasco Nunes, who, after ascertaining Cuba to be an island, landed in 1501 on the continent of South America; and, having traced the coast from the Orinoco to the Maranon, comprehended the whole tract in that extensive country, to which, in contradistinction to Cuba and the adjacent islands, he gave the general name of Terra Firma. But, though originally seen by the Spaniards, Guiana was little known, till it was visited by Sir Walter Raleigh in the year 1595; who not only explored the coast, but also sailed up the river Orinoco about 600 miles in quest of the imaginary El Dorado. Several English buccaneers next re-

Guiana. sorted to the coast; and, in 1634, about sixty persons, partly English and partly French, under the command of a Captain Marshall, were found in Surinam cultivating tobacco, and making trading voyages to the neighbouring coasts. In 1650, this voluntary settlement was taken under the protection of Great Britain, and Lord Willoughby of Parkham was appointed governor; but, in 1667, it was taken by the Dutch, and finally ceded to them by the treaty of Westminster in 1674, in exchange for the province of New York. Similar settlements were gradually made by other powers, on different parts of the coast: and the country of Guiana has thus been distributed by geographers into four distinct divisions; viz. Spanish Guiana, Dutch Guiana, French Guiana, and Portuguese Guiana. Spanish Guiana extends along the coast about thirty leagues from the mouth of the Orinoco to Cape Nassau, and runs inland about 150 leagues on the south of the Orinoco; Dutch Guiana lies between Cape Nassau and the river Maroni; French Guiana between the Maroni and the river Carapana; and Portuguese Guiana, between the Carapana and the river of the Amazons. The more inland part of the country, behind these settlements, may be considered as a fifth division, and called Indian Guiana. Of these, Spanish Guiana is by far the most extensive and valuable possession. Its breadth, indeed, for the space of 80 leagues eastward, does not exceed 30 leagues; but it afterwards widens to more than 150 leagues, running along the back of the Dutch and French possessions, till it reaches the equinoctial line, which separates it from the Portuguese territories. It is divided into Upper and Lower Guiana, of which the river Caroni may be considered as the separating boundary. Lower Guiana is intersected in all directions by numerous rivers, which from time immemorial have contributed to increase the vegetable mould on its surface, so that in point of fertility it is not surpassed by any other portion of territory in the American continent. But, for the space of 30 leagues from the coast, it is completely occupied by the Caribs, the most ferocious of the Indian tribes, who have hitherto massacred every Spanish missionary or settler, who ventured to approach their habitations; and whose hostility to the Spaniards, the Dutch have been accused of fomenting, for the purpose of extending their commerce along the coast of Spanish Guiana. The city of Saint Thomas, the capital of Spanish Guiana, is situated on the right bank of the Orinoco, about 90 leagues from the mouth of the river; and is the residence of a governor and a bishop. Its streets are regularly built and well paved; and its climate pure and healthy; but its port is incommodious, and its distance from the coast unfavourable to its commercial prosperity. From this port of Guiana, were exported, from 1791 to 1794, 10,380 oxen, and 3140 mules, all either bred in the province or brought from Varinas; and, in return, were imported 200 negroes, and 349,448 piastres in specie. From 1791 to 1795 the silver exported to Europe amounted to 25,203 piastres, and the commodities to 363,397 piastres. But this commerce is said to have greatly diminished. The population of Spanish Guiana, exclusive of the portion occupied by the Caribs near the coast, is estimated only at 34,000, of which 19,425 Indians are under the jurisdiction of the missionaries, 6575 reside in the capital, and the remaining 8000 are scattered through the different villages. Farther particulars respecting the political and ecclesiastical state of this province will be found under the articles CARACCAS and ORINOCO; and for an account of the other European settlements on the coast of Guiana, we refer to the articles BERBICE, CAYENNE, DEMERARY, SURINAM, &c. In the present article we confine ourselves to such topics as may be considered common to them all, especially to the natural history of Guiana, comprising its soil, climate, native productions, original inhabitants, &c.

Division.

Spanish Guiana.

Aspect.

Guiana was originally called by some navigators the wild coast; and its shores, accessible only by the mouths of its rivers, are every where covered by dangerous banks, quicksands, rocks, and impenetrable thickets. Its appearance from the sea is wild and uncultivated; and it is so low and flat, that, even where there are plantations along the coast, there is nothing visible at first, but a continued forest standing close to the beach; so that the country appears as a cluster of trees growing out of the water. The European settlers, particularly the Dutch, attempted at first to cultivate the banks of the rivers, at a considerable distance from the coast; but, by the example of the British, were persuaded to extend their plantations along the shore, where the soil is remarkably fertile, and adapted for every variety of tropical production. The ground, for a considerable way up the country, is every where level; and so low, that, during the rainy season, it is usually covered with water nearly two feet in height. This renders the soil so rich, that, on the surface, for 12 feet in depth, it is a stratum of perfect manure, and has been actually carried to Barbadoes for that purpose. In some places, 30 crops of rice can be raised in succession; whereas, in the West India islands, not more than two is ever expected from the richest lands. The whole country is intersected by deep swamps or marshes, numerous rivers, and extensive savannahs. The interior has been little explored; but, in proceeding inland, it becomes more hilly, and the soil poorer, sometimes rocky, and often sandy. It is covered with immense forests, rocks, and mountains; and, in some of the latter, a variety of mineral substances are found. The most prominent objects are a lake called Parima, whose extent varies with the seasons; and a chain of mountains called Mei, nearly parallel with the form of the coast. From these mountains, rivers flow in every direction; some, like the Essequibo, falling into the Atlantic; some, like the Caroni, joining the Orinoco; and others, like the Rio Blanco, uniting with the river of the Amazons.

Soil.

Climate.

The climate of Guiana is the mildest and most salubrious of any tropical country hitherto inhabited by Europeans. This has been ascribed principally to the regular blowing of the trade-wind over the surface of a vast tract of ocean, which thus carries a perpetual stream of cool air over Guiana from east to west; while, on the opposite coast of Africa, the same equatorial wind, coming over land, is heated with the sultry vapours of sandy deserts. Besides this general flow of the whole atmosphere in a westerly direction, there is a daily lateral fluctuation, termed the sea-breeze and the land-breeze; the former, which is the cooler of the two, blowing from the north-east during the day, temperating the ardour of noon; and the latter, which is the warmer of the two, blowing from the south-east during the night, preventing too rapid a chillness. The range of the thermometer on the coast, during the whole year, is from 72 to 87; and, between two or three hundred miles up the country, it is from 65½ to 84. Instead of the cold and the warm seasons of Europe, the year is divided by the rainy and the dry seasons, which may be termed the winter and summer of the country. But, in Guiana, there may be said to be annually two winters or wet seasons, and two summers or dry seasons, which are distinguished from each other by the appellation of the *greater* and the *smaller*, referring not to the intensity of the heat, or the violence of the rains in the one more than the other, but to their duration. The long wet season begins about the middle of April, declines in August, and ceases in September; when the short dry season commences, and continues till the middle of November. Then comes on the short wet season, which lasts till the middle of January, when the long dry season appears, which does not terminate till the middle of April. During this last period, especially in the month of March, the weather is most pleasant, the atmosphere clear and pure, the climate genial and cool. There are frequent variations in these stated periods; and the changes are generally accompanied with tremendous storms of thunder and lightning, which sometimes prove fatal both to the inhabitants and the cattle of the country. In the wet season, though the rain falls in torrents, yet it is generally in the afternoon; and in the dry season, there is rarely a drought, but showers occasionally come during the night. The earth is thus, during the whole year, adorned with perpetual verdure, the trees loaded at the same time with blossoms and ripe fruit; and the whole presenting to the view a delightful union of spring and of summer. There are no hurricanes to destroy the crops of the planter; and rarely are any earthquakes felt in the level districts.

Diseases. There are few contagious disorders in Guiana; and by temperate living, together with proper care to avoid the mid-day heat and evening dews, Europeans have been able to preserve a state of excellent health in the country. The principal disease is fever, in a variety of forms and degrees, from the simple intermittant to the dreaded yellow fever. A prickly heat, or scarlet eruption, is frequently experienced, which causes extreme itching, but is considered rather as friendly to health. The stings of the musquitoes or gnats are often succeeded by large pimples, which are apt to be converted by scratching into troublesome ulcers. The ring-worm consists of long scarlet spots, chiefly about the face and neck, and is prevented from spreading by the immediate application of lime-juice mixed with gun-powder. The chigoe, or jigger, is a kind of sand-flea, which lodges under the toe-nails, between the skin and the flesh, and unless extracted as soon as the itching which they occasion is felt, are apt to produce very deep and fretting ulcers. The yaws, a dreadful disorder resembling the small-pox, and covering the body with large ulcers, is extremely infectious, but seems peculiar to the negro race. Dry gripes, bloody flux, and dropsy, are also frequent.

Vegetable productions. The vegetable productions of Guiana are exceedingly numerous, and many of them particularly worthy of notice, both as objects of curiosity and as articles of utility. The trees in the forests grow to an immense size, many of their trunks rising to the height of 100 feet, and throwing out at the lower extremity a number of flattened projections, which surround the stem like supporting buttresses, and form deep recesses, capable sometimes of affording shelter to 10 or 12 persons. Mountain cabbage. The mountain cabbage, unrivalled in the vegetable world, has a straight tapering trunk 100 feet in height, and 7 or 8 feet in circumference, branches 20 feet in length, diverging in a horizontal direction, palmated narrow leaves above 2 feet long, a green husky pod 20 inches in length at the clefts of the lower branches, full of nuts, which are the seeds of the plant; and, on the summit of the trunk, the cabbage, consisting of thin white strata, and resembling an almond in taste. Silk cotton tree. The silk cotton tree, generally growing to the height of 100 feet, with a trunk 12 feet in circumference, and free of branches for the space of 70 feet, bears a pod full of silky filaments. Red mangrove tree. The red mangrove tree, growing in marshy places, rises from a number of roots, which appear several feet above ground, before they are joined together to form the main trunk, which is generally tall and large, hard, and good for building; and numerous ligneous shoots, without leaves or branches, descend from the stem and the lateral boughs towards the ground, where they take root, and like props or pillars, afford support to the tree in its watery soil. Cocoa nut tree. The cocoa nut tree, growing to the height of 60 or 80 feet, but seldom perfectly straight, bears fruit at the age of six or eight years. Pipeira tree. The pipeira tree, about 70 feet high, and 9 in circumference, affords a weighty durable timber, and bears a small round fruit of a farinaceous nature, which is sometimes used by the Indians as food. Among a variety of other valuable forest trees, growing to the height of 50 feet, may be mentioned the Iron wood tree. iron-wood tree, so called from its hard and heavy wood, which is used for clubs, windmills, and similar purposes; Bullet tree. the bullet-tree, which has a dark coloured wood, spotted with small white specks, very durable, and so weighty as to sink in salt water; Launa tree. the launa tree, which bears a fruit like an apple, yielding a purple coloured juice, employed by the Indians in painting their bodies; Mahogany. the mahogany tree, resembling the cedar, and preferring a rocky soil; Tonquin bean tree. the tonquin bean tree, which bears the sweet-smelling pulse of that name, and some of which sometimes grow to the height of 70 or 80 feet; Cassia fistula. the cassia fistula, covered with a light brown bark, and bearing pods 18 inches long, containing a sweet pulp resembling treacle. Of a smaller size are the bourracoura, or Letter wood tree. letter wood tree, which contains a heart of a deep red colour, marked with black spots, hard, ponderous, capable of the finest polish, and highly valued for its beauty; Hiarree. the hiarree tree, which grows near rivers, and generally at a distance from other trees, esteemed a strong poison, even the smoke of the wood when burning proving fatal to animal life; the cocoa tree, which bears a pod of the size and shape of a melon, containing rows of nuts in its longitudinal cavities.

Fruit trees. Guava. The most valuable fruit trees are the guava, which bears a round fruit of a light yellow colour, the internal part of which is a red pulp generally made into jellies, and the external part resembling the substance of an apple, employed in tarts, &c.; Tamarind. the tamarind tree, which grows to a considerable size, and produces its fruit in a large pod; the aviato or avogato pear tree, resembling a walnut tree, and bearing a delicious fruit like a large pear of a pale green colour, and yellow pulp, similar in taste and flavour to the finest peach; the female poppau, which produces an oval-shaped fruit, about six inches in length; plantains, bananas, pine apples, &c. Shrubs. Among the useful shrubs, we can only particularize the cotton bush, which produces two crops annually; the coffee bush, which also bears two crops, each tree yielding about a pound and a half at a crop; Castor bush. the palma christi, or castor bush, which bears nuts of a triangular form, covered with a thin brown fur, the kernels of which yield by expression the well known castor oil; the cassava shrub, of which the roots are ground into meal, and formed into an excellent bread; but the bitter cassava, though it becomes a wholesome food when boiled or baked, is in its raw state a fatal poison. Of many curious plants may be mentioned the Aloe. aloe, of which there are various kinds; the caruna shrub, bear-

Guiana.

Silk-grass plant.

ing a nut, of which the kernel is used by the Indians as a slow poison; the curretta, or silk-grass plant, a species of aloe, the leaves of which contain a saponaceous pulp, used in washing, mixed with fine and strong white filaments, which when properly cleaned, can scarcely be distinguished from threads of silk, and are employed in making nets, cords, &c.; the siliqua hirsuta, a slender creeping plant like the vine, bearing pods resembling the common pea, covered with fine stiff pointed hairs, which, upon being applied to the skin, produce an intolerable sensation of itching; troolies, or leaves of an enormous size, from 20 to 30 feet in length, and about 2 or 3 in breadth, growing from a short root close to the ground, and used as a thatch for houses, which they protect from the heaviest rains, and last for many years; nibbees, a kind of ligneous rope, without any foliage, growing to an immense length, and from 3 to 18 inches in circumference, sometimes entwining themselves together to the thickness of a ship's cable, and at other times interweaving themselves like nets, so as to intercept the game in their course, frequently climbing to the tops of the loftiest trees, and again descending to take root in the earth, often coiling themselves so closely around the trunks of the trees, as completely to check their growth, and so extremely tough as to be used by the natives for fastening the posts and thatch of their huts.

Troolies.

Nibbees.

Roots.

The roots most deserving of notice, are the ipecacuanha, the ginger, and the Indian yam, which last is about eight inches in length, and six in circumference, of a reddish purple colour, and affords an agreeable farinaceous food.

Animals.

The native animals of Guiana are not yet fully ascertained; and its unexplored forests contain, in all probability, many animated beings, which are but very imperfectly known to the zoologist. Many of the domestic animals, the bull, the cow, the ass, the hog, the sheep, &c. have been imported from the old continent; and some of these, having escaped into the woods, have run wild and multiplied rapidly. Most of them, however, have greatly degenerated both in size and in flesh, in consequence, it is conjectured, of the perpetual perspiration to which they are exposed, and the coarseness of the grass on which they feed. The sheep, particularly, are remarkably diminutive, and their wool converted into straight hair. The hogs, on the contrary, are large and fat, and superior to those of Europe. The goats are large and beautiful animals, common in all parts of the country; often kept on the plantations, where they breed quickly, and yield much milk. The poultry are as plentiful and excellent as in any part of the world. A smaller species of domestic hen with rumpled or inverted feathers, is reared by the natives in the inland parts of the country, and is considered as natural to Guiana.

Domestic animals.

Beasts of prey.

The beasts of prey, which abound in the forests of this country, though numerous, are not remarkably formidable to the human race. The most powerful is the tiger, of which there are several kinds; the jaguar, which resembles the African species, and sometimes measures six feet from the nose to the root of the tail, is very strong and ferocious, frequently attacking the cows, horses, and young negroes on the plantations; the couquar, or red tiger, resembling a grey hound in shape, but larger in size, and equally fierce as the last mentioned; and the tiger cat, a beautiful creature, not much larger than the domestic cat of Europe, but destructive and untameable like the rest of its kind. This is a ferocious little creature, called the crabbo-dago, not much larger than a common cat, and supposed to be the same with what Buffon calls the grison or grey-weasel, which is never glutted with blood, but murders whatever comes in its way, whether quadrupeds, fowls or reptiles, if it is able to vanquish them. There are various kinds of monkeys, but no apes in Guiana. The natives affirm, that the ouran-outang, five feet in height, is found in the woods, but no European has ever seen any of these animals in the country. Of the others, the most remarkable are, the quato, which has a naked face, a nose like that of a negro, deeply sunken eyes, large ears, and, excepting its long tail, bears a great resemblance to the human form; the howling baboon, which is about the size of a small bull dog, has a long black beard, and is chiefly remarkable for assembling in large crowds, and uttering a most disagreeable howl or yell, which is continued for a long time, and which is said to be a sure sign of approaching rain; and the saccawinkee, or schacomingky; sometimes called the lion monkey, a small and delicate creature, only about five or six ounces in weight, which perches like a bird upon the forefinger, and is frequently brought down to the plantations by the natives for sale, has a small head, round smooth ears, oval face covered with fine white hair, a tail much longer than its body, long bushy black hair, especially around its neck, like the main of a lion, is extremely susceptible of cold, and though frequently tamed, seldom lives longer than a few months. The coatimondi or Brasilian weasel, shaped like a dog, often as large as a fox, and resembling that animal in cunning, is a great destroyer of the poultry; and, equalling the monkies in the faculty of climbing trees, commits great ravages among bird nests. One of the most extraordinary animals in Guiana is the great ant-bear, which often weighs from 150 to 200 lbs. and measures not less than eight feet from the snout to the tip of the tail. It has a small head, covered with hair as soft as velvet, and a tail immensely large, flat, and covered with long hair like that of a horse, and as strong as the bristles of a hog, with which, during a shower, or when attacked, or when asleep, he protects his whole body. His feet are armed with long claws, with which he can defend himself against any dog, and even against the tiger, and never quits his hold while he has life. He has a long slender tongue, resembling a worm, sometimes almost two feet in length, and moistened with saliva of a sweetish taste, which he thrusts into the ants' nests, who settle upon it in crowds, when he draws it into his mouth, renewing the operation till no more are to be found. There are found in Guiana the porcupine, the armadillo, the sloth, several kinds of opossum, wood-rats, and hedge-hogs.

Jaguar.

Red tiger.

Tiger cat.

Guiana.

Ouran-outang.

Howling baboon.

Lion monkey.

Coatimondi.

Ant-bear.

Deer.

There are two kinds of deer, the largest of which, called bajew, are about the size of an English buck, and feed in great numbers in the savannahs; the smaller species, called wirreboeerra, are remarkably nimble, have no horns, and make the most delicate venison. The paccarara, or Indian coney, is common in all parts of Guiana, and greatly resembles the hare in shape and size; is very prolific, and easily taken; and its flesh, which is much like that of a rabbit, forms a principal part of the food of the natives. There are several kinds of wild hogs in the forests, particularly the pingos, or warree, resembling small English hogs, found in herds of 300 or more, running always in a line, and easily knocked on the head. A larger kind, called eras-pingos, are armed with strong tusks, and, when wounded or obstructed in their course, become extremely ferocious. But both these kinds are supposed to be merely

Wild hogs.

Guiana. the domestic hog of Africa or Europe in a wild state; and the only species indigenous in Guiana, is the piccaree, or Mexican hog, which is about 3 feet in length, without either tusks or tail, and is particularly remarkable, from having on its back, above the hind legs, a cavity about an inch deep, filled with a white fetid fluid, which, unless cut out as soon as the animal is killed, infects the whole flesh, so as render it unfit for being used as food. They are found in large herds in the drier and mountainous parts of the country; and their flesh is greatly admired by the natives. There is a great variety of lizards, of which the most remarkable is the guana, about three feet in length, and generally found among the shrubs and fruit trees. Its eggs, which are deposited in the sand, are reckoned excellent food; and its flesh particularly is esteemed a great delicacy, resembling in taste that of a chicken.

Amphibiæ. Tapira. The amphibious animals are very abundant in Guiana; of which we can only slightly notice the tapira, resembling the hippopotamus, but not larger than an ass, with the head of a horse, and a considerable prolongation of the upper lip, excessively thick skin, bristly mane, and short tail, feeds on grass and aquatic herbs, and its flesh is accounted superior to the finest ox beef, but it is rarely procured, as the animal is extremely shy, and plunges into the water upon the least alarm; the manatee, or sea cow, about 16 feet or more in length, with a head like that of a hog, nostrils like an ox, breasts like those of a woman, and a tail like that of the whale, seldom quits the water entirely, and its flesh, which is very fat, tastes much like veal; the alligator, or cayman, found sometimes 20 feet in length, but generally harmless, and even in water seldom attacking a man, as long as he keeps himself in motion; the laubba, which seems to be the same with what others call the paca, or spotted cavey, or aquatic hare, is peculiar to this part of the world, about the size of a sucking pig or large cat, with the head of a pug dog, extremely fat, and resembles the finest pork, feeds on herbs and grain, takes refuge in the water when pursued, swimming a long time at a short distance from the surface, so that it is often shot under water with arrows; the pipa, a kind of toad or frog, sometimes as large as an ordinary duck, a creature of a hideous appearance, covered with a brown shrivelled skin, and chiefly remarkable for the uncommon loudness of its voice; but still more for the peculiar manner of its propagation, the young being hatched in watery cells on the back of the female, or, according to others, placed there by the assistance of the male after they have become tadpoles, and continuing to nestle there till the second transformation is completed.

Sea cow. Alligator. Laubba. Pipa.

There are many snakes in Guiana, of which the best known are the rattle-snake, whip-snake, and dipsas; the papaw, or ammodytes, a harmless and beautiful creature, from three to five feet in length, which is revered by the natives as a sacred object; the oroocookoo, supposed to be the same with the small laboia, the bite of which has been known to prove fatal in a few minutes; and the aboma, an amphibious animal, delighting in low marshy places, found upwards of 20 feet in length, and said, when fully grown, to be from 30 to 40 feet long, and from 3 to 4 in circumference at the thickest part of the body. Its bite is not considered as venomous, and it is a sluggish unwieldy creature, but seizes its prey by surprize, and devours deer, hogs, or even the tyger without difficulty, entangling and crushing them in its grasp, besmearing them with saliva, and swallowing their bodies entire.

Papaw. Aboma.

Birds. The birds most commonly found in Guiana are the vulture, eagle, owl, falcon, butcher bird; parrots of various kinds; large and beautiful mackaws, some of which are about the size of a capon, toucan, pelican, wood-pecker, green sparrow, tiger bird, a kind of heron of a reddish colour, spotted with black; flamingo found in flocks on the banks of rivers, and so tame as frequently to mix with the poultry on the plantations; agame, or trumpeter, a kind of turkey peculiar to the country, and often domesticated; sun-bird, resembling the English partridge, and sometimes kept in the houses to destroy the ants; peacock-pheasant, or powese, resembling in size and flavour an English turkey; kishee-kishee, about the size of a sparrow, adorned with most beautiful plumage, and sometimes brought by the Indians from the interior of the country; the mocking bird, which hangs its nest, (about 14 inches in length, and 8 in circumference,) at the extremity of the twigs of the remotest branches, as a security from the monkies; and the humming bird, which is found here in great number and variety: the most common of these, of a green and crimson colour, is not bigger than a large cherry, and the smallest, of a black and green colour, with a golden tuft on its head, nearly a third less than the last mentioned, sometimes weighs little more than 50 grains. There are bats of a large size, some of which have been found to measure thirty-two inches between the tips of the extended wings, and which are known to open the veins in the feet of persons asleep, and to suck the blood till they are satisfied.

Flamingo. Kishee-kishee. Humming bird. Bats.

Fish. The fish caught on the coast are far from being delicate, as the water is extremely muddy for several leagues from the shore. The most remarkable of the salt water fish is the low-low, about six inches in length, and three in circumference; and the largest of the fresh water fish is the barroketa, about three feet long, and two in circumference, resembling a salmon, white, fat, and delicate. The peri, another fresh water fish, about 18 inches long, and of a flat form, has a large mouth armed with long sharp teeth, and is said to attack persons when bathing in the rivers. The frog fish is one of the greatest curiosities in Guiana, and is said to pass by regular gradations, through the form of a frog, a frog fish, and lastly a fish, but is affirmed by Stedman to proceed rather in the opposite direction, from a fish to a frog, and to be probably nothing else than a kind of tadpole, which grows to a large size before undergoing its usual transformation; in the fish state, it is about eight or ten inches long, without scales, and exceedingly fat and delicate. The galvanic eel is very common in the rivers of this country, generally about three feet in length, and 12 inches in circumference, though sometimes found of a much larger size; it comes frequently to the surface of the water, as if to inhale the air, and its flesh is esteemed delicate food by the natives. Multitudes of crabs are found in the bottoms of the muddy streams; and a large land crab, much used as food by the natives, abounds on the banks of the sea, at the mouth of the rivers.

Frog fish.

Insects. Insects abound in Guiana in vast numbers, owing to the continued warmth of the climate, which both favours their production, and prolongs their existence; and continually flying in the faces, or crawling about the bodies of the inhabitants, are the most intolerable pest of the country, especially to new settlers from Europe. Musquitoes are inconceivably numerous during the rainy season, particularly on the coast, and on the banks of rivers; and are said to prevail most in places, which are in a state of progress from a wild to a completely

Guiana. cultivated condition. The juice of lemons or limes, mixed with water and applied to the skin, is at once the best remedy for their stings, and a tolerable preservative against their attacks. Cock-roaches are found from one to two inches in length, which make their way into chests and boxes, and besides destroying cloths of every description, render every kind of victuals which they attack utterly disgusting, by the nauseous smell which they leave behind. As this creature is seldom seen to fly, the best preservative against its ravages is to place the boxes or trunks upon empty wine bottles, kept free from dust, so as by their smoothness to render its ascent more difficult. Ants of many different kinds are extremely numerous, and prove very destructive to the stores, (especially of sugar,) in the plantations. Their immense nests of black earth, built on the trunks of the trees, are often so high as to resemble large black bears at a distance; and some of their hillocks on the ground have been seen as high as 15 or 20 feet, and nearly 100 feet in circumference. Some of these insects are above an inch in length, and cause great pain by their bite. A small species, called the fire-ant, which flies in great numbers, occasions a burning sensation resembling that produced by boiling water, supposed to proceed from some venomous fluid injected into the wound. There are two kinds of fire-flies, the smallest of which seen only during night, emits sparks of fire at intervals; but the larger kind, which is more than an inch in length, affords so steady and clear a light, that two or three of them put into a glass will enable a person to read or write without difficulty. The bees of Guiana are very small, of a black colour, and armed with powerful stings; and one species, mentioned by Stedman, which builds its nest in the roofs of houses, is said to attack every stranger with the greatest fury, while it never molests the regular occupiers of the habitation in which it has taken up its abode. The grasshopper tribe is sufficiently numerous; but two kinds are peculiarly worthy of notice, one called "the walking leaf," from its wings, about three inches in length, being so folded on its back, as to give it a close resemblance to a brown leaf; the other, called in Surinam "Spaanse-juffer," has a body about seven inches in length, not thicker than a common quill; has no wings, but is mounted like a spider on six legs, nearly six inches long, and has on its head four antennæ, two of which are about five inches in length. An enormous and hideous looking spider, called the bush-spider, is found in the forests; and is of such a size, that one of them, when put into a case bottle eight inches high, actually reached the top with some of its claws, while its feet were resting on the bottom. It feeds upon all kinds of insects, and is said even to suck the blood of young birds. Its bite is so venomous, as to be supposed to prove sometimes fatal, and always at least occasions a fever. The groe-groe, or palm-tree worm, about three inches long, and thick as a man's thumb, of a light yellow colour, with a black head, breeds in the cabbage tree after it is cut down, is roasted and eaten as a great delicacy, equal to the finest marrow; and sometimes its fat, melted and clarified, is used instead of butter. There are centipedes above six inches in length, which move with equal rapidity backwards or forwards, and whose bite is venomous. Scorpions, also, are frequently found among old trees and rubbish; but their sting, though very painful, and apt to occasion fever, is said not to be mortal.

Insects. Cock-roaches. Ants. Fire-ant. Bees. Grasshoppers. Bush-spider. Palm-tree worm. Centipedes. Scorpions.

For an account of the native human inhabitants of this country, we refer to the general description of the American Indians, given under the article America; and shall only notice here, in a cursory manner, the particular tribes which occupy the interior of Guiana, but occasionally visit the European settlements on the coast. The chief of these are the Caribs, Accawaws, Arrowawes, and Worrows. The Caribs inhabit that part of the coast which lies between the Essequibo and the Orinoco, and are by far the most numerous, warlike, and active of the natives. Their stature is taller, their complexion lighter, and their features more sprightly and agreeable than those of the other tribes. They are also more industrious, and, besides the ordinary Indian occupations of hunting and fishing, they cultivate fields of plaintains and cassava around their dwellings. They carry on constant hostilities against the Spaniards; but are considered as allies of the Dutch. They frequently go to war also with the other tribes; and, in some instances, have been known to devour their enemies slain in battle. The Accawaws inhabit the inland districts behind the Caribs, and adjacent to the sources of the Essequibo, Demerary, and Berbice. They bear a nearer resemblance in their persons to the Caribs than the other tribes; but are more grave in their aspect and manners, and remarkable for their superior cunning. They are also addicted, more than any of their neighbours, to the use of poison, both against their enemies, and those of their own people who may have done them any injury. The Worrows occupy the coast between Demerary and Surinam, and are much darker in their colour, disagreeable in their aspect, and dirty in their habits, than any of the other tribes. They are said to be extremely pusillanimous and lazy, scarcely exerting themselves to provide any other clothing than the bark of trees, or to procure any better food than crabs and fresh water. The Arrowawes reside behind the Worrows, at the back of the settlements of Surinam and Demerary, and are described as the most gentle in manners, lively in temper, and handsome in person, of all the Indians of Guiana. They are remarkably friendly to the Europeans, and peaceable in their intercourse with the other Indian nations. Besides these four tribes, who are most frequently seen at the settlements on the coast, other two have been mentioned, namely, the Taiiras, residing on the sea-coast between Surinam and the river Amazon, who are said to be extremely numerous, but peaceable and indolent, resembling very much the Worrow tribe; and the Piannacotaws, who live far inland, and are violent enemies to all Europeans, with whom they obstinately refuse to have any kind of intercourse. It has long been the policy of the Dutch settlements to cultivate the friendship of these native tribes; and an annual sum is expended in purchasing blue cloth, beads, hatchets, ribbons, and other ornaments and implements as gifts to their Indian neighbours. They come down to the colonies occasionally in small parties, and make engagements to cut wood, an operation at which they are remarkably expert; but they soon become impatient of the restraint of regular industry; and sometimes take their departure suddenly without any apparent reason. They frequently appear also as traders, bringing as their merchandize, cotton hammocks, canoes, baskets, wax, balsam of capivi, arnotto, wild nutmeg, wild cinnamon, parrots, monkeys, ebony, and other curious woods; for which they receive, in return, chequered cloth, fire-arms, gunpowder, hatch-

Guiana. Natives. Caribs. Accawaws. Worrows. Arrowawes. Taiiras. Piannacotaws.

ets, knives, scissars, looking-glasses, fish-hooks, combs, needles, pins, beads, &c. One of their favourite purchases is rum, which they swallow with eagerness till they become completely intoxicated; but it is generally observed, that one half of the party keep themselves sober to watch their drunken friends, who afterwards perform the office of guards in their turn. Sometimes they bring down the prisoners whom they have taken in war, and sell them as slaves; but these captives serve only for show, as they absolutely refuse to work; and, if treated harshly, particularly if beaten, they pine and languish, refusing even to take food, till they finally die of want or dejection. The native Indians have a strong dislike of the negroes, whom they regard with contempt as an inferior race, and are generally ready to render assistance to the colonists in suppressing insurrections among the slaves, or apprehending the runaways. It is strongly recommended that every inducement should be offered to encourage their intercourse with the settlements; and that fairs should be held, at certain fixed seasons, for their barter trade, which might thus be greatly increased to the mutual advantage of both parties.

See Depon's *Travels in South America*; Pinckard's *Notes on the West Indies*; Bolingbroke's *Voyage to the Demerary*; Stedman's *Narrative of the Expedition against the Revolted Negroes of Surinam*; Bancroft's *Natural History of Guiana*; and *Letters to Dr Pitcairn*, published in 1766. (*q*)

GUIDO. See Rheni.

GUILDFORD, a borough and market town of England, in Surrey. It is the county town, and is situated on the side of a considerable chalk hill on the east bank of the Wey. This river is crossed by a stone bridge of five arches, which was lately widened with brick, and the centre arch enlarged to allow barges to pass. The town is large and well built, and consists principally of one excellent and spacious street, which, from the declivity of its situation, is particularly striking to strangers. Guildford contains three parish churches. Trinity church is situated on the top of the hill, and on the south side of the high street. The foundation stone was laid in 1740, and it was completed in 1763. It is a handsome brick structure, 82 feet long, and 52½ broad. The tower, which is also of brick, is about 90 feet high, and contains eight bells. St Mary's church is a very rude and ancient building, consisting of chalk, flint, pebbles, and rubble stones, coarsely put together. St Nicholas's church, which stands on the west bank of the Wey, is an ancient building of chalk and stone. The other public buildings and institutions are the hospital, the free grammar school, the town or guildhall, the theatre, and the gaol. The hospital, built in 1619, is a brick building, inclosing a quadrangular space of 66 feet broad, and 63 deep, with a noble tower gate, with four turrets, at its entrance. It was founded by George Abbot, archbishop of Canterbury, for the maintenance of a master, twelve brethren, and eight sisters. The free grammar school, built of brick and stone, was built in 1557, and is 65 feet long and 22 broad. The town or guildhall, is a spacious building, with a turret on the top. It was erected in 1683, and is 44 feet long. The hall was formerly used at the assizes; but in 1789, Lord Onslow and Lord Grantley purchased the Red Lion Inn, and on one part of the ground erected a room 40 feet long, 30 broad, and 20 high, in which the judges now sit. The theatre was built near this room a few years ago. The gaol, rebuilt of stone in 1765, is near St Mary's church. There is also here a charity school, a Roman Catholic chapel, and meeting houses for the Baptists, Presbyterians, and Quakers: a cold bath was erected at a house near the bridge, by Lord Grantley in 1775. There is a fine circular race course about two miles east of the town. A plate of 100 guineas, given by William III. and three subscription plates, exclusive of matches, are run for in Whitsun week. The castle of Guildford, one of the principal objects in the town, is situated about 300 yards southward of the high street. The keep is now the chief part that remains. It is a quadrangle 47 feet by 45½, and 70 feet high. The walls are ten feet thick. On the west side of the keep may be seen the outer gate of the castle. The ruins occupy at present about five acres. In the chalky cliff on which the castle is situated, is a series of caverns. One of these caverns is 45 feet by 20 wide, and 9 feet high. This town formerly enjoyed a considerable share of the clothing trade; but a small part of it only remains. The trade of the place consists chiefly in sending timber and corn to London by the Wey, and in supplying the surrounding villages with their requisite merchandize. A direct communication has lately been made with Brighton and the coast of Sussex by a turnpike road to Horsham, and a fund has been raised for joining the river Wey and the Arun, so as to form a navigable line from London to the sea at Little Hampton.

The town is supplied with water by means of an engine, which discharges it into a reservoir at the foot of Poyle hill, from which it is carried by pipes to the houses of the inhabitants.

The following is the population abstract for the borough for 1811.

Inhabited houses	495
Number of families	596
Families employed in agriculture	46
Do. in trade and manufactures	434
Males	1382
Females	1592
Total population	2974
Increase since 1801	340

See the *Beauties of England and Wales*, vol. xiv. p. 251.

GUILLOTINE, is the name of an instrument of death, invented by Dr Guillotin of Lyons, a member of the National Assembly of France, and used during all the horrors of the French revolution. M. Louis, a celebrated surgeon in Paris, is said to have been rewarded with 2000 livres for a dissertation on the advantages of the guillotine; and the inventor himself suffered death by his own instrument in the reign of Robespierre.

The hands of the sufferer being tied behind his back, he is fixed to a plank standing vertically, not reaching higher than his neck. This plank is suddenly brought by machinery into a horizontal position, and moved below the loaded axe, which descends with a slanting edge, and severs the head from the body.

An instrument of a similar kind seems to have been first used at Halifax in Yorkshire. It was introduced into Scotland under the name of the *Maiden* by the Regent Morton, who accidentally saw it in use when passing through Halifax; and one of these instruments is still to be seen in Edinburgh, in the Museum of the Society of the Antiquaries of Scotland.

GUINEA.

Guinea.

Boundaries and extent.

GUINEA, is a maritime district in the south-west part of Africa, to which various limits are assigned by different nations. The Dutch consider it as extending from Cape Blanco, 21° North Lat. to Cape Lopez, in 1° South Lat. making Sierra Leona, in 8½° North Lat. the boundary between North and South Guinea. The Portuguese include under the general name, the whole of the coast from Cape Ledo or Tagrin, 8° North Lat. to Cape Negro, 16° South Lat. making Cape Lopez the division between Upper and Lower Guinea. According to the French, Guinea lies betwixt Cabo Monte, 11½° West Long. and Cape Lopez; and, by the English, the tract between the mouth of the river Gambia, 12½°, and Cape Palmas, 4° North Lat. is called North Guinea; while South Guinea reaches from Cape Palmas to Cape Lopez. By the greater part of geographers, Upper Guinea is limited to that part of the coast which runs from east to west about 500 leagues, comprehending Sierra Leona, Malaguetta, or the Grain Coast, the Ivory Coast, the Gold Coast, the Slave Coast, and the kingdom of Benin. Of Lower Guinea, in the more confined application of the name, extending from the kingdom of Benin to Cape Lopez, very little is known except the line of coast; and we have only to refer our readers to the map of Africa in this work, for the names and situations of its principal districts. The southern division, between Cape Lopez and Cape Negro, has been explored, and occupied chiefly by the Portuguese; and its different countries, ANGOLA, BENGUELA, CONGO *Proper*, and LOANGO, are described under separate articles. It is to Upper Guinea, that our attention is at present to be directed, and particularly to that portion of it which is generally denominated Guinea Proper, comprehending the Ivory, Gold, and Slave Coasts. BENIN has been already noticed; and SIERRA LEONA will form the subject of a distinct article.

Grain Coast.

The interior of the Grain country is very little known, and its line of coast may be described in a few words. It is sometimes called the Pepper Coast, and Malaguetta, from the long pepper of that name; but generally the Grain Coast, from the grain of paradise with which it abounds. It extends about 100 leagues from Cape Mesurado to the vicinity of Cape Palmas; and is in general low, flat, covered with forests, and watered by numerous streams. The principal places along the coast, are Rio Junco, or Rio del Punto, about 50 miles east of Cape Mesurado, a shallow stream, about 500 paces broad at its entrance, flowing through a level and delightful tract of country, which is inhabited by a peaceable and industrious people, who are principally employed in making salt and cultivating rice, and who trade in cotton cloth, sea horse teeth, skins of wild beasts, and slaves;—the country of the Foljas, or Pholeys, a powerful tribe, who are noted for the superior elegance of their speech, and whose territories are partly watered by the Junco;—Tabo-Dragon, a large and populous village on the east bank of the Tabo, or Rio Corso, where the merchants of Dieppe established a factory;—Rio Sestos, about 50 miles from Rio Junco, said to be navigable by small barks for 25 miles, has several villages at its mouth and on its banks; and the inhabitants, called Quabo-monou, are a pacific and well-proportioned race, subsisting on millet, fruits, and fish;—Sanguin, Baffa, Setuna, Batoua, Cape Sino, Sestro-krou, Wappo, Great Sestro, &c. all villages along the coast, of which the last mentioned is the most populous, and most noted for its trade in pepper and ivory, and is situated near Rio das Escravas. The Grain Coast is generally bordered with shoals; and its staple commodities are long pepper, leather, ivory, gold-dust, and slaves.

Ivory Coast.

The Ivory Coast extends about 110 leagues from west to east, from Cape Palmas to Cape Apollonia, in a low strait line, with few bays or islands; but a foul bottom and high surf prevent vessels from anchoring or landing upon any part of it with safety. Cape Palmas, formed by two hills covered with palms, in 4° 25′ North Lat. and 12° East Long. has a small gulf behind it, where vessels may be sheltered from the south wind. Grova, a few miles eastward of Cape Palmas; Tabo-Duno, where there is a commodious road for shipping; Drevin Petri, a considerable village about 50 leagues east of Cape Palmas; Giron, on the border of a well-watered meadow; Lahou, a populous town frequented by Europeans, and abounding in provisions, and from which, eastward to Cape Apollonia, the coast is commonly called the country of the Quaquas; Gammo, a place to which the inhabitants of the interior bring down their articles of traffic; Sueiro d'Acosta, where there is a small road for ships; Issini, where the French built a fort at the beginning of the 18th century; Assoko, about five or six miles from the sea coast, and said to contain about 1000 inhabitants; Albiani and Tabo, environed with plantations of palm trees; Akani Mina, in the vicinity of Cape Apollonia, are the principal villages on the coast, and most of them are situated on the borders of rivers. The soil of the lower and maritime tracts produces cotton, indigo, cocoa nuts, fruits, rice, and other grain. The chief articles of trade are gold, ivory, salt, cotton, palm-wine, and oil. All sorts of tame animals, abound in the country; and immense numbers of elephants, tigers, panthers, serpents, &c. are found in the forests. This level coast is bounded by mountains well covered with wood, and where the vallies are generally fertile and populous.

Gold Coast.

The Gold Coast commences a few leagues westward of Cape Apollonia, and terminates at Rio Volta, an extent of about 350 miles, lying between 4° 40′, and 5° 40′ of North Lat. and between the meridian and 3° West Long. Cape Apollonia is low on the coast, but rises into three hills, covered with trees, and seen from a great distance at sea. The first fort on the windward part is Apollonia, about three miles eastward of the Cape, situated in a spacious plain, which is bounded towards the interior by a fine lake of fresh water, about six miles in circumference, and full of fish. In this lake, a small village is erected on wooden piles, the inhabitants of which are said to have been exiles from the interior, who were not allowed to build upon the land. Along the whole coast of Apollonia, the surf is exceedingly dangerous, and there are no creeks or harbours. This territory or state extends about 100 miles along the coast, and probably not more than 20 inland. The next settlement is Axim, which belongs to the Dutch, and forms part of the extensive and fertile country of Ahantah. The fort, originally built by the Por-

Guinea. Gold Coast.

tuguese, and called Fort Anthony, stands up on a promontory, which forms the western part of Cape Three Points. The landing is here perfectly safe, and may be approached by boats in the dry season without any danger. About four leagues from Fort Anthony is Fort Fredericksburgh, first erected by the Prussians, but afterwards sold to the Dutch, and now in ruins. At three leagues distance is Accoda, another Dutch settlement; and three leagues farther is Dix Cove, belonging to the British, advantageously situated at the entrance of a small cove, which is capable of admitting vessels of 40 tons at high water. Boutry, Taccorary, and Succondee, all Dutch settlements, lie at the distance of a few miles from each other; and the last mentioned forms the extremity of the Ahanta country, which is the richest and best provided with harbours of all the Gold Coast. It stretches farther inland than Apollonia, and is bounded by the Warsaw and Dinkara states. About three leagues from Succondee is Chamah, where the Dutch have a small fort called Sebastian, supposed to have been originally built by the Portuguese. About eight miles from Chamah, is Commenda, where the British and Dutch have settlements and forts, and where the inhabitants are chiefly employed in supplying vessels with canoes and canoe men for trading on the leeward coast. About 9 miles from Commenda, is Elmina, the most respectable fortress on the Gold Coast, and the head-quarters of the Dutch settlements. The town is large, and some of the houses built of stone. The river admits vessels of 100 tons at high water, which can unload under the walls of the castle. The inhabitants consist of traders, fishermen, and a few mulatto mechanics. The population amounts to about 15,000; and a considerable trade is carried on, particularly in gold and slaves. About 9 miles from Elmina, is Cape Coast Castle, the principal British fort and settlement on the Gold Coast. It was built by the Portuguese, who ceded it to the Dutch, from whom it was taken in 1665. It has been considerably improved and strengthened by the African Company; and the castle is capable of making a powerful resistance on the side towards the sea. The town is irregular, and the houses chiefly built of clay. The population amounts to 8000; and the trade consists chiefly in gold. The adjoining country is called Fetu, and is subject to the Fantee state. During the existence of the slave trade, the countries from Cape Coast to Acra were the great centre of that nefarious traffic, which brought a rapid accumulation of wealth to the native traders in every town and village, the result of which was a spirit of idleness, licentiousness, and turbulence, which threatened the overthrow of all order and security in the settlement. About four miles from Cape Coast, is a Dutch fort called Nassau, situated at a village named Mouree. About six miles from Mouree, is the British fort Anamaboa, the most compact and well built in the country; and the town, in its former flourishing state, contained at least 15,000 inhabitants. But it was destroyed in a war with the Ashantees, a powerful people in the interior; and the abolition of the slave trade, in which it formerly bore a principal share, is likely to retard its re-establishment. About three miles from Anamaboa is the town of Cormantine, where the Dutch have a fort called Amsterdam, originally built by the British, and the first that was erected on the Gold Coast. About six leagues eastward is Tantumquerry, where landing is very difficult; and, nine miles farther, is the district of Assam, or Apang, where the Dutch have a small fort, and where the coast is more accessible. About 8 miles from Assam is the town of Winnebah, where there is a small fort belonging to the British, and where the landing is generally safe. The town has been reduced, by wars and other casualties, from a population of 4000 to 2000, and was formerly a part of the Agoona country, which has recently fallen under the power of the Fantees. About three leagues from Winnebah is the Dutch fort of Berracoe; and nine leagues farther west is Acra, where there are settlements of the British, Dutch, and Danes. Acra is an independent state, which formerly belonged to the kings of Aquamboe, but has at present most intercourse with the Ashantees. It is the most healthy situation on the Gold Coast; and the inhabitants are more civilized than most of their neighbours. About 32 miles from Acra, is a small British fort named Pram Pram; and 8 miles farther, is the Danish fort of Ningo, around which the country is level and fertile, abounding in game, and in a large breed of horned cattle. About 36 miles from Ningo is Adda, where there is a Danish fort, and is situated on the left bank of the Rio Volta, which terminates the Gold Coast. This river runs nearly north-west and south-east, separating the countries of Aquamboe and Aquapim, and is navigable for small craft to the distance of 100 miles from its mouth. See Acra, Anamaboa, and Aquamboe.

Slave Coast.

The slave coast extends from Rio Volta to Rio Sagos, which separates it from the kingdom of Benin. It reaches about 50 leagues from west to east, and contains the following districts or provinces: Koto, lying between Rio Volta and Cape Monte, which is a flat, sandy territory, little frequented. Near Cape Pucalo, is a village named Quilta, where there is a British fort; and at a little distance is Koto, the capital of the country. Popo or Papa, about 10 leagues in length, between Cape Monte and Juida, is low and sandy, in some places marshy, and generally inaccessible on the coast. At the mouth of the Tari is a village of the same name, and a Dutch factory. Juida or Whidah extending several leagues, is more fertile and populous than the districts already noticed; and at the mouth of one of its rivers, called Euphrates, is a port where ships may unload, though not without considerable inconvenience from the surf. Near this river, but about two leagues from the shore, is a populous town named Sabi or Xavier, where merchants resort. At the mouth of another river, named Jaquin, are British, Portuguese, and Dutch settlements, in an island called Gregoi. Ardra extends about 15 leagues along the coast, and is a fertile but insalubrious tract. Foulaon, Assem, Jago, and Appak are the names of its principal villages. Whidah and Ardrah have been long subject to the king of Dahomy, a powerful state in the interior. The principal trade of the slave coast consists in salt, palm-oil, and slaves. See Ardrah and Dahomy.

Aspect of the country.

There are several tracts along the coast of Guinea of a sandy and sterile nature, without any other trees than the palm; but the general appearance of the country from the sea is that of an immense forest, with a few high grounds covered with lofty trees, and the thickest underwood. Many of the vallies are richly planted, and extensive plains may be seen, beautifully studded with natural clumps of trees and bushes. In the more inland parts, where the moisture is more abundant than on the coast, the woods are almost impenetrable, on account of their luxuriant growth; and the surface of the ground is completely concealed by shrubs and

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herbs. The rivers generally run in a very winding direction, and in some places overflow their banks during the wet season, forming large stagnant ponds.

Soil.

The soil varies considerably along the coast, from a light sand or gravel, to a fine black mould and loamy clay; but it is more uniformly rich and productive towards the interior of the country. For the space of six or eight miles from the sea may be found soil of every description, suited to every kind of cultivation.

Climate.

The climate is not so hot as in many other parts of Africa, nearer the tropics; and it is generally observed that the countries on the equator, from five to six degrees on either side of it, are the most temperate in the tropical regions of Africa. The temperature is found in these countries to be affected, not merely by the latitude, but by various other causes; and is always cooler where the soil is good, cultivation extensive, and the country open, with high lands in the vicinity. At Cape Coast, though accounted the hottest situation on the Gold Coast, the thermometer is usually, during the hottest months, from 85 to 90 degrees of Fahrenheit. At Winnebah and Acra, it is seldom known to exceed 87; and, during the months of June, July, August, not higher than 78 degrees.

Seasons.

The seasons, as in other tropical countries, may be distinguished into wet and dry; or rather into two wet and one dry period. The first wet season commences in the end of May, or beginning of June, when the rains fall with great violence, and without intermission for several days. Strong breezes commonly follow this first deluge, and the rains are seldom very heavy during the remainder of the wet season, which terminates with the month of July. Then begins the foggy season, which is extremely unhealthy, especially in low, swampy, or woody situations, and continues for two or three weeks. About the month of October, the second rainy season begins; but the rains do not fall with so much violence as the first, nor are they succeeded by mists and foggy weather. The dry season begins with November, and continues during the remainder of the year to the month of May; but, in the course of this period, the coast is visited with violent storms of wind, generally denominated tornadoes and harmattans. Tornadoes * commonly commence in March, and cease with the beginning of the first rains; but sometimes blow before or after the second rains or preceding a harmattan. They invariably come from the eastward, and are generally experienced a day or two after the full and change of the moon. Their approach is sufficiently indicated by vivid and successive flashes of lightning in the east, attended with thunder and heavy clouds, and by the clear and bluish appearance of the horizon. Their nearer approach is announced by the darkening of the horizon, especially in the eastern hemisphere, the increase of the lightning, and, finally, as an immediate prelude to the tempest, by a solemn stillness and entire calm in the lower part of the atmosphere, while the upper regions appear in dreadful commotion. A gentle air is then perceived, which is almost instantaneously succeeded by violent gusts of wind, usually accompanied with rain; and seldom continuing above half an hour or fifty minutes. Tremendous peals of thunder, and torrents of rain, for the space of two or more hours, terminate the storm. During its continuance, the thermometer suffers a rapid depression of five degrees or more; the air is subsequently cooled, vegetation refreshed, and the human constitution invigorated. A harmattan † is an easterly wind, which prevails in the months of December, January, and February, along the coast from Cape Verd and Cape Lopez. It comes on indiscriminately at any time of the day, or of the tide, or of the moon; and continues, sometimes one or two days, sometimes five or six, and sometimes even fifteen or sixteen. It is always accompanied by a fog or haze, which occasions a considerable obscurity, and renders the sun, which appears only a few hours about noon, of a mild red colour. Extreme dryness is another attendant of a harmattan, and, during its continuance, no moisture is perceived in the atmosphere, or any falling of dew on the earth. All vegetation is checked, and the more tender plants are completely destroyed. The grass becomes like hay, and the most vigorous ever-greens droop under its influence. Its parching effects are severely felt on the external parts of the body, particularly the eyes, nostrils, lips, and palate, which become dry and uneasy. Drink is often required, not so much to quench thirst, as to remove a painful aridity in the fauces; and, though the air is cool, a troublesome sensation of prickly heat is felt on the skin. If the wind should continue for four or five days, the scarf-skin generally peels off from the hands and face, and even from the whole of the body. Notwithstanding these disagreeable effects, it is found, on the coast of Guinea, to be highly conducive to health, restoring persons labouring under dysenteries, fevers, or any debilitating evacuations, arresting the progress of epidemics, and apparently preventing even the artificial communication of infection. ‡

Vegetable productions.

The principal vegetable productions of the coast of Guinea, are maize, millet, rice, yams, cassada, potatoes, pulse, plantains, guavas, bananas, chillees, &c. The sugar cane grows spontaneously, to a tolerable size; and the cotton shrub is found in a wild state. The indigo plant is common in many parts of the coast; and black pepper has been discovered in the inland districts. European cabbage and eschallots are cultivated in some places; and a mucilaginous vegetable, called *encrumah*, the same as the ockra of the West Indies, (*Heluscus esculentus,*) is very plentiful in the country. Besides the ordinary tropical fruits, there is one of a very nutritious nature, called *enteraba*, which is much used, and is about the shape and size of the largest onions. The silk-cotton tree is found in every part of the coast, and grows to a majestic size, so as to furnish excellent materials for the formation of canoes. There is a great variety of useful timber in the country, but the palm-tree is the most profitable to the natives. Of the leaf they make rope, thread, nets, fishing lines, &c. From the fruit they express an oil of great delicacy, which is used in all their dishes, and, when eaten fresh, is equal to excellent butter. The kernel contains a hard pulpy substance, which is sometimes roasted and eaten by the women, as promoting corpulency. From the trunk of the tallest species, which sometimes reach 100 feet in height, they draw an intoxicating liquid which they call palm-wine, and which is procured by inserting a reed into a hole at the top of the tree, through which the liquor flows into an earthen pot. A similar liquid, of a more agreeable flavour, and less intoxicating qua-

* The name *tornadoe* is supposed to be a corruption of the Portuguese word *trevado*, a thunder storm.

† Supposed to be a Fantee word, pronounced by the natives *harmanta*, and said by them to signify a cold dry wind.

‡ It appears to be the same kind of wind as the *sammiel* of Egypt, and the *sirocco* of the Mediterranean.

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lity, is procured from the low-palm; but, in order to procure it, the tree is generally dug up, and the trunk heated by fire, that the juice may flow more abundantly. This wine is drunk in a state of effervescence, and will not keep above a few hours.

Minerals.

The mountains of Guinea, as far as they have been examined, are in general granitic and schistous, and are filled with mines of gold and iron. The latter of these metals is little known to the natives, and Europeans have not thought it their interest to instruct them in the subject; but the first has been sought from time immemorial, and is likely to become a still more extensive object of traffic, in proportion as the exportation of human beings shall cease.

Gold mines.

Gold is found in these mountains in a primitive state, between two layers of a granite, finer, more solid, and more highly coloured than the rest of the rock; but the natives, unacquainted with the art of mining, and unprovided with proper tools for the purpose, have never attempted to work it in these places. They confine their operations to digging at the base of the mountains, where the schistous beds and banks of granite are more friable, and washing the sands in the beds of rivers and water courses at the bottom of the hills, when the rain water has run off. In digging, they work downwards, as if forming a well; or sometimes make a ditch about 20 or 30 feet deep, till they become alarmed for the crumbling down of the earth. They generally begin to find the gold at the depth of three feet; and, as they advance in the work, put the lumps of the metal into pouches which are fixed round their waists. Pieces are sometimes found of a considerable size, and the king of Ashantee is said to possess a lump of native gold, so large that four men are required to lift it. The earth, which is thrown out in the course of the digging, is laid in heaps at the side of the pit, and is carried by other labourers, chiefly women and children, to the nearest river, where it is washed in bags or wooden bowls, and the particles of gold afterwards separated from the heavier parts, which remain in the vessel. This ore is sometimes so rich, that a piece of it, weighing four or five ounces, has been known, when pounded and washed, to produce about four pennyweights of gold dust; and the general fertility of the mines may be estimated from the circumstance of the slaves employed by the king of Ashantee in 1790, engaging to supply him with half an ounce a-day for each labourer. The gold-finders, who wash the sands on the banks of rivers, and the sea-shore, are less successful in their researches, and it is generally the women only who are thus employed; but this precious metal, it is sufficiently ascertained, is very abundant in the interior of the country, and the mines may be considered as still virgin mines.

Animals.

The animals of Guinea are numerous, but only such as are common to the western coast of Africa. The ordinary domestic animals, dogs, cats, sheep, goats, and hogs, are plentiful in most places; and poultry, particularly, is found in great abundance. There are horned cattle in some parts of the coast, especially in Apollonia, but only in the possession of the chiefs. The wild animals are buffaloes, tiger cats, leopards, hyænas, jackals, antbears, porcupines, monkeys, deer, hares, squirrels, musk-cats, alligators, lizards, land-crabs, chameleons, guanos, scorpions, centipedes, and a variety of snakes. The hippopotamus is occasionally seen on the banks of the river Volta. The feathered tribe in a wild state are extremely various; and the smaller birds, particularly, are remarkable for the beauty of their plumage. The lakes and rivers abound with mullet and other kinds of fish; oysters and prawns are plentiful in some places; and turtles are not uncommon. There is a variety of excellent fish on the coast, which is procured in abundance, during the dry season, when the surf is least violent.

Natives.

There are several distinct nations along the coast of Guinea; but their general customs are so extremely similar, that they may be described as one people. The most powerful tribes are found in the interior of the country, and they are, in many respects, superior to those who inhabit the maritime districts. The two most extensive of these kingdoms are Dahomy (see DAHOMY) and Ashantee, both of which have made their power at times severely felt on the coast. The former is described in a preceding article; but very little was known of the latter, till its king appeared on the coast, in a war against the Fantees in 1807; when the discipline and bravery of the army, and the order and regularity of the court, evinced a considerable degree of civilization. The following account of an interview between the governor of the British fort at Annamaboe and the king may furnish some idea of this people. " The governor was obliged to visit each man of rank, before he could be received by the king; a ceremony that could not be prudently denied, and which occupied some time; for those men had their several courts, and collectively had formed an extensive circle. Every one of them was seated under a huge umbrella, surrounded by attendants and guards, with young persons employed in fanning the air, and dispersing the flies." " After the ceremony of visiting those persons was over, the governor was conducted towards the king, who was surrounded by a number of attendants, whose appearance bore evident marks of riches and authority. Chairs, stools, axes, swords, flutes, message-canes, &c. were either of solid gold, or richly adorned with that metal. Those dazzling appearances, added to damask, taffety, and other rich dresses, gave a splendour to the scene, highly interesting. When the governor approached the king, and when an interchange of compliments had passed, the air resounded with the noise of musical instruments, such as drums, horns, and flutes. After some conversation, during which much politeness was observed in the behaviour of the king, the governor wished this ceremonial visit to be returned, &c.—The king was of the middle size, well-formed, and perfectly black, with regular features, and an open and pleasing countenance. His manner indicated understanding, and was adorned with gracefulness; and in all respects he exceeded the expectations of every person. His dress was plain; it consisted of a piece of silk wrapt loosely about him; a wreath of green silk ornamented his head; his sandals were neatly made, and curiously studded with gold. He was not distinguished by any gold ornaments as his attendants were." *

Government and laws.

The kingdoms along the coast are considerably different in respect of government. Among some tribes, as in Apollonia and the Slave Coast, it is absolute monarchy; in others, as in the Ahanta country, a kind of aristocracy; and in others, as among the Fantees, it consists of a variety of forms, according to some of which the power is lodged in the hands of the community at large, as in a democracy;

* Meredith's Account of the Gold Coast.

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and in others, as in Acra, it is a mixture of aristocracy and democracy. In this last mentioned country, the inhabitants of different states are known to unite occasionally for general safety under the absolute command of individuals, as in a dictatorship; and, when the danger is past, to revert to their accustomed forms of government. The laws consequently differ considerably in the form of administration, according to the nature of the government; but. during the continuance of the slave trade, the most trifling offence was every where examined with the utmost strictness, and almost every punishment was commuted into slavery. The prevailing penalties are fines, or servitude, which are almost the same punishment, as every convict, if unable to pay his fine, becomes a slave. Even murder, though by law generally punishable with death, may be compensated by the payment of seven slaves, or their value; but if the person murdered should have been of any consequence or authority, the law of retaliation is enforced, and much bloodshed ensues. In the Fantee country the laws are more rigorous than in any other part of the coast. If any person be detected in the act of committing the most trifling theft, he forfeits his freedom; and if the article stolen should be valuable, his family becomes involved in his fate. If any one, either by accident or design, should kill a hog, a goat, even a hen, or any other animal which is the property of another, he loses his liberty, unless he can soften the injured party by presents. The law against witchcraft is peculiarly severe, and extends to all under the same roof with the offender, as they are supposed to possess some portion of the evil influence; but, since the abolition of the slave traffic, few convictions of this kind have taken place, and the rigour of the laws respecting trifling offences has begun to relax. Another oppressive law, peculiar to the Fantee country, deserves to be noticed, chiefly as demonstrating the baneful effects of the same odious trade in human beings. If a person become involved in debt, and was either unable or unwilling to pay, the creditor was at liberty to "panyar," that is, to seize and confine any person or persons belonging to the family, or the town, or even the country of the debtor; and these captives, if opportunity offered, were sold as slaves without any delay or ceremony. During the time of the slave trade, this custom was often practised under false pretexts of debts or offences, and many innocent persons forcibly seized, and instantly sold by private individuals, without any possibility of redress.

In the monarchical state of Apollonia, the right of succession devolves on the son of the king's sister. The reigning sovereign is the sole administrator of justice; and passes sentence without the advice of any of his subjects; but, if the accused be a person of rank, he generally receives a message requiring him to prove his innocence by the ordeal. This consists in swallowing a portion of a certain bark, accounted poisonous, which, if rejected from the stomach, is a token of innocence, but if retained, (in which case it commonly proves fatal,) it is an evidence of guilt. In the more mixed governments, as in the Fantee country, the administration of justice and of public affairs resides principally in the pynins or elders, who are elected by the public voice, and sometimes succeed by hereditary right. They are the oracles of the laws, which they commit to memory with extraordinary correctness; and, in the trial of causes, they act at once as judges and jurors. They assemble their courts in the market-place, where both parties are attentively heard, witnesses regularly examined, and sentence duly pronounced. They have a share in all fines and forfeitures, and generally receive a present of rum when any cause of importance is brought before them. If the condemned party think himself aggrieved, he may appeal to the elders of another town or district, and sometimes to the governor of the neighbouring European fort. The natives are said to plead their causes with much ability, and to accompany their words with suitable and energetic gesture. In consequence of the strictness of the laws, crimes are extremely rare; but, during the prevalence of the slave trade, when false accusations and false witnesses abounded, condemnations occurred every day. But, though the natives rarely commit thefts against the property of their countrymen, every thing belonging to a white man is considered as a fair object of plunder. In cases of slander or evil speaking, a peculiar trial, called "brandeeing," is instituted between the parties. The injured person repairs to the market-place with a portion of spirits, and invites his accuser to make good his assertions, who is obliged to produce an equal quantity of liquor before he can obtain a hearing. The person found guilty is required to make a pecuniary compensation to the other; and the spirits, which in the case of wealthy individuals sometimes exceed a hundred gallons, go to the elders, and the friends of the person who is acquitted.

Religion.

The religion of the natives of Guinea is not easily described. They have some notion of a Supreme Being; but their worship consists in a mass of strange and unmeaning superstitions, of which they do not attempt to give any account. They do not generally engage in any external worship; and though, on certain days, they abstain from their ordinary employments, they have no reason to assign, except that it has been the custom. In some places there is an annual sacrifice of a deer to the divinity. They seem to hold the moon in greater veneration than the sun, and welcome her appearance with great rejoicings. Their system of belief, however, is little else than a constant fear of some malignant influence, and a superstitious confidence in certain charms to avert the dreaded evil. Their object of worship, whatever it be, bears the undefinable name of Fetish, a word which some suppose to be derived from the Portuguese *fetischo*, witchcraft; but which is applied with great latitude to any thing sacred, prohibited, unlucky, or unaccountable, and is considered as equivalent to the "Obi" of the West Indies, perhaps also to the "taboo" of the South Sea islands. In Acra, the principal image, or deity, is a large mass of solid gold in the form of a human head. In the Fantee capital, Abrah, their chief object of adoration, is denominated, Woorah, woorah! Agah, nannah! that is, Master, master! Father of all! But every town or village has its own favourite idol, and even in every house is some object emblematic of a divinity. The Fetishmen or women, who are considered as alone possessed of any knowledge, are not only the priests, but also the lawyers and physicians of the country. They are supposed to have communications with the demon or Fetish, and to be able to instruct their votaries in every case of actual or apprehended evil. Their good offices must be procured by presents, which are often of considerable value, and are appropriated to their own use. They are usually connected with persons in power, and are frequently useful in enforcing the authority of the laws. Where there is no monarch, and the government is lodged in the community, these persons assume great consequence, and render it hazardous for any one to

Guinea. withstand their influence, or to be guilty of any neglect towards the Fetish.

Languages. There are innumerable languages and dialects along the whole of the west coast of Africa; but the most prevalent in Guinea is the Fantee, which is understood from Apollonia to Acra, and to a considerable distance inland. It is soft and harmonious; but has never been reduced to writing. The following specimen gives the proper names of men and women, according to the day of the week on which they were born.

Days of the week.	Men.	Women.
Sunday	Quashie	Aquishervah
Monday	Cudjoe	Adjuah
Tuesday	Quabino	Abinabah
Wednesday	Quacoe	Eccoah
Thursday	Quow	Abbah
Friday	Couffee	Effuah
Saturday	Quamina	Ambah.

Character of the natives. The natives of the coast of Guinea are in general extremely similar in their physical qualities, and in their prevailing customs; but differ considerably in their dispositions and morals. The diversity in this respect is ascribed, with sufficient probability, to their intercourse with Europeans, and especially to the degree in which they engage in the slave trade; but seems also to arise partly from the form and character of the native governments. In most of the districts they are tall, well formed, with the usual negro features, thick lips, and flat noses. On the Grain Coast, especially in the western parts, they are mild, peaceable, honest, and industrious; but on the Ivory Coast they have become deceitful and cruel. In Apollonia, they are extremely courteous, hospitable, and brave; but generally reserved in their manners, a circumstance which has been attributed more to the despotic form of their government than their natural disposition. In the Ahantah country, they are friendly in their manners, and more free in conversation than the Apollonians, but less hospitable and courteous. The people of Chamah and Commenda are very turbulent and ferocious, addicted to frequent quarrels, and much inclined to maltreat Europeans. Those of Elmina have generally been found to be civil and peaceable; but some recent instances have occurred of their ferocity when roused by provocation. The Fantees are generally an indolent, ferocious, and faithless people; and their petty chiefs are extremely avaricious and deceitful, watching every opportunity to gratify their vicious passions. The natives of the Agonna country, especially around Winnebah, have long been noted for every species of licentiousness, living entirely by plunder, and displaying a degree of ferocity unparalleled in any other part of the coast. In Acra and Adampe, the inhabitants are remarkably indolent, addicted to drunkenness, and full of deceit; but those of Acra have been considerably improved by their intercourse with the Ashantees, a powerful people in the interior, already mentioned, and who manifest a greater attention to the rules of decency and morality than any other tribe yet discovered in the country.

"Notwithstanding some years acquaintance with the natives," (says Mr Meredith, referring principally to the Gold Coast,) "I find it no easy matter to lay down their true character; for they appear to us in a variety of forms, according to the nature of our intercourse with them, and to their employment. Those persons who are indifferent to exceed a further intimacy with Europeans, than an interchange of commodities will admit of, are to be viewed in the true light of peddling traders. When there is a prospect of a good bargain to be obtained, every species of low cunning and mercenary artifice is practised to acquire it. They accommodate themselves with much ingenuity and facility to our humours and fancies; every attitude, every expression, is carefully recommended by flexibility and supplication; yet they carefully avoid (showing) too great a desire of obtaining what would turn out profitable or advantageous to them; and, when they know that their wishes are not to be gratified as easily as was expected, disappointment is carefully concealed, and a seeming indifference is preserved in their behaviour."—"They may be justly pronounced as possessing all the chicanery inseparable from their calling, and are not readily outwitted. Those who gain a livelihood by fishing, are a laborious people; and our knowledge of them extends a little further than of the trader, because they are employed frequently by us as canoemen and labourers. When thus employed, they perform their duty with cheerfulness; and, if encouraged, will go through a vast deal of labour; but they must be treated with exactness and punctuality. When they call for any customary allowance, or for payment, they do not like to be put off, and expect that their labour should meet with its instant reward. If they be not punctually attended to, they become neglectful, and inattentive to the interest of their employer. They are much addicted to that vice (theft), which prevails in almost every part of the world, and are very expert in the practice of it, particularly as to small articles which they can easily conceal. Men who follow an agricultural life, and who chiefly inhabit the inland parts, will be found more uniform in their conduct than the traders or fishermen. To consider them in a general view, and to make allowances for the failings attached to the uncivilized part of mankind, they may be considered a well-meaning set of men. They are divested of that low cunning and deceitful artifice, known and practised by those who gain a livelihood by a more intimate connection with Europeans. They possess no small share of honesty, sincerity, and benevolence; and are strangers to the corrupt and licentious conduct plainly to be seen among the inhabitants of the water side."—"The natives of the sea coast, from a more immediate connection with Europeans we should suppose, are more inclined to industry than those inland; but it will be found that real industry prevails more uniformly inland, and vice is less encouraged. Every person on the coast appears very diligent in acquiring the profits of his occupation; but profligacy, drunkenness, and debauchery, are practised to a pernicious extent."

Manners and customs. Young persons of both sexes generally go naked till the age of puberty, (which takes place in males at the age of twelve, and in females at ten,) except a girdle about the loins, with a small slip of cloth affixed to it for the sake of decency. Dress. The dress of both sexes is nearly alike, and consists in a piece of cloth, about four yards long and two broad, wrapped loosely around them; but, when engaged in any occupation, part of it is folded about the loins, and the remainder hanging down, covers the lower part of the body. The more wealthy, especially when they travel, are provided with hats, and sometimes with sandals. The women generally have their breasts uncovered; and their garment is fastened round their middle by a girdle or zone called tombah, which is supported behind by folds of cloth, forming a protuberance, in proportion to the age and rank of the

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wearer. Women of quality have likewise a number of silver keys suspended by a ring to the front of the girdle. The women also wear bracelets and necklaces of gold and beads, and frequently oval brass rings on their ankles. Both sexes are remarkably attentive to the decoration of their heads, and cut the hair with great nicety and taste. Some of the men allow the hair to grow on the chin, and occasionally wear whiskers and mustaches. The old men shave the whole of the head, leaving only one or two locks behind, to which they commonly keep a piece of gold suspended. The Fantees are distinguished from the other natives by small scarifications on the upper part of the cheek bones, and on the back of the neck. Both the men and women among this tribe are remarkably cleanly, and generally wash their whole bodies twice a day. The Fetish men, especially in Acra, are habited in white, a colour which is held in great veneration in all parts of the country, as emblematic of purity and perfection. The principal article of food in the Fantee country is bread, which is unleavened, and made of maize or Indian corn. In all their dishes, pepper is a necessary ingredient. Their chief mess consists of fish or poultry made into soup, with fresh palm oil, pepper, salt, and eschallots; and with this high-seasoned dish they eat bread, or yams and plantains made into a pudding. The men and women generally eat separately; and seat themselves in small parties round a bowl of soup, into which they alternately dip some bread or pudding. They do not drink during their meals; but, after finishing the repast, sometimes indulge freely in the use of palm wine or spirits. The houses are commonly made of bamboo, and plaistered with a strong loamy clay, with which also the floors are laid. The towns and villages are generally surrounded by a strong fence of bamboo cane, as a protection against wild beasts.

Arts and manufactures are in a very low state among the natives. They make canoes, baskets, mats, bills, hoes, fishing nets, hooks, lines, &c. and some of them work as masons and carpenters. The women, who are literally the slaves of the men, perform most of the laborious offices, such as grinding corn, procuring food and water, every thing in short except fishing and planting. In the Ahantah country particularly, the people are much inclined to agriculture, which is in a very rude and defective state; but, in many of the maritime villages, besides acting as fishermen, they used to procure their subsistence, in a great measure, by hiring themselves as canoe men to the slave ships bound to the leeward coast. Their canoes are of various sizes, requiring from 3 to 21 oars, or rather paddles; and some of the larger have a platform in the bottom, with an awning erected over the fore part of the deck, for the shelter of the passengers. These canoes are made of the trunks of the silk cotton tree, shaped and hollowed by a very simple iron instrument like a large chisel, answering either as axe or adze, according to the form of its handle. The wood of these trees, especially when green, is soft, and easily worked; when dry, almost as light as cork; and sometimes large enough to make a canoe paddled by twenty men, and carrying four puncheons of liquor. Those who are acquainted with the management of these canoes, conduct them through the high surf on the coast with great dexterity. On coming ashore, they watch the sea when on the point of breaking, and betake themselves to steering, by keeping the flat part of the paddle parallel to the canoe, and giving it a quick motion, moving it nearly at right angles with the canoe; and, when it is on the summit of the wave which is ready to break, this quick motion is discontinued, the paddle kept firmly in a parallel position, and the canoe, steadily balanced and directed in a straight course, flies on shore with amazing velocity.

Travelling. In travelling by land, Europeans make use of a large cotton hammock, which is slung from a bamboo pole about nine feet long, and covered by a cloth in such a manner, that the person carried in it may either sit up or lie down. For a distance of 25 or 30 miles, this conveyance requires six or eight bearers, two of whom carry it by turns; and, if well supplied with rum, will travel at the rate of five miles an hour. When a party of Europeans travelling in this way arrive at a town or village, they are met by the men in their war dresses, jumping and firing their muskets heavily loaded with powder almost in the faces of the visitors; a ceremony which is not without hazard, from the occasional bursting of the pieces, and which it is necessary nevertheless to requite by a present of liquor and gunpowder.

Amusements. The recreations of the younger part of the people consist chiefly in dancing and singing; and they are in most places fond of music. Their instruments consist of drums of various forms and sizes; horns made of the tusks of young elephants, and sounding like a bugle; and flutes made of a large reed, about four feet in length, open at both ends, and producing a soft and plaintive note.

Marriages. Polygamy prevails in every part of the coast, and every man may have as many wives as he can maintain; but the first wife has the sole management of the domestic affairs within the house, besides acting as a watch over the fidelity of the rest. Mothers have the entire disposal of their daughters in marriage, and their consent must be procured by presents. After the payment of a certain sum, which is regulated by custom, the young woman is dressed according to her rank with rich cloths, valuable beads and ornaments of gold; and conducted by the female relatives to the house of her husband, where she is formally received by his relations and friends. On the following day she receives visits, and must continue to appear in her wedding dress for a week.

Funerals. The Fantees, and most of the other tribes, bury their dead within their houses; and they are very reluctant to leave the spot where their relatives are interred. If any one die in a state of insolvency, his body does not receive the rites of burial till his debts are discharged; and the corpses of persons guilty of suicide are burned, unless a considerable sum be paid to the elders for permission to commit them to the earth. In Apollonia funerals are in general solemnized by a mixture of condoling and carousing; and every friend of the deceased contributes something expressive of regard for his memory. Cloth, spirits, and gunpowder, are lavished on these occasions; and, till the body be deposited in the ground, there is a continual succession of dances, songs, volleys of guns, and lamentable exclamations. These customary revellings, however, are performed by persons hired for the purpose, and, after the interment, the habitation of the deceased exhibits sufficient tokens of real affliction. The dead body is exposed for several days to public view, decorated with ornaments and valuable articles; and, when buried, gold, rich cloths, and other things of value, are put into the grave. At the funeral of any person of eminence, some of his slaves, generally the old and infirm, are offered in sacrifice. "In the year 1800," says Mr Me-

Guinea. redith, "when a king of Apollonia died, one or two human beings were sacrificed every Saturday, until the grand ceremony took place, which did not happen till six months after his decease. On that occasion, upwards of fifty persons were sacrificed, and two of his youngest wives were put into the grave. The lid of the coffin was covered with human blood, and gold dust sprinkled upon it, and much gold and rich cloths were deposited in the grave.

Diseases. The diseases incident to the natives of Guinea are, leprosy, which is greatly dreaded, and generally considered incurable; though, in its milder form, and when early attended to, it is sometimes removed. It is in some places supposed to be contagious, and the sufferers are excluded from society. The natives employ chiefly vesicating and excoriating substances in the milder cases. Yaws, appearing in white crusted spots on the skin, not a common but a very infectious disease, and though repressed for a time, is never radically cured. Elephantiasis, an enormous hard swelling of the legs, which is also incurable. Smallpox, which causes great ravages wherever it appears, and to which the natives in general apply no remedy; but, in some parts of the coast, inoculation is practised, and the puncture usually made at the wrist. Guinea-worm, peculiar to the sea coast, and supposed to be occasioned by drinking water full of animalculæ, as it is seldom experienced in places provided with good water. It is considered by others as rather produced by absorption through the pores of the skin, as persons are known to receive it by going to the pools for water, and by infection from others. The legs are the most common seat of the disease, though occasionally it has appeared in other parts of the body. The worm itself appears no bigger than a large woollen thread, of a whitish colour, and rather flattened in its form; but some have been extracted above thirteen feet in length. Much pain is felt before it protrudes through the skin, and an inflammatory tumour is produced, through which the creature makes its appearance. The natives then apply a slip of wood to the sore; and, when the worm comes in contact with it, they carefully turn it round, so as to wind the worm upon it, leaving it suspended in this situation, that the weight may draw it out more speedily. If the animal is broken, the part remaining in the flesh generally recedes, and may not reappear for months; and, unless properly managed, much pain and dangerous sores are often the consequence.—Enlarged scrotum, supposed to be caused by an immoderate use of palm wine.—Dysentery, which the natives treat with great success, by administering drastic purgatives, followed by stimulating astringent clysters, making use of suppositories, keeping the patient warm, and frequently imbrocating the loins and belly with a composition of pepper.—Ophthalmia, which though not common, is troublesome at some seasons, but chiefly occasioned by excesses in living; and is treated by the natives only with topical remedies, inserting lime juice into the eye, and drawing blood from the temples.—Fevers, which are most prevalent after the periodical rains; and, excepting a few external applications, such as ablutions with warm water, and rubbing the body with certain herbs, are left by the natives to the powers of nature.—Rheumatism, a common disorder, successfully removed by tepid applications and warm clothing.—Internal inflammations, pleurisies, and pulmonary diseases, are very general during the rainy season. The medical practitioners of the country are principally females, whose skill is transmitted from one generation to another, and who perform the operations of scarification and cupping with great dexterity, as well as discover considerable botanical knowledge in the selection of herbs and plants. The male physicians are generally ranked among the Fetish men, and are much greater empyrics than the women, imposing upon the credulity, or working upon the imaginations of their patients, by pretending to expel the evil influence, or extract the supposed cause of their sufferings.

Climate. The insalubrity of the climate to Europeans is understood to have been greatly exaggerated, and to be chiefly owing to their own excesses and neglect of proper precautions. The climate of Guinea is greatly superior to that of Guiana, which lies under the same parallel; and any part of the coast, if cleared and improved, would not be less healthful, it has been affirmed, than Barbadoes, the most salubrious of the West India islands. Strangers arriving in the country are directed, by Mr Meredith, to avoid, as much as possible, the meridian sun, by keeping within doors from eight o'clock in the morning to three in the afternoon, but to take regular exercise before and after these hours; to travel during the night with heavy clothing to protect the body from the dews, or, if necessitated to go out in the day-time, to use an umbrella, and place a handkerchief or two between the head and the hat, to rub the body well with coarse cloths, and put on warm clothing after getting wet, and, if much exposed to rain, to bathe in salt water, but never to apply spirits to the surface of the body; to use cold bathing frequently, to practise early rising, to take animal food only once a day, and to wear flannel next the body; to counteract the damp air of the wet season by heavy clothing, warm apartments, and even occasional fumigation of the rooms with vinegar, sulphur, or tobacco; and, in the dry months of December and January, to be more attentive to exercise in the open air, temperance in living, and the use of cooling laxatives. Persons just arrived in the country are particularly warned to be sparing in diet, refraining from salt meat, and freely using vegetables and acid fruits; to drink also sparingly, using chiefly rum and water, wine and water, lemonade, &c.; to take the cold bath every day, and avoid the heat of the sun as much as possible; and to keep the body gently open by means of salts, cream of tartar, or similar cooling purgatives, of which a dose should be taken every week for two months, till the constitution becomes habituated to the climate.

Trade. Europeans have hitherto made no attempt to extend their commerce to the interior of the country; but, with the exception of slaves, (which must soon cease, it is hoped, to be enumerated among articles of traffic,) have confined themselves to a very limited coast-trade. The articles of which it consists are chiefly pepper, palm oil, cowries, ivory, gold; in exchange for which, they import lead, iron, fire-arms, gunpowder, tobacco, spirits, tobacco-pipes, vessels of brass, woollens and cottons of British manufacture, and especially East India cotton goods, which are most esteemed in the country. All the ivory is procured from the interior, and, in all the inland countries, gold is found in considerable quantities. The native traders penetrate to a great distance into the interior in quest of these articles, or rather they pass through numerous hands from nation to nation till they reach the commercial establishments on the coast; but all the people, concerned in this inland traffic, are extremely mysterious in their operations, and very reluctant to communicate the slightest intelligence on the subject. It is only gold-dust that they sell to the Europeans, as they generally convert into ornaments the solid pieces, and even hold them sacred, if tolerably large. The gold of this country, whether in grains or in dust, is extremely pale, though very pure; and greatly resembles the filings of yellow copper, with which it is sometimes fraudulently mixed. This alloy is easily discovered by means of aqua fortis; but it is sometimes also imperfectly cleaned from the sand, which is of a quartzose nature, and which requires a keen eye, a glass, or even the crucible to detect its presence. The native brokers or gold-takers are extremely skilful in this commerce, and know with the utmost precision the value of what they sell; but they are often equally well versed in the arts of knavery, requiring to be trusted with great caution, and only upon good recommendation. In Apollonia, it is said, the trader is more secure, either from exactions or impositions, and his person is considered as sacred. The gold trade is understood to have diminished considerably of late, in consequence of the more powerful princes having attempted to secure a monopoly for themselves, by compelling the weaker to renounce the working of their mines. Cowries and gold form the current medium of exchange, especially the former, as being easily reduced to the smallest sums. Forty cowries make a string; fifty strings a head, which is equal to one ackey of gold; and sixteen ackies make an ounce, which is valued at four pounds sterling.* The price of gold never fluctuates; and it is commonly estimated to yield in Europe a profit of 25 per cent. Much attention has recently been directed to the improvement and civilization of this and other tracts on the western coast of Africa; and a more interesting topic could scarcely be presented to enlightened humanity, than an enquiry into the most effectual means of promoting the benevolent object. It has been suggested, in general, to extend our trade inland, by forming alliances with the princes, and placing residents in the principal towns; thus reaching the resources of the country, securing the confidence of the natives, and enlarging the demand for European manufactures;—to encourage the progress of cultivation, by protecting planters from Europe, and directing the industry of the natives to the production of new articles of export;—to annihilate absolutely every vestige of the slave trade, to establish schools for the instruction of the people, and to exercise, in the vicinity of our settlements, as much controuling power of government as possible, for introducing salutary regulations, and enforcing orderly obedience.† "There exists no country in the world," says the French mineralogist De Montfort, "so susceptible of general cultivation. We know that certain districts of Africa are fertile in corn, and grain of every kind grows there intermixed with sugar-canes lately introduced, and which protect the grain from hail. The plants of India, Europe, America, Australasia, or the fifth portion of the globe, will flourish there in perpetual spring, and the animals of all climates can be easily naturalized. The negroes, whose respect for the whites is extreme, notwithstanding what they have suffered from them, will cheerfully give up their lands to be cultivated by us." *Philosophical Magazine*, vol. xlvi. p. 302. See Meredith's *Account of the Gold Coast*; Smith's *Voyage to Guinea*; Peuchet's *Dict. De la Geog.*; and Playfair's *Geography*. (*q*)

GUITAR, *Guitarra* Spanish, *Chitarra* Italian, from *Cithara*, is the name of a musical instrument, commonly strung with wire; but in Spain, the guitars are always strung with catgut or bowel strings, which gives them a much finer tone. The Guitar seems to have been introduced into Spain by the Moors, and has at particular times been more or less in use in almost every part of Europe.

GULF STREAM, is the name given to a constant current in the ocean, produced by the trade winds, which are constantly blowing from east to west. This current, coming from the Pacific and Indian Oceans, passes round the Cape of Good Hope, and, after going along the coast of Africa, it crosses to America towards the equator. It is there divided, and reflected southwards to the Brazils, and running along the shores of Guiana and Terra Firma, it passes through the Caribbean Sea, and coasts along the Gulf of Mexico. Issuing from the Gulf between Cape Florida and the island of Cuba, it traverses the coasts of East Florida, the United States, New Brunswick, and Nova Scotia, and advances eastward to the banks of Newfoundland, where it turns off to the south-east and runs through the Western Islands, from which it goes to the coast of Africa, and in a southerly direction along that coast, till it supplies the place of the waters carried away to the west by the trade winds. "It is perhaps on account of these currents," says Dr Thomas Young, "that the Red Sea is found to be about 25 feet higher than the Mediterranean.‡ Their direction may possibly have been somewhat changed in the course of many ages, and with it the level of the Mediterranean also, since the floor of the cathedral at Ravenna is now several feet lower with respect to the sea than it is supposed to have been formerly; and some steps have been found in the rock of Malta, apparently intended for ascending it, which are at present under water." M. Humboldt remarks, "that the Gulf Stream is occasioned by the current of rotation, (trade winds,) which strikes against the coasts of Veragua and Honduras, and ascending towards the Gulf of Mexico between Cape Caloche and Cape St Antoine, issues through the canal of Bahama. It is owing to this motion, that the vegetable productions of the Antilles are carried to Norway, Ireland, and the Canaries."

The general breadth of the Gulf Stream is about 50 or 60 miles. Sir Charles Blagden, in a voyage to America in the year 1774, found that the water of the Gulf Stream was from 6° to 11° warmer than the waters of the sea through which it ran. The heat at its commencement in the Gulf of Florida was about 82°, and it lost 2° for every 3° of latitude in going northwards. It continued sensible off Nantucket.

The Gulf Stream may be easily distinguished from the other waters of the ocean, by the gulf-weed with which it is every where interspersed, and by its not sparkling in the night. In high latitudes it is always covered with a thick fog. Its breadth is diminished by north-east and east winds, which also increase the rapidity of its motion, and drive it nearer the coast. A

* It is said that a labouring man, during the plentiful season, from September to May, can subsist abundantly on two strings, or twopence farthing a day; and that the usual pay of a labourer is from two to three ackies per month, *i. e.* from 10s. to 15s. currency.

† For the best views of this interesting subject, the readers may be referred to the *Reports of the African Institution*; and the accounts of these publications in the *Edinburgh Review*.

‡ The observations of the French engineers make it 6 toises or 38 feet.

contrary effect is produced by north-west, and west winds.

The Gulf Stream passes at the distance of about 75 miles from the coast of the southern states of America. This distance, however, augments as it advances northwards. Its common velocity is about three miles an hour, and it takes about 20 days to run from Cape Florida to Newfoundland.

See Franklin's *Maritime Observations* in the Transactions of the American Philosophical Society, vol. ii. p. 314. This paper contains a chart of the Gulf Stream, principally from the observations of Captain Folger. Blagden *On the Heat of the Water in the Gulf Stream* in the Phil. Trans. 1781, page 334. Pownall's *Hydraulic and Nautical Observations,* 4to, London, 1787. This last work also contains a chart of the Gulf Stream. Rennel, *Phil. Trans.* 1793, vol. lxxxiii. p. 8. Humboldt's *Political Essay on the Kingdom of New Spain,* vol. i. p. 53; and Humboldt's *Voyage to the Tropics,* vol. ii. chap. i. Young's *Natural Philosophy,* vol. i. p. 587; and Morse's *Geography.* See also PHYSICAL *Geography.*

GUMS. See CHEMISTRY, vol. vi. p. 108, 121—128.

GUM *Amber.* See AMBER, and CHEMISTRY, p. 124.

GUM *Ammoniac.* See CHEMISTRY, page 128. This gum should be chosen full of drops or tears, dry, brittle, easily softened by the fire, reducible to a white powder, and of a sharp taste and smell. When thrown on live coals, the drops should burn away in a flame. In 1804, the quantity imported by the East India Company was 81 cwt. and the price per cwt. £3, 11s. 1d. In 1805, the quantity was 333 cwt. and the price £1, 12s. 2d. In 1806, 81 cwt. were imported at the price of £1, 8s. 2d. And in 1807, 59 cwt. were imported at the price of £1, 15s.

GUM *Anime.* See CHEMISTRY, p. 123. This gum should be chosen in large pieces, clear and transparent. When laid on a red hot iron it melts, flames, and burns quickly away with a fragrant smell, leaving a few light coloured ashes. Small dark coloured and opaque pieces should be rejected. The quantity imported by the East India Company from 1804 to 1808, was

	Cwt.	Average Price per Cwt.
1804	166	£6 8 11
1805	452	7 5 8
1806	268	4 19 2
1807	986	4 6 7
1808	1099	1 15 3

This gum is often sold for gum copal.

GUM *Arabic.* See CHEMISTRY, Sect. v. p. 108. In choosing this gum, great care should be taken that it is not mixed with another kind of gum, generally in larger pieces, which, instead of dissolving completely in water, only swells in it. The following quantities were imported by the East India Company from 1804 to 1808:

	Cwt.	Average Price per Cwt.
1804	1767	£4 12 1
1805	3931	4 1 11
1806	1534	2 17 8
1807	6565	2 6 10
1808	1382	2 3 3

GUM *Assafœtida.* See CHEMISTRY, p. 128. The use of this gum was introduced by the Arabians about 1000 years ago. It should be chosen clear, fresh, strong-scented, and of a pale reddish colour. When broken, it should have a resemblance to marble; and by exposure to the air, it should turn of a violet red colour. That which is soft, black, and foul, is adulterated. The following quantities were imported by the East India Company from 1804 to 1808:

	Cwt.	Average Price per Cwt.
1804	141	£3 15 2
1805	157	5 11 2
1806	82	3 12 8
1807	40	3 12 6
1808	72	3 17 9

GUM *Bdellium,* is a gum which is brought from Persia and the East Indies. It has a reddish brown colour externally, but is like glue internally. The loose drops in which it is brought home are sometimes as large as hazel nuts, but often less than a pea. They are commonly of an irregular shape. It is moderately heavy and hard, and grows tough in the mouth. It readily takes fire, burns with a bright white flame, and crackles, throwing out small fragments. It dissolves completely in vinegar.

GUM from *Botany Bay.* See CHEMISTRY, p. 123.

GUM *Caoutchouc.* See CAOUTCHOUC, and CHEMISTRY, Sect. xxvi. p. 126.

GUM *Cherry Tree.* See GUM *Prunus Avium.*

GUM *Copal.* See CHEMISTRY, p. 123.

GUM *Dragon's Blood.* See GUM *Sanguis Draconis.*

GUM *Dragon.* See GUM *Tragacanth.*

GUM *Elemi.* See CHEMISTRY, p. 123. This gum is obtained from the East Indies, as well as from Canada and Spanish America. The East India elemi is semitransparent, of a pale yellow colour inclining to green, and is bought in cakes of 2 or 3 lbs. each, wrapped up in flag leaves. That which is soft, with a strong smell and a bitterish taste, is the best. The hard and dark coloured is never good.

GUM *Euphorbium,* is the concrete resinous juice of a prickly shrub, which grows in Malabar and various parts of India. The irregularly shaped tears of which it consists, sometimes enclose thorns, twigs, &c. The best kind is dry, clear, and of a bright light yellow colour; and is so sharp to the taste, that a small piece held a short time in the mouth will inflame it.

GUM called *Frankincense.* See GUM *Olibanum.*

GUM *Galbanum.* See CHEMISTRY, p. 127, and GALBANUM.

GUM *Gamboge,* or *Gumgutt.* See CHEMISTRY, page 128, and GAMBOGE.

GUM *Guiacum.* See CHEMISTRY, Sect. xxiv. p. 124.

GUM *Juniper,* the same as GUM *Olibanum,* which see.

GUM *Labdanum.* See CHEMISTRY, p. 123, and LABDANUM.

GUM *Lac.* See CHEMISTRY, p. 123, and LAC.

GUM *Manna.* See CHEMISTRY, p. 108.

GUM *Mastich.* See CHEMISTRY, page 122, and MASTICH.

GUM *Myrrh.* See CHEMISTRY, p. 128, and MYRRH.

GUM *Olibanum,* or *Frankincense.* See CHEMISTRY, p. 128, and OLIBANUM.

GUM *Opium.* See CHEMISTRY, Sect. xviii. p. 117, and OPIUM.

GUM *Opoponax.* See CHEMISTRY, p. 128, and OPOPONAX.

GUM *Prunus Avium.* See CHEMISTRY, p. 109.

GUM *Sagapenum.* See SAGAPENUM.

Gums, Gun-Flints.

Gum *Sandarach*. See Chemistry, p. 123.

Gum *Sanguis Draconis*. See Chemistry, page 126. Dragon's blood in drops is preferable to that which is obtained in cakes, being more pure and compact. Genuine dragon's blood readily melts and flames, but is not soluble in water. The following quantities were imported by the East India Company:

	Cwt.	Average Price per Cwt.
1804	53	£11 0 0
1805	103	3 13 0
1806	26	9 19 11
1808	19	11 6 9

Gum *Scammony*. See Chemistry, page 128, and Scammony.

Gum *Senegal*. See Chemistry, p. 109. This gum exudes from a prickly shrub, of the same genus with that from which gum arabic is obtained. It is chiefly used by calico printers, and in other trades where gums are employed. It dries more slowly than gum arabic.

Gum *Tacamahac*. See Chemistry, p. 123.

Gum *Thus*, or *Frankincense*. See Gum *Olibanum*, and Olibanum.

Gum *Tragacanth*, or Gum *Dragon*. See Chemistry, p. 109.

There are many other gums than those which have been mentioned, but they are not of much importance as articles of commerce. Dr Francis Buchanan informs us, that gums are collected between Seringapatam and Bangalore from the following trees:

Andersonia panshmoum. (Dr Roxburgh's MSS.)
Melia azadirachta.
Chirongia glabra. (Dr Buchanan's MSS.)
Mangifera Indica.
Cassia auriculata.
Ægle marmelos.
Shorea jala. (Dr Buchanan's MSS.)
Chloroxylon dupada. (Do.)
Bomboc gossypinum.

See Buchanan's *Journey from Madras*, &c. vol. i. p. 169. See also Milburn's *Oriental Commerce*, passim.

GUN-Flints, are small pieces of flint cut into regular shapes, for the purpose of setting fire by their collision against a piece of steel, to the priming of fowling pieces, muskets, &c.

The first stones used for this purpose were a kind of compact pyrites, or marcasite, and they were long known by that name. The species of stone used in the greater part of Europe, is called by Wallerius *silex ignarius*, and by Linnæus *silex cretaceus*. In Germany it was called *flins* or *vlins*; in the Swedish and Danish *flinta*; and in English *flint*. This name is said to be of great antiquity, as the Wends had a Pagan deity which they placed on a stone called *flynsteiu*. From the word flint arose the names of *flintgewehr*, *flint*, or *flinte*, which the Germans have given to guns fired by that stone. Stones seem to have been first used about the middle of the 16th century.

The manufacture of gun flints has been long kept a profound secret; and we are indebted to Dolomieu for the first exposition of the method employed in France.

The masses of flint which are best fitted for this purpose, are of a convex surface, approaching to globular. The knobbed and branched flints are commonly full of imperfections. The best flint nodules are generally between 2 and 20 pounds weight. They should be unctuous, or rather shining internally, with a grain so fine as to be imperceptible to the eye. The colour should be uniform in the same nodule, and may vary from honey yellow to a blackish brown. The fracture should be smooth and equal, and the fragments slightly conchoidal; and the transparency should be such as to allow letters to be distinguished through a thickness of one-fourth of a line when laid close to the paper. When flints do not possess these properties, either naturally, or after a long exposure to the air, they are rejected by the workmen.

Gun-Flints.

Tools for making gun-flints. Plate CCLXXXIV.

Four tools are necessary in the manufacture of gun flints. 1. An iron hammer with a square head, a handle seven or eight inches long, and not exceeding two pounds in weight. This instrument is shewn in Fig 3. Plate CCLXXXIV. 2. A hammer of well-hardened steel, with two points, a handle seven inches long, and from 10 to 16 ounces in weight. The handle must pass through in such a manner that the two points may be nearer the hand of the workman than the centre of gravity of the mass. This hammer is represented in Fig. 4. 3. A disk hammer, or roller, like a solid wheel, or the section of a cylinder, two inches and four lines in diameter, and not exceeding 12 ounces in weight. It is made of steel, not hardened, and has a handle six inches long, which passes through a square hole in the centre. It is shewn in Fig. 5. 4. A chisel, tapering and bevelled at both ends. It should be made of steel, not hardened, and six, seven, or eight inches long, and two inches wide. This chisel is represented in Fig. 6. This is set on a wooden block, which is also used, as a bench for the workman. A file is necessary for restoring the edge of the chisel. With these tools the flints are formed in the following manner, which we have abridged from Dolomieu's Memoir.

1. *To break the block.* The workman seated on the ground, places the nodule of flint on his left thigh, and applies slight strokes with the square hammer, to divide it into smaller pieces of about a pound and a half each, with broad surfaces, and almost even fracture.

2. *To cleave or chip the flint.* The workman holds the piece of flint in his left hand, not supported, and strikes with the pointed hammer, No. 2. on the edges of the great planes produced by the first breaking, by which means the white coating of the flint is removed in the form of small scales, and the mass of the flint itself laid bare in the manner represented, Fig. 7. After which he continues to chip off similar scaly portions from the pure mass of the flint. These scaly portions are nearly one inch and a half wide, two inches and a half long; and their thickness in the middle is of about two lines. They are slightly convex below, and consequently leave in the part of the flint from which they were separated, a space slightly concave, longitudinally bordered by two rather projecting straight lines, or ridges, Fig. 8. These ridges, produced by the separation of the first scales, must naturally constitute nearly the middle of the subsequent piece; and such scales alone as have their ridges thus placed in the middle are fit to be made into gun flints. In this manner the workman continues to split or chip the mass of flint in various directions, until the defects usually found in the interior render it impossible to make the fracture required, or until the piece is reduced too much to receive the small blows by which the flint is divided.

3. *To shape the gun flint.* Five different parts may be distinguished in a gun flint. 1*st*, The sloping facet, or bevel part, which is impelled against the hammer of the lock of the gun. Its width should be from two to

Gun-Flints. three-twelfths of an inch; if it were broader it would be too liable to break: and if more obtuse the scintillation would be less brisk. *2dly*, The sides or lateral ridges, which are always rather irregular. *3dly*, The back, or the part opposite the tapering edge: this is the thickest part of the flint. *4thly*, The under surface, which is uninterrupted and rather convex. And, *5thly*, The upper facet, or small square facet between the tapering edge and the back, which receives the upper claw of the cock; it is slightly concave. In order to fashion the flint, those scales are selected that have at least one of the above-mentioned longitudinal ridges: The workman fixes on one of the two tapering borders to form the striking edge; after which, the two sides of the stone that are to form the lateral edges, as well as the part which is to form the back, are successively placed on the edge of the chisel, in such a manner that the convex surface of the flint which rests on the fore-finger of his left hand is turned towards that tool. He then with the roulette applies some slight strokes to the flint, just opposite the edge of the chisel underneath; by which means the flint breaks exactly along the edge of the chisel.

4. *To trim the flint.* The last operation is to *trim*, or give the flint a smooth and equal edge; this is done by turning the stone, and placing the edge of its tapering end on the chisel, in which situation it is completed by five or six slight strokes with the roulette. See Fig. 9.

Plate CCLXXXIV. Fig. 9.

The whole operation of making a gun flint is performed in less than one minute. A good workman is able to manufacture a thousand good chips or scales a day, (if the flint nodules be of a good quality;) and in the same manner he can fashion 500 gun flints in a day, so that, in the space of three days, he is able to cleave and finish a thousand gun flints without farther assistance.

In this manner, five or six blows with the hammer are sufficient to produce a perfection of figure which would require more than an hour's labour, if the faces were formed by grinding them against harder substances; and less than a farthing will pay for a gun flint from the hand of the workman, though fifty times that sum would be insufficient to purchase it, if it were formed in any other way.

When the gun flints are completed, they are sorted into two classes, fine and common flints, and according to their application into flints for pistols, fowling-pieces, and muskets. A good gun flint will give 50 strokes without being unfit for service. They are sold in France at from four pence halfpenny to seven pence per hundred. They cost twice as much in Italy, and, in 1745, when they were exported from the department of the Loire and Cher to Lyons, Strasburg, and St Quintin, they cost 12 francs per thousand, or one shilling per hundred.

The manufacture of gun flints in France, employed above 800 of the inhabitants in the communes of Noyers, Couffy, and Meunes, in the department of the Loire and Cher. The mine, which is four leagues square, is thirty or forty feet deep, and thirty million of flints manufactured here were stored up in 1794. They are also made in the communes of Lye, in the department of the Indre, of Maysse and St Vincent, in the department of Ardeche, and at Cerilly in the department of the Yonne. Dolomieu received the information contained in the preceding article from Stephen Buffet, who emigrated from the commune of Meunes to the banks of the Seine, where he carried on his profession for above 30 years.

Gun flints are made also in the territory of Vicenza, and in one of the cantons of Sicily. They were manufactured in great quantities at Stevensklint in Zeeland. They are also manufactured at Purfleet in Kent, and in various other parts of England in a very superior stile.

See Dolomieu's Memoir in the *Memoires de l' Institut.* vol. iii. p. 148; in the *Journal des Mines*, No. xxxiii. p. 693; and in Nicholson's *Journal*, vol. i. 8vo. p. 88. In the *Journal des Mines*, No. xxxiii. p 713, and 719, will also be found a Memoir by M Solivet, and observations by M. Tonellier on the manufacture of gun flints in the commune of Cerilly. See also the *Hanoverian Magazine* for 1772; and Beckmann's *History of Inventions*, vol iv. p. 609, &c.

Gun-making. GUN-MAKING is the art of manufacturing small arms, for the purposes of war and the chace. The name harquebuss, which was first given to small arms, is said to have been derived from the Italian word *arcobousa*, or bow with a hole, and the instrument was successively designated harquebuss, hackbut, hand-gun, match lock, musket, snaplance, petrinal, firelock, carabine, and fowling-piece; hence the workmen acquired the appellation from the French harquebussiers; and the British gun-smiths, and gun-makers.

History of gun-making. The first application of gunpowder to small arms, appears to have been made by the Germans soon after the invention of cannon; for in 1471 we find that Edward the IV. brought over into England 300 Flemings, armed with hackbuts or harquebusses. The Spaniards are said to have, so early as the reign of Philip the II., adopted them in the army; and that monarch caused them to be made of a large calibre, and so heavy that a forked rest was requisite to level them in taking aim. They were used at the siege of Rhige, and by the Emperor and Pope Leo in 1521. The French had availed themselves of this arm, in 1667, to the extent of four harquebusses in each company of their army. England appears to have been earlier apprized of their superiority over the weapons then in use. Harquebuss soldiers formed a part of their forces in 1540; and Peter Van Collins is mentioned by Stowe, as the first gunsmith, in 1543. By an act of Henry the VIII. the length of the hand, gun stock, and barrel, is directed not to exceed one yard; and that of the hackbut three quarters of a yard. By a statute of Elizabeth, they are ordered to be made all of one size and calibre, from which they acquired the name of culivers, a light kind of matchlock, fired without a rest; and their price was fixed at 13 shillings and sixpence, with flask, touch-box, laces and mould. In James the First's reign, the price was fixed at 14 shillings and ten pence. Charles the Second directs the musket barrel not to be under three feet in length, and to receive a ball of twelve in the pound; and in 1638, he grants a charter to the gun-smiths of London, by the name of master wardens, and society of gun-makers; at which period they made wheel and snap-lance locks. The Scotch used the harquebuss or match-lock soon after its invention, from their intimate correspondence with France and Flanders; yet we have no certain information of their having any artists in that profession sooner than 1640, when they became incorporated with the hammermen of Edinburgh, as a pendicle of the lock-smith art. The city guard were armed with muskets or harquebusses in 1682, the expence of purchasing and maintaining of which was directed to be defrayed from the money exacted from those who entered burgess. After the union of the two kingdoms, the manufacture of small arms, (if ever carried on to any extent,) seems to have been confined to a few individuals. From the records of the hammermen, it appears that in 1715 there were only two, viz. Murdoch Grant, and John Simpson; and in 1741 there was only one in the profession. Since that period, however, greater encouragement has been given to that art in Edinburgh, there being at the present time (1816) six master gun-makers, who employ about thirty workmen; and there is one in a few of the principal towns in Scotland. This business has been carried on to a very considerable extent, in England, by private individuals; and government, within these few years, has established extensive manufactories at Lewisham, and in the Tower of London, employing about 500 workmen, who complete at the rate of 5000 stand of muskets every week: Expert workmen have been paid seven guineas and upwards for their week's labour. The London gun-makers, who are employed in the making of fowling-pieces, rifles, and pistols, amount to about forty-three, and they have not less than 300 people in their service. Birmingham is the place where all kinds of fire-arms are manufactured to the greatest extent; although it is to be regretted that the effect of competition has introduced a superficial style of working, which is greatly detrimental to the character of the article, and to its extension as a branch of commercial export.

The manufacture of a gun is performed by the following workmen, viz. barrel forger, borer and filer, lock forger and filer, furniture filer, ribber and breecher, rough stocker, screwer together, polisher, and engraver, in all ten different persons, few of whom can execute any other branch of the art but one. Most of the principal towns in England have one or two master gun-makers, but none of them carry on the business in all its different branches, except London, Birmingham, and Edinburgh. The makers of the first and last cities have the highest prices for their guns, single fowling-pieces being from 15 to 30 guineas, and double ones from 35 to 70 guineas; indeed, to such a perfection has this instrument been brought, of late years, by the British artists, that it cannot be doubted but that they are greatly superior to every other nation in Europe; although we have learned that, at the Versailles manufactory, under the first consul's special patronage, fowling-pieces were made at the high price of 800 guineas. Instances, however, can be produced where London makers have had a thousand guineas for one gun. The variety and ingenuity in the construction of small arms, in order to gain peculiar advantages, are so various and extensive, that it would be very difficult to enter into any details upon the subject: We shall, however, enumerate a few of the different kinds of guns which are in use: guns with one barrel to discharge from one to three balls successively; magazine guns that prime and load by one motion, and discharge from 10 to 20 balls in succession; double guns, with their barrels placed perpendicular, horizontal, and to turn round a centre; three, four, and seven barreled guns; harpoon guns; muskets and carabines, &c.

Gun barrel.

The gun barrel.—The length, shape, and bore of gun barrels, have materially changed as the instrument became more generally used and better understood. Hence we find, in different countries and at different periods, their lengths fluctuating from six feet to 25 inches, and their diameters from half an inch to one and a quarter inch: They are generally cylindrical, but in some instances square, internally and externally with chambers at the breech to contain the powder, as is the case with all the Asiatic matchlocks of most ancient construction. The Spaniards were the first people in Europe who excelled in the manufacture of barrels, remarkable for lightness and safety: Possessing finer iron from their smelting their ores with wood; and being sensible that the more it is wrought by heating and hammering, the purer it becomes, they naturally resorted to the old nails extracted from the shoes of their horses and mules. Juan Sanchez di Mirvena, is the first that forged the barrel in separate pieces, in the reign of Philip IV.; and so highly were the Madrid makers esteemed, in 1720, that the French gave 1000 livres, or £43, 13s. sterling, for the barrels of Nicholas Biz, Juan Beler, and Juan Fernendez. About the year 1650, we find Lazerino Cominazio, of Brescia, in high repute. France has also had her eminent workmen, such as Nicol le Clerc, Des Champs, Jean Franc Renet, and Henry Renet, all of Paris, whose barrels are still much prized. The British are now, however, confessedly much superior to every other people in the manufacture of this article. They have, of late, introduced many ingenious improvements, such as patent steel barrels, and narrow and wire-twist barrels, with a beautiful application of the fibres of the metal in welding, so as to resemble exactly the Damascus steel of Persia, or what is seen in the finest arms of Indian workmanship. At first the European barrels were all of one diameter throughout, until within these 30 years, that a London tradesman obtained a patent for a chambered breech, which, though it possessed peculiar merit, was nothing but a copy from the principle of the carronade, and both are obviously borrowed from the Indian matchlock; hence his privilege of original invention being untenable, this construction became general in a few years, and still continues, with some slight variation, to the present period.

In forming the common gun barrel, the workmen begin by heating and hammering out a bar of the best iron, into the form of a flat ruler, thinner at the end intended for the muzzle, and thicker at that for the breach, the length, breadth, and thickness of the whole plate being regulated by the intended length, diameter, and weight of the barrel. This oblong plate is then, by repeated heating and hammering, turned round a cylindrical rod of steel, called a mandril, whose diameter is considerably less than the intended bore of the barrel. The edges of the plate are made to overlap each other about half an inch, and are welded together by heating the tube in lengths of two or three inches at a time, and hammering it with very brisk but moderate strokes, upon an anvil which has a number of semicircular furrows in it, adapted to barrels of different sizes. The heat required for welding is the bright white heat which immediately precedes fusion, and at which the particles of the metal unite and blend so intimately with each other, that when properly managed, not a trace is left of their former separation. Every time the barrel is withdrawn from the forge, the workmen strike the end of it once or twice gently against the anvil in an horizontal direction; this operation, which is called jumping, serves to consolidate the particles of the metal more perfectly, as well as to disengage the scoria from the inside and outside of the tube, and to obliterate any appearance of a seam. The mandril is then introduced into the bore, or cavity; and the barrel being placed in one of the furrows or moulds of the anvil, is hammered very briskly by two persons; the forger all the while turning it round in the mould, so that every point of the heated portion may come equally under the action of the hammer. These heatings and hammerings are repeated until the whole of the barrel has undergone the same operation, and is rendered as perfectly continuous as if it had been bored out of a solid piece. Twisted barrels are now generally used for the finest fowling-pieces, the method of fabricating of which is as follows. Four bars of stub iron, two feet in length, half an inch in breadth, and the first two bars half an inch thick or more, according to the size of the barrel, are previously prepared. An old barrel being welded to the extremity of one of those bars for a handle, it is heated and turned round like a cork-screw, by means of the hammer and anvil; after this, the turns of the spiral are united by heating the tube two or three inches at a time to a bright white heat, and striking the end of it several times against the anvil in a horizontal direction, with considerable force: This is called jumping the barrel, and the heats given for that purpose jumping heats: A mandril is immediately introduced into the cavity, and a quick light hammering is kept up on the welding part, until the ridges raised at the seams by the jumping are flattened, and the piece appears sound. As soon as one bar is rounded and jumped in this manner, another is welded to it, and treated in the same way, until the four pieces are united and form one tube: The old barrel is then cut off as being no longer requisite, and the operation of heating and hammering is frequently repeated in its whole length, until its external figure is correctly acquired, and the metal has arrived at the utmost closeness of fibre in all its parts. It is a circumstance of considerable importance with respect to a gun barrel, that it should be forged as nearly as possible to its weight when finished, so that very little may be taken away in the boring and filing; for as the outer surface, by having undergone the action of the hammer more immediately than any other part, is rendered more compact and pure, the less that is removed the better will the barrel be.

Process of boring.

The next process is the boring, the apparatus for which is either driven by a water wheel, steam engine, or the hand, according to the extent of the manufacturer's demand. This operation consists in giving to the barrel its proper calibre. The boring bit is a rod of iron, somewhat longer than the barrel, one end being fitted into the socket of the crank, and the other furnished with a cylindrical plug of tempered steel, about an inch and a half long, and having its surface cut with spiral grooves, flat at bottom, and a quarter of an inch in breadth. This form gives the bit a very strong hold of the metal, and the threads sharp at the edges, scoop out and remove every roughness and inequality from the inside of the barrel, and render the cavity smooth and equal throughout. Several bits, each a little larger than the preceding one, are afterwards successively passed through the barrel in the same way, until it has acquired the intended calibre. After this the fine boring bit is introduced, being a similar rod to the former, with a square bar of tempered steel, 10 or 12 inches long at its extremity, and finely sharpened on one of its sides; on the opposite side is placed a semicircular slip of wood, of a size sufficient to fill up with the bit the entire diameter of the barrel, two of its edges only acting on the tube, which passing through its whole length, and kept well oiled, is frequently repeated, and the bore enlarged by small slips of paper placed between the wood and the bit, until the inside presents a perfectly equal and polished surface. The trueness of the bore is then proved, either by a steel or leaden plug passed through its whole length. The next step towards completing the barrel is the operation on its exterior surface, which in common barrels is done by grinding on a large stone; two steel pins being inserted into the mouth and breach of the tube, and smaller than its diameter. The workman holding them in his hands, presses the barrel to the stone, which revolving on the pins, grinds off the inequalities left by the hammer; after which it is passed to another person who files and smooths it from one end to the other. The best barrel makers do not grind, but turn their barrels on a lathe, which is well calculated to insure that perfect equality of thickness on which the strength and safety of the piece so greatly depend. The filing and smoothing is afterwards performed in the usual manner. The imperfections to which gun barrels are liable, and which render them dangerous to use, and apt to burst, are the *chink*, *crack*, and *flaw*. The first is a small rent in the direction of the length of the barrel, the second across it, and the third is a scale or plate adhering to the barrel, by a narrow base, from which it spreads out like the head of a nail from its shank, and when separated leaves a pit or hollow in the metal. Chinks or flaws are of much worse consequence than the crack in fire-arms, the expansive force of the powder being exerted more upon the circumference than the length of the barrel; the flaw is much more frequent than the chink, the latter scarcely ever occurring but in plain barrels, formed out of a single plate of iron. The proof of gun-barrels, both musket and fowling pieces, as established by Government and the Gunmakers Company of London, is a ball that fits the diameter of the piece, and a charge of powder of equal weight, which being fired, either bursts the barrel, or demonstrates its soundness and safety. Some gunmakers are in the habit of following this test, by a water proof, in order to ascertain if the pores of the metal continue perfectly secure. Pistol barrels are forged in one piece, two at a time, joined by their muzzles, and are bored before they are cut asunder, by which means there is not only a saving of time and labour, but a greater certainty of the bores being the same.

Rifle barrels.

Rifle barrels are of modern invention: The Germans have the merit of this contrivance. The rifle barrels of Kuchanrieter senior of Ratisbon are in the greatest esteem; and so fond are the Germans of excelling in the use of the rifle, that it has become one of their principal amusements, in which all ranks of society frequently indulge. Every town and village has their practising ground, or butts, where small prizes are competed for, with an accuracy of aim that is truly surprizing. The Americans have also, from their habits of hunting, acquired great correctness in the use of rifle guns; and within these few years our government has introduced them into the army; the ninety-fifth regiment being peculiarly clothed, and armed with that weapon. The manufacture of rifles, in their first formation, is exactly similar to that of other barrels, except that their external form is generally octagonal.

Process of rifling.

The process of rifling is as follows; the barrel being previously bored, and finished to a true cylindrical form, is placed on the rifling machine, an instrument formed on a square plank of wood seven feet long, to which is fitted a tube about an inch in diameter, with spiral grooves deeply cut internally through its whole length, and to which is attached a circular plate, about five inches diameter, accurately divided in concentric circles, into from five to ten equal parts, and supported by two rings affixed to the plank, in which it revolves; an arm connected with the dividing plate, and pierced

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with holes, through which a pin is passed, regulates the change of the tube in giving the proper number of rifles to the barrel. An iron rod with a moveable handle at one end, and a steel cutter in the other, passes through the rifling tube. This rod is covered with a core of lead one foot in length, and the barrel is firmly fixed by means of two rings on the plank standing in a straight line to the tube. The rod is then repeatedly drawn through the whole length of the barrel, until the cutter has formed one groove to the proper depth; the pin being shifted to another hole in the dividing plate, the operation of grooving is continued until the whole number that was required is complete. The barrel is then taken out of the machine and finished. This is done by casting on the end of a small iron rod a core of lead, which, when coated with fine emery and oil, is drawn for a length of time by the workman from one end of the barrel to the other, till it has acquired a high degree of smoothness and polish. The process is then complete, and the barrel is ready for the ribber and breacher, &c. The best degree of spirality is found to be half a turn in a length of three feet.

Gun lock.

The Lock, was originally a cleft piece of iron, moving on a pin fixed into the stock. The match was held in the cleft, and conveyed into the priming in the pan: A lever carried down the under part of the stock, and projecting at its extremity, served for a trigger. This simple contrivance was followed by the wheel-lock, so called from a small solid wheel of steel, nearly a quarter of an inch in thickness, and one and a half in diameter, cut on its edge with grooves, and notched transversely. The upper part of the circumference of this wheel rose up through the middle of the pan: It had an axis placed in its centre, to which a chain was attached, connecting itself to the extremity of a strong spring on the outside of the lock-plate, and the whole was fixed to the barrel by screws passing through the stock. Its application was by turning the wheel with a key, or spanger, which rolled the chain round its axis, and drew up the spring to its full tension. By this movement, a slider that covered the pan containing the priming, retired from over it, so as to permit the dog, which held the flint, to place itself on the edge of the wheel, which being let off by the trigger, the rapid revolutions of the wheel elicited fire from the flint, and inflamed the priming. See Fig. 8. To this succeeded the *Snaplance*, in which a motion was given to the dog, or cock, and a moveable plate of steel, called the frizel, or hammer, was placed vertically above the pan to receive the action of the flint. Numerous important advantages were acquired by this improvement over the wheel-lock, first, by securing the priming until the instant the piece was to be fired; and by increasing the quickness of its action and the lightness of its construction, &c. The great perfection to which this part of a gun has been carried within these 40 years in Britain, justly acquired the profession an acknowledged celebrity over every other nation. The important requisites in a gun lock are, that the action of the cock be as rapid as possible, and that it should be so placed that on uncovering the pan, the flint may point into the centre of the priming, and as near to it as possible, without touching it. The main-spring should have a smooth and active motion; the hammer-spring should be light, and should give a slight resistance to the cock on its striking the steel, which ought to move on a roller; and the temper should not be too hard or too soft, the one extreme being known by a roughness on its surface, and the other by the flint's making scarcely any impression on it, and producing little or no fire. The inside of the lock ought to be freed and swivelled, and the tumbler and seer of steel, and also the nails, should be tempered.

Plate CCLXXXV. Fig. 8.

A very great improvement in the construction of gun-locks has lately been made by the Rev. Mr Forsyth, minister of Belhelvie, in Aberdeenshire. This ingenious gentleman contrived and made with his own hands a lock to fire without a flint, and by percussion alone to inflame certain powders. This contrivance possesses so many advantages over the present lock, (even in its most perfect state) that it will ultimately supersede it entirely. Although it is not more than five or six years since it was made public; yet both the German and Prussian gun-makers have adopted it, and there is little doubt it will become general here, so soon as his patent expires. The great advantages of this discovery are, the rapid and complete inflammation of the *whole* charge in the chamber of the barrel, a prevention of the loss of force through the touch-hole, perfect security against rain or damp in the priming, no flash from the pan, and less risk of accidental discharge of the piece than when the common lock is used.

Forsyth's lock. Plate CCLXXXV. Figs. 1—4.

This lock is represented in Figs. 1, 2, 3, 4, of Plate CCLXXXV. It consists of a hammer or dog-head H, and a magazine MN. This magazine MN, a section of which is shewn in Fig. 3. consists of a roller A round which the magazine is moveable as about an axis, one end of which is screwed into the breach of the barrel, as shewn in Fig. 4. The roller is perforated through its axis by a channel *m*, Fig. 4. which communicates with the chamber S of the gun. On the upper side of the roller is a pan B, which communicates by a hole in its centre with the channel *m*, and consequently with the chamber of the piece. The priming powder, which consists of *three* parts of the hyper-oxymuriate of potash, *one* part of sulphur, and *one* part of charcoal, is put into the cavity C of the magazine, which will hold 40 primings. The opposite cavity D contains the steel punch and spiral spring E. When this punch is pressed down, it strikes the pan B, and is again raised from the pan by the elasticity of the spiral spring. F, F are the screws between the points of which, and the cork fixed on the inside of the magazine, the grease for oiling the roller is contained. In order to use this lock, the magazine is brought into the position shewn in Fig. 1. where the cavity containing the priming powder is above the pan. A small portion of the powder therefore falls into the pan. The magazine is then turned round into the position of Fig. 2. where the steel punch is uppermost at M. The hammer H being raised, and the trigger being pulled, it gives a blow to the steel punch, which strikes the priming powder in the pan, and inflames it by the concussion. The flame having no other exit, passes along the channel *m*, Fig. 4. and inflames the charge. One of the great advantages of this lock is, that it may be used during rain, and the piece will go off even if the lock is immersed in water.

Simplification of Forsyth's lock.

A very elegant simplification of this lock has been made, by giving the magazine MN a horizontal instead of a rotatory motion. The magazine is connected with the hammer by a lever, so that when the hammer is raised, or the piece cocked, the lever pulls the magazine over the pan, and fills it with priming. When the hammer is let go, by pulling the trigger, the magazine is moved from the priming pan, and the powder is inflamed by the percussion of the extremity of the hammer. This form of the lock, however, is not water proof.

Stock and mounting.

The Stock and Mounting of Guns has assumed a great variety of forms, and not only the figure, but the mode of holding small arms has undergone a change; the

Gunmaking.

straight stocked match-lock being placed under the right arm, the crooked short hagbut and the poitrinal on the breast, and the modern musket at the right shoulder. Guns of sport, till within these thirty years, were made very crooked in the stock, and no regard was then paid to the balance of the piece; since that period straight stocks have been universally adopted, and the length of the stock has been accommodated to the stature of the person for whom it is made. For a view of various constructions of small arms, see Plate CCLXXXV.

Plate CCLXXXV.

Fig. 5. Represents the Indian match-lock, where M is the match held in a tube or pair of pincers, and P the pan, which holds the priming.

Fig. 6. Represents the European matchlock, or harquebuss.

Fig. 7. Represents the Rest for the matchlock.

Fig. 8. Represents the wheel-lock.

Fig. 9. Represents a modern fowling-piece.

Fig. 10. Represents a modern Spanish lock.

GUNNERY,

Gunnery.

Is the art of constructing and using great guns, for the purpose of hitting a distant object, with shot or shells, discharged from the gun by the explosive force of gunpowder.

In the present article we propose to confine ourselves to the theory of gunnery, as founded on the mathematical doctrine of projectiles, corrected and modified by experimental investigations. The art of constructing and mounting great guns, and the description of the apparatus connected with them, will form a separate article under the head of Ordnance.

HISTORY.*

History.

The Italians seem to have been the first people that directed their attention to the subject of the motion of cannon shot. Nicholas Tartaglia, a Venetian, who was born at Brescia, published at Venice, in 1537, his *Nuova Scienza*, and in 1546 his *Quesiti e Invenzioni diverse*, in both of which he treats the subject of projectiles. In the last of these works, he gives an account of the calibre rod, or artillery measuring rod, of which he seems to have been the inventor. In another work, translated into English by Cyprian Lucas, and entitled *Colloquies concerning the Art of Shooting in Great and Small Pieces of Artillery*, Lond. 1588, he has entered more minutely into the subject. Having no knowledge of the practical part of artillery, Tartaglia investigated the subject theoretically upon fallacious principles, and can scarcely be considered as having done any great service to this branch of science. He is supposed, however, to have discovered that projectiles may be thrown to the greatest distance when they are projected at an angle of 45 degrees; and, in opposition to the notion of practical gunners, he maintained that no part of the path of a cannon ball was a straight line, but that it was like the surface of the sea, which, though to all appearance a plane, was nevertheless a portion of a circle described by the radius of the earth. Tartaglia appears also to have been the inventor of the gunner's quadrant.

The researches of Tartaglia, imperfect and unsatisfactory as they were, had the merit of directing the attention both of military engineers and mathematicians to this curious subject. Many fallacious theories of the motions of cannon shot were brought forward, and Ufano, Galeus, Ulrick, and several other writers, published tables of the comparative ranges of military projectiles, that were quite irreconcileable with experiment.

Collado's experiments.

The first experimental examination of this subject was made by M. Collado, a Spaniard, who served as an engineer with the Spanish army in Italy. In his work entitled *Practica Manuale de Artiglieria*, Venice, 1586, which was first published in Italian and afterwards in Spanish, he has given for each point of the gunner's quadrant the ranges of a falconet which carries a three pound shot. Mr Robins remarks, that it is manifest, from the number, that the falconet was not loaded with the usual quantity of powder. The following are Collado's results:

Points of the Gunner's Quadrant.	Angle of Elevation.	Range in paces, or common steps.
0	0° point blank	268
1	$7\frac{1}{2}$	594
2	15	794
3	$22\frac{1}{2}$	954
4	30°	1010
5	$37\frac{1}{2}$	1040
6	45	1053
7	$52\frac{1}{2}$ between the 3d and 4th range.	
8	60 between the 2d and 3d range.	
9	$67\frac{1}{2}$ between the 1st and 2d range.	
10	75 between the 0 and 1st range.	
11	$82\frac{1}{2}$ the ball fell very near the piece.	

Bourne's experiments.

The next experiments which were made on this subject, appeared in the *Art of Shooting in Great Ordnance*, a work which was published in 1643 by Mr William Bourne. He assumes unity as the range for a point blank shot, and ascertains the ratio of the ranges at different elevations. Bourne does not mention the nature of the piece which he used, but Mr Robins presumes that it must have been a small one. The following Table contains the results given in Chap. vii. of the above work:

Angles of Elevation.	Ranges.
0	1.000
5	2.222
10	3.366
15	4.366
20	4.833
36	Greatest range when a strong wind favours the motion of the projectile.
42	Greatest range in a calm day.
45	Greatest range when a strong wind opposes the motion of the projectile.

Eldred's experiments.

A very admirable series of experiments were made early in the 17th century, by our countryman Eldred, who was for many years master gunner at Dover castle. His earliest experiments are dated 1611; but the book which contains them, entitled *The Gunner's Glasse*, was not published till 1646. His experiments, which are very numerous, were made with great care, and the principles on which he proceeded were simple

* An account of the invention and history of Artillery will be found under that article.

History.

and tolerably correct. He has published the actual ranges of different pieces of artillery, at small elevations, not exceeding ten degrees, and among these are some trials made with the famous cannon called the *basilisk*, a piece 23 feet long, and well known to those who visit Dover castle. He found that this gun, which carries a 10 lb. shot, ranged 3600 feet with 18 lb. of powder, at an inclination of 2°, and 6000 feet at an elevation of 43°

Discoveries of Galileo.

The subject of gunnery was now destined to receive the most important improvements from the genius of Galileo. By the application of mathematics to the doctrines of motion, he has given the form of a science to this branch of natural philosophy, and has enabled us to ascertain every thing that relates to the flight of military projectiles, on the supposition that they are discharged in a non-resisting medium. His *Discursus et Demonstrationes Mathematicæ*, &c. which contains these fine investigations, were published in 1638. They are given in the fourth dialogue, entitled *De Motu Projectorum*, and occupy fourteen propositions, in which he has proved that a projectile must describe a parabolic curve by the combination of the force of gravity with the force of projection, and has shewn how to compute the distance to which the body will be thrown, the time of its flight, and the momentum with which it falls, when projected in a given direction, and with a given velocity. Galileo was perfectly sensible that the resistance of the air would produce a considerable change in these results, and he has described a method of discovering the magnitude of the effects which this resistance would produce on the motion of a bullet at some given distance from the gun.

The opinions which prevailed at this time respecting the extreme rarity and tenuity of the air, prevented philosophers and military engineers from availing themselves of this important part of Galileo's work. They anticipated no great variation from the theory, and accordingly we find it to have been, for a long time, the received opinion, that all projectiles moved in a parabolic curve.

Experiments of Anderson.

This erroneous opinion was stoutly maintained by our countryman Anderson, in his treatise *Of the Genuine use and effects of the Gun*, published in 1674. This work is founded on the Galilean theory; and its author boldly undertakes to overturn all objections that can be urged against the parabolic motion of projectiles.

Of Blondel.

A similar notion is maintained by M. Blondel, in his *L'Art de jetter les bombes*, which appeared at Paris in 1683. He applies the doctrines of Galileo to the flight of shells and bullets of every kind; and after a long discussion relative to the air's resistance, he concludes that it is too minute to affect the accuracy of his deductions.

Experiments of Halley.

The celebrated Dr Halley held the same false opinion. He was, however, not merely misled by a belief in the extreme tenuity of the air; but he was confirmed in his errors by some very imperfect experiments. After treating of the motion of projectiles, (See *Phil. Trans.* 1685, No. 179. p. 3.) he observes, that "these rules would be rigidly true, were it not for the resistance of the medium, by which not only the direct impressed motion is continually retarded, but likewise the increase of the velocity of the fall, so that the spaces described thence are not exactly as the squares of the times; but what this resistance of the air is, against several velocities, bulks, and weights, is not so easy to determine. It is certain that the weight of air to that of water is nearly as 1 to 800; whence its weight to that of any project is given. It is very likely, that to the same velocity and magnitude, but of different matter, the resistance will be reciprocally as the weights of the shot; as also, that to shot of the same velocity and matter, but of different sizes, it should be as the diameters reciprocally; whence, generally, the resistance to shot with the same velocity, but of different diameters and materials, should be as their specific gravities into their diameters reciprocally; but whether the opposition to different velocities of the same shot be as the squares of those velocities, or as the velocities themselves, or otherwise, is yet a more difficult question. However it be, it is certain that in large shot of metal, whose weight many thousand times surpasses that of the air, and whose force is very great in proportion to the surface, this resistance is scarcely discernible; for by several experiments made with all care and circumspection, with a mortar-piece, extraordinarily well fixed to the earth on purpose, which carried a solid brass shot of 4½ inches diameter, and of about 14 lb. weight, the ranges above and below 45 degrees were found nearly equal; if there were any difference, the under ranges went rather the farthest; but those differences were usually less than the errors committed in ordinary practice, by the unequal goodness and dryness of the same sort of powder, by the unfitness of the shot to the bore, and by the looseness of the carriage.

In a smaller brass shot, of about 1½ inch diameter, cast by a cross-bow, which ranged it at most about 400 feet, the force being much more equal than in the mortar-piece, this difference was found more curiously and constantly, and most evidently the under ranges exceeded the upper. From which trials I conclude, that although, in small and light shot, the opposition of the air ought and must be accounted for; yet in shooting of great and weighty bombs, there need be very little or no allowance made; so that these rules may be put in practice, to all intents and purposes, as if this impediment were absolutely removed."

Subsequent experiments by Anderson.

Although the opinion which we have been considering was entertained chiefly by speculative writers, yet those who made extensive experiments on the motion of projected bodies, began to suspect some lurking error. Anderson, whom we have already mentioned, as a keen abettor of the parabolic theory, had occasion to make a number of new experiments on the ranges of shells discharged with small velocities, which he published in 1690, in his treatise entitled, *To hit a mark.* He found that the track of shells and bullets was much less incurvated in the first part of their path than they ought to be, on the Galilean theory; but instead of supposing the theory practically incorrect, or conjecturing that the deviations were produced by the resistance of the air, he imagined that the shell or bullet was discharged from the gun to a certain distance in a right line, and that gravity only began to deflect it into a parabolic curve at the end of this line, which he calls the *line of the impulse of the fire*, and which he supposes to be the same at all elevations. By giving a proper magnitude to this imaginary line, he was always able to reconcile the ranges of any two shells projected at different elevations; though, as Mr Robins remarks, he would have found it impossible to reconcile the irregularities of three or more ranges.

Newton on the resistance of the air.

So deeply rooted was the erroneous notion that the air offered only an unappreciable resistance to moving balls, that the publication of Sir Isaac Newton's *Principia*, in which the resistance of the air in slow motions is ascertained and confirmed by experiment, was not able to correct it. By extending the law for slow motions to those in which the velocity was very great, it was obvious that the resistance opposed to cannon balls

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Newton on the resistance of the air.

was too great to be overlooked; though it did not amount, by the calculation, to that enormous degree which was afterwards deduced from direct experiment. Newton has not attempted to investigate, in a direct manner, the path which a body will describe when projected into the atmosphere with a given velocity, and in a given direction. He shews, however, the particular state of density in the air, which will agree with the motion of a body in any curve whatever; and, by the application of the principle to curves, which have some resemblance to the path of a projectile, he finds it differing little from what may be considered as the path of a body projected in our atmosphere. In the second edition of the *Principia*, which appeared in 1713, he corrects some of the oversights into which he had formerly been led; and he shews that a projectile, moving in a medium, whose density varies according to certain laws, and acted upon by a force directed to the centre of the earth, will describe an eccentric spiral, whose properties he describes.

Bernoulli's investigations.

The complete solution of this problem was not obtained till Dr Keill challenged John Bernoulli to determine the curve described by a body projected through a medium resisting as the square of the velocity. The Swiss geometer very soon gave a much more general solution than was demanded, independent of any limitation of the law of resistance, of the law of gravity, or of the law of density, provided that they were capable of being expressed algebraically. Dr Brook Taylor gave a solution of the problem in its limited form.

Labours of Huygens.

In the year 1690, the celebrated Huygens published a treatise on Gravity, in which he endeavoured to prove, from a series of experiments, that projectiles discharged through the air with great velocity, described paths very different from a parabola. The inconsistency of the Galilean theory, with the practice of artillery, was now particularly noticed by M. Ressons, a French artillery officer, who drew up a memoir on the subject, and presented it to the Academy of Sciences. * In this memoir, which was entitled *Methode pour tirer les bombes avec succes*, he attempts to shew that the theory is of very little service in the use of mortars, and that the theoretical path of projectiles is justly described in the works of Blondel; yet by directing mortars according to that theory, he could never obtain results that had the slightest agreement with it.

Experiments at Woolwich in 1736.

In the year 1736, a series of experiments was made at Woolwich, in order to determine the length of cannon that could enable them to shoot most efficaciously. These experiments were made with six 24 pounders, cast on purpose, and of the same weight, but varying in length from 8 feet to 10½ feet. These pieces were all loaded alike, with allotments of powder equal to half the weight of the bullet; and five shot were fired from each, at an elevation of 7¼°. The following are the results which were obtained:

Length of Pieces.	June 1st. Medium of Five Ranges.	June 18th. Medium of Three Ranges.	July 2d. Medium of Three Ranges.
Feet.	Yards.	Yards.	Yards.
10½	2486	2614	2406
10	2570	2532	2436
9½	2633	2560	2500
9	2790	2494	2563
8½	2586	2490	2466
8	2438	2473	2452

From the average range of these five shot, the effects of the different lengths were supposed to be deducible. The result of the experiments was, that the pieces of 9 and 9½ feet had the greatest range. Mr Robins has, however, shewn that these experiments are by no means inconsistent with his opinion, that the largest pieces ought to have the greatest range. The ranges with the 9 and 9½ feet guns ought not to differ more than 35 yards from the ranges of the 8 and the 10½ feet guns, according to his theory; and yet with two subsequent trials with the 9 feet gun, the ranges differ no less than 650 yards; and the average ranges made in these successive days differ from each other 300 yards. Hence it is obvious that these experiments differ so much from each other, that they are not sufficient to decide the point for which they were undertaken.

Experiments of the Royal Society of London.

No step of importance seems to have been made in gunnery till the year 1742, when Dr Jurin proposed some questions, which the Royal Society appointed a committee to investigate. The first of these questions was, Whether all the powder of the charge be fired? 2*d*, Whether all the powder that is fired, be fired before the bullet is sensibly moved from its place? And, 3*dly*, Whether the distance to which the bullet is thrown may not become greater or less by changing the form of the chamber, though the charge of powder and all other circumstances remain unchanged? The committee, after numerous experiments, found that all the powder was not fired; that the bullet was sensibly moved from its place, before all the powder that was fired had taken fire; and that a change in the form of the chamber would produce a change in the distance to which the bullet is thrown; the largest chamber of equal capacity always driving the ball farthest. † The committee, however, seem to have made some mistake; for Mr Robins afterwards proved, that the ball has not sensibly changed its place when the powder is fired.

Several experiments were about this time made in France on the ranges of cannon. M. St Remy has given us an account of a series made with pieces of cannon 10 feet in length, of the usual calibre, and elevated at an angle of 45°. The following were his results, the quantity of powder being two-thirds of the weight of the bullet.

	Range in Yards.		Range in Yards.
24 Pounder . . .	4490	8 Pounder . . .	3320
16 Ditto	4040	4 Ditto	3040
12 Ditto	3740		

Pieces of the same calibre as the preceding, but somewhat shorter, had almost the same ranges when fired with only one-half the former charge, or one-third of the weight of the ball in powder. See Remy's *Memoirs of Artillery*, vol. i. p. 69.

Experiments at La Fere by Borda in 1739.

Another series of experiments was made at La Fere, in the year 1739, under the direction of the Chevalier de Borda. They were made with the usual pieces of all the preceding calibres, and were charged with various quantities of powder, and elevated to 4°, to 15°, and to 45°. Experiments were also made with a 24 pounder, at different elevations, from 4° to 45°, and the following results were obtained with a charge of nine libs of powder.

Angle of Elevation.	Actual Range. Yards.	Angle of Elevation.	Actual Range. Yards.
40 . . .	. . . 4100	20 . . .	. . . 3480
35 . . .	. . . 4040	15 . . .	. . . 3350
30 . . .	. . . 3820	4 . . .	. . . 1640
25 . . .	. . . 3650		

* See Mem. Acad. Par. 1716, p. 79.

† See Phil. Trans. 1742, Vol. xlii. p. 172.

tory.

Experiments at La Fere.

Another series of experiments was made at La Fere, with different pieces, elevated to different angles, and charged with different quantities of powder. The following were the results.

Nature of the Piece.	Pounds of Powder.	Angle of Elevation.	Actual Range. Yards.
16	6	15	3560
16	6	4	1650
12	4	15	3000
12	4	4	1640
8	3	15	2880
8	3	4	1540
4	2	15	3000
4	2	6	1724

Experiments at Metz in 1740.

In the year 1740, a series of experiments were made at Metz with great care and attention. In the experiments of La Fere, the medium ranges only were given, but at Metz the result of each trial was set down. The piece which was used was a 24 pounder, 10 feet long. It was charged with different quantities of powder, from 8 to 20 lb. It had always an elevation of 4°; but as it was placed about 78 feet above the plain where the bullets fell, the elevation should be considered as 5°. The following are the results.

Pounds of Powder.	Ranges in Yards.	Pounds of Powder.	Ranges in Yards
8	1598	10	1676
—	1688	11	1674
—	1658	—	1568
—	1774	—	1900
9	1430	—	1784
—	1834	—	1584
—	1710	—	1660
—	1624	12	1624
—	1484	—	1614
—	1612	—	1764
—	1740	—	1798
—	1708	—	1684
—	1708	14	1680
—	1644	—	1696
—	1716	—	1756
—	1652	—	1900
—	1616	—	2120
—	1712	—	1686
—	2020	16	2000
—	1470	—	1796
—	1800	—	1940
—	1566	—	1670
10	1668	18	1900
—	1744	—	2000
—	1702	20	2200
—	1690	—	1682
—	1742		

Investigations of Benjamin Robins.

Hitherto no general principle had been established by the numerous experiments of which we have given a short account; but the subject of gunnery was now destined to receive the most important improvements from the labours of Mr Benjamin Robins, who published an account of them in 1742, in his *New Principles of Gunnery, containing the determination of the force of Gunpowder, and the investigation of the differences in the resisting power of the air to swift and slow motions.* In this valuable work, he begins by determining the explosive force of gunpowder, (see our article GUNPOWDER, p. 586.) and he found that this force was owing to an elastic fluid like air which existed in a highly condensed state in the powder, and being suddenly separated from it by combustion, expanded and impelled the bullet with prodigious force.

Mr Robins then proceeds to determine the velocity with which gunpowder will impel a shot of a given weight from a cannon of given dimensions; and in order to compare the velocities thus computed with the real velocities, he invented an instrument called the Ballistic Pendulum, by which he was enabled to measure the real velocities of bullets of all kinds with such accuracy, that in the case of a bullet moving with a velocity of 1700 feet per second, the error will never amount to $\frac{1}{150}$th part of the whole.

With this machine he made a great number of experiments, with musket barrels of different lengths, charged with different quantities of powder, and carrying balls of different weights; and the agreement between the calculated and observed velocities is so surprising as to establish his theory on the firmest foundation.

Mr Robins proceeds to point out the changes which take place in the force of gunpowder, from variations in the heat and moisture of the atmosphere: He determines the velocity which the flame of gunpowder acquires by expanding itself, to be 7000 feet per second: He ascertains the manner in which the flame of the powder impels a ball, placed at a considerable distance from the charge; and he enumerates the various kinds of powder, and describes the best methods of examining its goodness.

Mr Robins then treats of the resistance of the air, and of the track described by the flight of shot and shells. He shews, from experiments made with the ballistic pendulum, that at different velocities there was a gradual increase of the resistance over the law of the square of the velocity, as the body moved quicker. He then proves, that a 24 pound ball fired with a full charge of powder, experiences, when it first issues from the piece, a resistance more than 20 times its weight; that the paths of projectiles, when the velocity of projection is considerable, is not nearly a parabola; and that, in their flight, bullets are not only depressed beneath their original direction by the action of gravity, but are frequently deflected to the right or left of that direction by the action of some other force. Robins' *Principles of Gunnery* was translated into German by Euler, who honoured it with learned and valuable commentaries.

Labours of the Chevalier D'Arcy.

About eight or ten years after the publication of Robins' Works, the Chevalier D'Arcy published, in the Memoirs of the Academy for 1751, a Treatise on the Theory of Artillery, in which he gives an account of a series of experiments made with great care. He employed two pendulums, against one of which he fired the ball, while the other, from which the small cannon was suspended, served to measure the recoil. These experiments were afterwards extended, and published in his *Essais d'une Theorie de l'Artillerie*, which appeared in 1760.

Experiments at Turin in 1746.

In the year 1746, between the 7th February and the 30th of March, a series of experiments were made by the officers of artillery at Turin, for the pupose of determining the charges of powder that give the largest ranges. The guns were mounted on a part of the fortifications of the city, where the axis of the piece was 30 feet higher than the level of the country where the

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Experiments at Turin in 1746.

shot fell. The guns were fired with their axes always horizontal. The smallest charges were at first used, and increased gradually till the ranges began to diminish. The following Table shows the results of the experiments:

Nature of Guns.	Length of Bore.	Weight.	Weight of Powder.	Range.	Recoil.
	Calibres.	Cwt. qr. lb.	lb. oz.	Yards.	Inches.
4	27	9 1 9	1 4	478	43
			1 10	489	62
			2 1	472	72
8	27	18 2 10	2 7	512	45
			3 5	532	64
			4 2	532	82
16	23	31 3 26	3 5	505	42
			4 6	526	55
			4 15	522	78
32	20	57 2 17	6 9	485	54
			8 12	492	71
			9 13	489	82

From these results it follows, that the charge of powder which gives the longest range is equal to half the weight of the shot in four and eight pounders, and to one-third of its weight in 16 and 32 pounders. The recoil always increases in proportion to the augmentation of the charge. The length of the range increases to a certain point, and afterwards decreases in a much less ratio than the recoil increases. The charge which gives the longest range in pieces of small calibre, is proportionally longer than in pieces of large calibre.

Experiments at Turin in 1750.

In the spring of 1750, the Chevalier Ferrero di Ponsiglione made a series of experiments with pieces of the same calibre and proportions at Turin, for the purpose of ascertaining the charge that gives the longest range when the piece is fired at the greatest elevation its carriage will admit of. The ranges were measured on a flat piece of ground, nearly on the same level with the battery. The shot being rather larger, the windage was less than in the experiments of 1746.

Nature of Guns.		Weight of Powder.	Length of Range.	Recoil.
Pounders.	Elevation.	lb. oz.	Yards.	Inches.
4	14°	2 1	2375	52
		2 8	2219	60
		2 14	2422	70
		3 5	2526	76
8	11°	3 5	2321	46
		4 2	2463	65
		4 15	2486	85
		5 12	2375	102
		6 9	2675	119
16	12°	5 12	2659	71
		6 9	2860	76
		7 3	2663	90
		8 3	2810	97
		9 0	2764	108
		9 13	2892	113
32	11½°	11 8	3172	117
		13 2	3032	120
		14 6	2995	124
		16 6	3220	146
		18 0	3084	168

From these experiments it follows, that the charges that give the longest ranges when cannon are fired from the greatest elevations their carriages will permit, are greater than those which produce the same effect when they are fired horizontally. Several experiments which were some time afterwards made in France, shewed, that in cannon of a large calibre, the charge should be about three-eighths of the weight of a shot. In the month of August 1747, Signior Marandone made a series of experiments for the same purpose, by orders of the Knights of Malta. From these he concluded, that the charge that ought to produce the longest range, must exceed three-eighths of the weight of the shot.

Marandone's experiments.

Signior Mattei, mathematical instrument maker to the King of Sardinia, invented a machine for finding the initial velocity of balls measured near the mouth of the gun; and a number of valuable experiments were made with it by Antoni, of which we shall afterwards give a more particular account. Mattei's machine consists of a horizontal circle, supported by its centre on the upper end of a vertical axis, and serving as a base to a hollow paper drum. This drum is made to revolve by means of a weight at the end of a cord passing over a pulley; and the projectile, thrown in a horizontal direction, traverses the paper drum in two points. The arc described by the system, while the projectile, in traversing the interior of the drum, is measured by the distance of the second point from the diameter which passes through the first. See the Description of Plates, and p. 577.

Mattei's machine for measuring initial velocities. PLATE CCLXVI. Fig. 5.

Another very simple machine for the same purpose, was invented in 1764, by Lieutenant De Butet. "He applies a little plate of metal, provided with a moveable index, to any wheel that turns with an equable motion and sufficient velocity; the index is held at some distance from the circumference of the wheel, by a thread that is stretched across the mouth of the gun. When the gun is fired, the shot breaks the thread and sets at liberty a spring, which instantly presses the index against the wheel, upon which it describes an arch, till it is checked by the impact of the shot against a moveable butt placed at the distance of a few feet: to this effect, one extremity of a rod is fastened to the butt, and the other to the plate; thus the index is drawn back by the rod which follows the movement of the butt, and ceases to describe the arch on the circumference of the wheel. The motion of the wheel, the distance from the muzzle of the gun to the butt, and the arch described by the index being known, it is easy to ascertain the space that the shot passes through in one second of time with an uniform velocity; or, in other words, its initial velocity. To diminish the friction as much as possible, a small groove is made in the part of the wheel that receives the index, and filled with grease, which presents a very slight resistance. By means of this instrument, the time of the shot's passage along the bore of the gun, the initial velocity of shells, and the resistance of the air to their motion, may be determined; if allowance be made for the modifications that must ensue."

De Butet's machine for measuring initial velocities.

In the year 1779, the learned Dr Hutton of Woolwich, in conjunction with several officers of artillery, undertook a series of experiments on the motion of cannon balls. They used ballistic pendulums from 300 to nearly 600 pounds weight, and they employed cannon shot of 1, 2, and 3 pounds weight, and they varied the charge of powder from 2 to 8 ounces. From these experiments, of which a full account was published in the *Philosophical Transactions* for 1778, Dr Hutton deduced the following inferences.

Hutton's experiments at Woolwich in 177[illegible]

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1. That gunpowder fires almost instantaneously. 2. That the velocities communicated to balls or shot of the same weight by different quantities of powder, are nearly in the subduplicate ratio of those quantities: a small variation in defect taking place when the quantities of powder become great. 3. And when shot of different weights are employed, with the same quantity of powder, the velocities communicated to them are nearly in the reciprocal subduplicate ratio of their weights. 4. So that, universally, shot which are of different weights, and impelled by the firing of different quantities of powder, acquire velocities which are directly as the square roots of the quantities of powder, and inversely as the square roots of the weights of the shot, nearly. 5. It would therefore be a great improvement in artillery to make use of shot of a long form, or of heavier matter; for thus the momentum of a shot, when fired with the same weight of powder, would be increased in the ratio of the square root of the weight of the shot. 6. It would also be an improvement to diminish the windage; for by so doing, one third or more of the quantity of powder might be saved. 7. When the improvements mentioned in the last two articles are considered as both taking place, it is evident that about half the quantity of powder might be saved, which is a very considerable object. But important as this saving may be, it seems to be still exceeded by that of the article of the guns; for thus a small gun may be made to have the effect and execution of another of two or three times its size in the present mode, by discharging a shot of two or three times the weight of its natural ball or round shot: And thus a small ship might discharge shot as heavy as those of the greatest now made use of.

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In the year 1781, Count Rumford instituted a series of experiments with musket barrels. The machinery which he used was ingeniously contrived and well executed, and his object was to determine the initial velocity of bullets, the recoil of the barrel, the effect of firing the charge in different parts of it, and the most advantageous situation for the vent. The following were the principal results which he obtained. He found that when the weights and dimensions of the bullets are the same, their velocities, when discharged from the same piece, are in the subduplicate ratio of the weight of the charges; and he concludes, from numerous experiments, that the vent may be placed in any part of the chamber where it will best answer on other accounts. Hence Count Rumford recommends that the bottom of the bore should be of a hemispherical form; that the vent should be brought directly through the side of the barrel in a line perpendicular to its axis, and pointing to the centre of the hemispherical concavity of the chamber.

In these experiments, the ballistic pendulum of Robins was employed; but in consequence of a suggestion contained in Robins's new principles of gunnery, Count Rumford proposed, and put in practice, another method of determining the velocities of bullets, by suspending the gun in a horizontal position by two pendulous rods, and determining the velocity of its recoil from the arc of its ascent, measured by a ribbon, as in the ballistic pendulum. The velocity of the bullet will be $v = \frac{V - U}{B} \times W$; where W is the weight of the gun, V the velocity of its recoil when fired without a bullet; V the velocity of the recoil when the same charge impels a bullet, B the weight of the bullet, and v its velocity. By comparing the results obtained in this way, with others obtained from the ballistic pendulum, Count Rumford found, that in several cases they agreed, but that in others the differences were so great, that the new method ought not in general to be relied upon.

Dr Hutton's second set of experiments from 1783 to 1791.

Another very extensive set of experiments was undertaken in the year 1783, under the direction of Major Bloomfield, and by the orders of the Duke of Richmond, Master-General of the Ordnance. They were carried on in the summers of 1783, 1784, 1785, 1787, 1788, 1789, 1791, &c. principally with a view to the following objects:

1. To determine the velocity of balls impelled by equal charges, from pieces of different lengths, but of the same weight and calibre.

2. To determine their velocities with different charges, when the weight and length of the gun are the same.

3. To determine the greatest velocity due to different lengths, by making the charge as great as the gun will bear.

4. To determine the effect of varying the weight of the gun, every thing else remaining the same.

5. To determine the penetration of balls into blocks of wood.

6. To determine the ranges and times of flight, and the velocities of balls, by striking the ballistic pendulum at various distances, and to compare them with their initial velocities, in order to ascertain the air's resistance.

7. To determine the effect of wads; of different degrees of ramming; of different degrees of windage, and of different positions of the vent; of chambers and trunnions, and every other circumstance necessary to be known for the improvement of artillery.

These experiments were carried on with great success, excepting in the subject of ranges, which were less regular and uniform than could have been wished. The ballistic pendulum was from 600 to 800 pounds weight. The balls were generally one pound weight, and the powder was increased from one ounce till the bore was quite full.

The following are the general results, as given by Dr Hutton:

General results deduced by Dr Hutton.

"1. That the velocity is directly as the square root of the weight of powder, as far as to about the charge of eight ounces; and so it would continue for all charges, were the guns of an indefinite length. But as the length of the charge is increased, and bears a more considerable proportion to the length of the bore, the velocity falls the more short of that proportion.

2. That the velocity of the ball increases with the charge to a certain point, which is peculiar to each gun where it is greatest; and that, by further increasing the charge, the velocity gradually diminishes till the bore is quite full of powder. That this charge, for the greatest velocity, is greater as the gun is longer, but not greater, however, in so high a proportion as the length of the gun is; so that the part of the bore filled with powder bears a less proportion to the whole in the long guns than it does in the short ones; the part of the whole which is filled being indeed nearly in the reciprocal subduplicate ratio of the length of the empty part. And the other circumstances are as in this Table.

Table of Charges producing the greatest Velocity.

Gun.	Length of the Bore.	Length filled.	Part of the whole.	Weight of the Powder.
Number	Inches.	Inches.		Ounces.
1	28.2	8.2	[illegible]	12
2	38.1	9.5	[illegible]	14
3	57.4	10.7	[illegible]	16
4	79.9	12.1	[illegible]	18

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General results deduced by Dr Hutton.

3. It appears that the velocity continually increases as the gun is longer, though the increase in velocity is but very small in respect of the increase in length, the velocities being in a ratio somewhat less than that of the square roots of the length of the bore, but somewhat greater than that of the cube roots of the length, and is indeed nearly in the middle ratio between the two.

4. The range increases in a much less ratio than the velocity, and indeed is nearly as the square root of the velocity, the gun and elevation being the same. And when this is compared with the property of the velocity and length of gun in the foregoing paragraph, we perceive that very little is gained in the range by a great increase in the length of the gun, the charge being the same.

And, indeed, the range is nearly as the 5th root of the length of the bore, which is so small an increase, as to amount only to about one-seventh part more range for a double length of gun.

5. It appears also that the time of the ball's flight is nearly as the range; the gun and the elevation being the same.

6. It appears that there is no sensible difference caused in the velocity or range, by varying the weight of the gun, nor by the use of wads, nor by different degrees of ramming, nor by firing the charge of powder in different parts of it.

7. But a great difference in the velocity arises from a small degree of windage. Indeed, with the usual established windage only, namely, about 1-20th of the calibre, no less than between 1-3d and 1-4th of the powder escapes and is lost. And as the balls are often smaller than that size, it frequently happens that half the powder is lost by unnecessary windage.

8. It appears that the resisting force of wood to balls fired into it, is not constant. And that the depths penetrated by different velocities or charges are nearly as the logarithms of the charges, instead of being as the charges themselves, or, which is the same thing, as the square of the velocity.

9. These, and most other experiments, shew, that balls are greatly deflected from the direction they are projected in, and that so much as 300 or 400 yards in a range of a mile, or almost 1-4th of the range, which is nearly a deflection of an angle of 15°.

10. Finally, these experiments furnish us with the following data to a tolerable degree of accuracy, viz. the dimensions and elevation of the gun, the weight and dimensions of the powder and shot, with the range and time of flight, and the first velocity of the ball.

The experiments made by Dr Hutton in the years 1787, 1788, 1789, and 1791, were principally intended to ascertain the resistance of the air to military projectiles. Balls of 2 inches, 2.78 inches, and 3.55 inches in diameter, were employed, to determine the resistance of very high velocities. They were discharged with velocities from 300 to 2000 feet per second, and were made to strike the pendulum at several different distances from the guns. In all these experiments, the resistances varied nearly as the $2\frac{1}{10}$th power of the velocity, the exponent being 2.028 for a velocity of 200 feet per second, and increasing gradually to 2.136, which it reached when the velocity was 2000 feet per second.

Grobert's apparatus for measuring the initial velocity of projectiles.

In the year 1804, a new machine for measuring the initial velocity of projectiles was proposed and used by Col. Grobert; and a very favourable report of its accuracy was made to the National Institute of France, by Messrs Bossut and Monge. The apparatus consists of a horizontal revolving axis about 34 decimetres long, having at each of its extremities a circle or disc of pasteboard placed perpendicular to the axis. A rotatory motion is communicated to the axes, and consequently to the discs, by means of a weight suspended at the extremity of a rope, which, passing over a pulley 10 or 12 yards above the ground, coils itself about the arbor of a wheel and axle fixed at the same level as the discs. The motion given to the wheel and axle by the descent of the weight is communicated to the axis of the discs by an endless chain passing round the wheel and axle, and also round a pulley on the axis of the discs. The instrument being thus constructed, let us suppose that a ball traverses the two discs when in motion, in a direction parallel to their axes. It is obvious that the hole in each disc will not coincide with one another, and that the angular motion which the second disc has made while the ball was passing between them will be a measure from which the velocity of the ball can be computed. Hence it is necessary to impress upon the discs an uniform and known velocity, and to measure accurately the arch passed over by the second disc during the transit of the ball from the one to the other. In the experiments which were made with this machine, the motion became sensibly uniform when the weight had arrived nearly at the half of the vertical space which it traversed. The following is the formula for calculating the velocity of the ball.

$$V = \frac{2\pi n}{kt} \cdot \frac{r}{a} b, \text{ or}$$

$$V = \frac{6.282\,n}{kt} \cdot \frac{r}{a} b, \text{ in which}$$

V = the velocity of the ball between the discs, considered as uniform;

π = 3.141, the ratio of the circumference to the diameter of a circle;

k = the ratio between the respective numbers of the turns made at the same time by the wheel of the axle, and the pulley of the axis of the discs, which in the following experiments was $\frac{1}{7.875}$;

t = the time employed by the wheel of the axle to make n number of turns;

r = the distance of the hole made by the ball in the second disc from the axis of the discs;

a = the arc passed over by that hole while the disc goes from the one to the other;

b = the distance between the two discs.

The following experiments were made with a horse musketoon, 0.765 metres of interior length. The weight of the ball was 24.7 grammes, and it was projected with half its weight of powder. The mean velocity deduced from these experiments is 390.47; whereas the mean velocity found from experiments with the common infantry musket, 1.137 metre of interior length, was 428, exceeding the former in the ratio of 11 to 10. All the values of a are referred to that of r = 1 metre.

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Experi-
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Number of the experiments.	Values of n, or the number of turns made by the wheel of the axle.	Values of t, or the time in which the number of turns were made.	Values of a, or the arc passed over by the hole in the second disc.	Values of V, or the velocity of the ball.
		Seconds.	Metres.	Metres.
1	8	10	0.3510	402.3
2	8	10	0.3800	371.7
3	8	10	0.368	362.5
4	15	22	0.296	384.1
5	15	22	0.264	430.7
6	10	18	0.268	345.7
7	15	16	0.392	398.8
8	15	16	0.392	398.8
9	15	16	0.416	375.8
10	15	16	0.360	434.3

In order to afford the means of traversing the discs by throwing balls in different directions from 0° to 45°, Colonel Grobert gives to each disc a particular horizontal axis, to which a pulley is affixed; and the rotatory motion is communicated by an endless chain to both axes, so that they may perform the same number of revolutions in the same period. The supporter of the second disc is capable of rising vertically, and fixing itself at different heights. The adjustment of this apparatus must, however, be attended with great difficulty.

CHAP. I.

On the Parabolic Theory of Gunnery. *

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In the process of our examination of the motions in the solar system, it appears that terrestrial gravity, or the heaviness of common sublunary bodies, is only a particular case of the mutual tendency of all matter towards all matter. It further appears, that a body on the surface of our globe gravitates in a line that is directed very nearly to the centre of the earth; and that the intensity of this gravitation is inversely proportional to the square of its distance from this centre.

Bodies let fall, or projected in any direction on the surface of this earth, move under the influence of this force; and their motions may be computed from the general doctrines of dynamics in the same manner as we computed the motions of the planets. They will either fall in the direction of gravity, or will rise in the opposite direction, or will describe a curve line concave toward the earth, which will be an ellipsis, parabola, hyperbola, or circle, according as the velocity and direction of the projection may have been combined.

But, in the greatest projections that we can make, the force of gravity is so nearly the same in every point of the path, that we may suppose it to be accurately so, without any sensible error, were it ten times greater than it is. Therefore in all disquisitions about projectiles, it would be useless affectation to embarrass ourselves with the variations. None of our projectiles rise a mile in the air, which is about $\frac{1}{3960}$ of the mean radius of the earth, and will occasion a diminution of gravity nearly equal to $\frac{1}{1980}$, a quantity altogether insignificant.

For the same reasons, although the directions of gravity in the different points of the projectile's flight, are lines converging nearly to the centre of the earth, we may consider them as all parallel, because none of our projectiles fly four miles, which produces a convergency of nearly four minutes, a deviation from parallelism which needs not be regarded.

Parabolic Theory of Gunnery.

In general, therefore, we may consider all such projectiles as under the influence of equal gravity acting in lines parallel to the vertical or plumb-line drawn through the place of projection. This reduces the theory of projectiles to a great degree of simplicity.

Accordingly, this is the first department of mechanical philosophy which first received improvement by the application of mathematical knowledge. We are indebted for this fortunate introduction of mathematics into the doctrines of motion, to the celebrated Florentine, Galileo Galilei. This excellent philosopher read his discourses on local motion, about the beginning of the 17th century. Those lectures contain the whole of this doctrine, nearly in the state in which it continued till about the middle of last century. There is no branch of natural philosophy that has met with so much assistance and encouragement, it having been considered in all nations as the foundation of the art of gunnery; an art unfortunately too much connected with the security of every nation. It has therefore been patronised by princes and magistrates—most costly establishments have been made for its cultivation; the mathematicians have occupied themselves with its problems, and more numerous and expensive volumes have been published on this than on any other part of mechanical philosophy. Yet there is none in which so little improvement has been made. Galileo's lessons contain every thing that has been done in a scientific way, till M. Robins, in 1742, gave it a form altogether new.

We shall first consider the perpendicular ascents and descents of heavy bodies; and in the next place, their curvilineal motion when projected in directions deviating from the vertical.

The motion of a falling body is uniformly accelerated, and that of a body thrown straight upward is uniformly retarded.

For the accelerating or retarding force is constant, and therefore the motions are such as were considered in Dynamics.

All the characteristic phenomena of these motions having already been sufficiently considered, all that is wanted for the application to this class of mechanical phenomena, is merely one experimental determination of the accelerative power of gravity, that is, the velocity, or increment of velocity, which gravity will generate in a body by acting on it uniformly during some given time. Galileo, who first demonstrated that an invariable gravity must produce a uniformly accelerated motion, was also among the first who appealed to experiment in all inquiries. We now think lightly of this, and wonder that a man shall think of another argument who has this in his power. But when Galileo began to communicate his knowledge to the world, this was the last support that a philosopher would think of. They had received a parcel of topics from their master, which had been handed down in the schools during many ages; and from these was every thing accounted

* This valuable Chapter was written by the late John Robison, LL. D. F. R. S. E. It was intended to form a part of his *System of Mechanical Philosophy*, and was the last production of that eminent philosopher. It is now published for the first time, with the permission of Mr Murray the proprietor of the MSS. and will appear in the first volume of his *System of Mechanical Philosophy*, now in the press.

for or explained. Aristotle, or his immediate pupils, had said that the velocities of falling bodies increased with their weights; Galileo's doctrine was incompatible with this, and he thought himself obliged to use arguments in his support. He said that if Aristotle's doctrine be true, two crown pieces must fall faster when sticking together than when unconnected, which, said he, is contrary to common experience. Not doubting that he had convinced his audience, he described the experiments which he was to exhibit next day, shewing that in a double time a body would fall four times as far, &c. The experiments were performed in the dome of the great church, before a vast concourse of people, and succeeded most perfectly. Yet so little were the philosophers moved by this kind of argument, that they represented Galileo as a dangerous person, unfriendly to the state; and he was obliged to leave his native city in a few days, and take shelter in Padua. It is very remarkable, that Baliani, one of the first geometers and mathematicians of that age, and who perfectly understood Galileo's speculations on this subject, should teach another doctrine, reviving or supporting an old scholastic assertion, that the velocity of a falling body might be as the space fallen through, calling this motion also a uniformly accelerated motion.

Galileo found more difficulty than one should expect in his endeavours to obtain an exact measure of the power of gravity; and indeed could not obtain one that was satisfactory. But the difficulty of the task, and his struggle to accomplish it, were big with advantages to science. A body falls so fast, that a considerable error in the conclusion arises from a very small error in estimating the time; and the great difficulty was how to estimate the time. It was in this casting about for a measure of a small portion of time that Galileo first thought of the pendulum. His penetrating and sagacious mind enabled him to see that there must be a fixed proportion between the time of a vibration and that of falling through its length, although his mathematical knowledge did not yet enable him to find it out; he saw an immediate consequence of this if true, namely, that the vibrations of two pendulums should be in the subduplicate ratio of the lengths, because this must be the proportions of the times of falling through those lengths. This he would try; and he found that it was so. Delighted with this success, he immediately compared the time of falling from the top of the great dome with that of a pendulous vibration, by making a pendulum of such a length that it performed precisely one vibration in the time of the fall. In this time, the body, moving with the final velocity, would describe a space double of that fallen through. He then counted with patience the number of vibrations made by his pendulum in an interval of time, measured by the transit of two stars. Thus he obtained the time, and the velocity generated in that time by the uniform action of gravity. Galileo made this to be about 31 feet of our measure in a second, and said that it was certainly somewhat more; because his experiments on falling bodies convinced him that their motion is retarded by the air.

These efforts and resources of an ingenious mind are worthy of record, and are instructive to others. But Galileo did not attain the accuracy in this measure that we now possess. The honour of the accurate statement of the time of a pendulous oscillation, and that of the fall through its length, was reserved for Mr Huygens. This proportion was determined by him by a most ingenious and elegant physico-mathematical process. He also gave us the pendulum clock, by which time can be measured with as much accuracy as a line can be divided.

Aided by these inventions, we have now obtained the most precise measure of the accelerating powers of gravity; and we can now say that its intensity is such in the latitude of London, that by acting uniformly on a body for one second of time, it generates in it the velocity of 32 feet two inches per second, and a heavy body falls 16 feet one inch in that time.

These are standard numbers, of continual use in all mechanical discussions, and should be carefully kept in remembrance. Not only so, but we should acquire distinct notions of them in this respect, viz. as standard numbers. Gravity is known to us in two ways; our most familiar acquaintance with it is as a pressure, which we feel when we carry a heavy body. With this we can compare the pressure of a spring, the exertion of an animal, the pressure of a stream of water or wind, the intensity of an attraction, &c. by setting them in opposition and equilibrium. The philosopher, and especially the physical astronomer, and cultivator of the Newtonian philosophy, is well acquainted with gravity as an accelerating and a moving force, capable of accelerating, retarding, or deflecting the body in which it inheres, or on whose intimate particles it acts without intermedium. He can compare the gravity of a stone with that of the moon, or of Jupiter, or with the force that produces the precession of the equinoxes. The general mechanician, observing that all other pressures, such as that of a spring, of an animal, &c. are also moving forces, by combining those two aspects of gravity, makes a most important use of it by comparing other forces with weights, and thence inferring the motions which those forces will produce. Thus, knowing that an arrow $\frac{7}{8}$ oz. weight, by falling 18 inches acquires the velocity of $10\frac{1}{2}$ feet per second, he infers, that when drawn to the head by a bow of 62 pounds, it will be discharged with the velocity of 233 feet per second.

We shall therefore, in future, compare every force with gravity, and express the accelerative power of this standard by 32, meaning that by acting on every particle of a body for a second, it will generate the velocity of 32 feet per second, and cause the body to describe 16 feet with a motion uniformly accelerated. We may find it convenient, on some occasions, to use the numbers 386, and 193, which are the inches in $32\frac{2}{12}$ and $16\frac{1}{12}$ feet.

The questions that interest us at present are those concerning the relations between the time t of any fall, the height h of that fall, and the velocity v that is uniformly acquired in falling; so that when any one of those things is given, the others may be found out.

I. Since the variations of velocity are proportional to the times in which they are produced, we have

$$1' : t'' = 32 : 32\,t''$$
$$\text{and } v' = 32\,t''$$
$$\text{and } t'' = \frac{v'}{32}.$$

N.B. The time t is always supposed to be a number of seconds, and the height h a number of feet, and the velocity v a number of feet uniformly moved over in one second.

A falling body, therefore, acquires an increment of 32 feet per second in every second of its fall, and an ascending body has its velocity lessened as much during every second of its rise. A body *falling* during four seconds, acquires the velocity of 128 feet per second.

But if the body has been projected downward, with the velocity of 100 feet per second, then, at the end of 4″, it is moving at the rate of 228 feet per second.

A body projected straight upwards with the velocity of 160 feet per second, will at the end of the first second of its rise, have the velocity 128. At the end of 2″ it will be moving at the rate of 96 feet per second. Its velocity at the end of the third second will be 64. At the end of the fourth second it will be 32, and at the end of five seconds it will stop, and begin to fall.

The times of the rise and the subsequent fall are equal.

II. Since the heights are as the squares of the times of the fall or ascent, we have

$$1'' : t^2 = 16 : 16\,t^2$$
$$\text{and } h = 16\,t^2 \text{ and } \sqrt{h} = 4\,t.$$
$$\text{also } t^2 = \frac{h}{16}, \text{ and } t = \frac{\sqrt{h}}{4}.$$

A heavy body, falling during four seconds, falls 256 feet.

A body rising straight upwards 144 feet employs 3 seconds in its ascent.

III. Because the heights fallen through are also proportional to the squares of the velocities acquired at the end of the fall, we have

$$32^2 : v^2 = 16 : h$$
$$\text{and } h = \frac{16}{32^2} v^2, \text{ and } \sqrt{h} = \frac{4}{32} v, = \frac{v}{8}$$

and, conversely, $v = 8\sqrt{h}$, and $v^2 = 64\,h$.

All questions concerning the perpendicular ascents and descents of heavy bodies may be solved by means of the two equations

$$v = 32\,t = g\,t$$
$$h = 16\,t^2 = \tfrac{1}{2} g\,t^2.$$

An easy mode of extempore computations is had, by remarking, that since a heavy body falls 16 feet in a second, and acquires the velocity 32, it falls 1 foot in $\frac{1}{4}$th of a second, and acquires the velocity 8.

In every second of the fall, the velocity is increased by 32; and in every foot of the fall, the square of the velocity is increased by 64.

In many questions, particularly in hydraulics, it is convenient to have the measures in inches.

Now, $\sqrt{193} : \sqrt{1} = 386 : 27{,}785$. Therefore a heavy body by falling one inch acquires the velocity 27,785 inches, or nearly $27\frac{3}{4}$ inches per second.

Did gravity impel a body uniformly along a space equal to the radius of the earth, it would generate the velocity, which would enable the body to describe a parabola, having the centre of the earth for its focus. If projected straight upwards with this velocity it would never return.

Now $\sqrt{16} : \sqrt{\text{Earth's rad.}} = 32 : 36{,}680$ feet. This is the velocity now spoken of. Suppose the earth uniformly dense, and a pit to the centre. A heavy body would acquire, by falling down this pit, the velocity 25,866. Greater velocities than either of these can be produced by forces which we know. *Aurum fulminans* expands with the velocity of at least 42 miles per second.

It does not seem necessary to insist further on the rectilineal ascents and descents of heavy bodies, and therefore we proceed to consider their curvilineal motions, when projected in any direction that deviates from the perpendicular. These are the motions which are understood to form what is called Projectiles.

These motions are not only interesting to the philosophical mechanist, as examples of a constant deflecting force, and a uniform deflection in parallel lines, but also to the artillerist; because the motion of shot and shells are cases of this question, which comprehend the whole of his art. It has therefore been very much cultivated; and there is no branch of mechanical philosophy on which so much has been written, or so many experiments made for its improvement. The experimental cultivation of this branch could scarcely be prosecuted by private persons; but, in all the states of Europe, there are public establishments for this purpose, and no expence has been spared for bringing to perfection an art in which the fate of nations has unfortunately much dependence.

But, notwithstanding this liberal encouragement, and the numberless volumes which have been published on the subject, it cannot be said to have improved much as a science since it came out of the hands of its inventor, and his immediate pupil Tartaglia; and we shall be greatly disappointed if we look for that nice agreement between the results of the most approved theory and what we observe in the flight of great shot and shells. The theory, however, is unexceptionable; and the enormous deviations that we see in the actual performance of artillery, is owing to the resistance of the air. This was long considered as insignificant, even after Newton had given us sufficient information to the contrary. But the gentlemen of the profession made little account of the speculations of a private philosopher, and continued to regulate their theories by notions of their own. They have been at last convinced of their mistake by the curious experiments and discoveries of Mr Robins, and are improving their practice in some measure. But we now find, that the theory of the motion of heavy bodies through a resisting fluid, is one of the most abstruse and difficult tasks that the mechanician can take in hand.

At present, we are about to consider this subject merely as a particular case of motions regulated by gravitation, reserving the particular consideration of the modifications of these motions by the resistance of the air, till we shall have made ourselves acquainted with the general laws of such resistance.

Let a body (Plate CCLXXVI. Fig. 1.) be projected in any direction AB, which deviates from the vertical AW. Then it would move on in this direction, and in equal succeeding moments would describe the equal spaces AB, BH, HI, IK, KL, &c. But suppose, that when the body is at B it receives an instantaneous impulse in the direction of the vertical BB′, such that by this impulse it would describe the line B *b* uniformly in the same time that it would have continued its motion along BH. Or, to speak more accurately, let the motion or velocity B *b* be compounded with the motion BH. The body must describe the diagonal BC of a parallelogram B *b* CH, and, at the end of this second moment, it must be in C, in the vertical line HCC′, and moving with the velocity BC. Therefore, in the third moment it would describe CN, equal to BC. But let another impulse in the direction of the vertical CC′ generate the velocity C *c*, equal to B *b*. By the composition of this with the motion CN, the body will describe the diagonal CD of the parallelogram C *c* DN, and at the end of the third moment must be in D, moving in the direction and with the velocity CD. It would describe DO equal to CD in the fourth moment. Another impulse of gravity D *d*, in the vertical, and equal to either of the former impulses, will make the body describe DE; and an equal impulse E *e* will deflect the body into EF; and another impulse F *f* will deflect it into FG, &c.

Thus it is plain that the body, by the composition of these equal and parallel impulses, will describe the

Plate CCLXXVI. Fig. 1.

Parabolic Theory of Gunnery.

PLATE CCLXXXVI. Fig. 1.

polygonal figure ABCDEFG, all in one vertical plane, and in every instant or point, such as E, will be found in the vertical line KE, drawn from the point at which it would have arrived in that instant by the primitive projection.

Now, let the interval between these impulses be diminished, and their number be increased without end. It is evident that this polygonal motion will ultimately coincide with the motion in a path of continued curvation, by the continual and unvaried action of gravity.

The line described by the body has evidently the following properties.

1st, If a number of equidistant vertical lines BB′, HCC′, IDD′, KEE′, &c. be drawn, cutting the curve in B, C, D, E, &c.; and if the chords AB, BC, CD, DE, &c. drawn through the points of intersection, be produced till they cut the verticals in H, N, O, P, &c. the intercepted portions HC, ND, OE, PF, &c. are all equal.

2d, The curve is a parabola, in which the verticals BB′, CC′, &c. are diameters. The property mentioned in the last paragraph belongs exclusively to the parabola. As the circle is the curve of uniform deflection in the direction of the radius, so the parabola is the curve of uniform deflection in the direction of the diameter. That the curve in which the chords drawn through the intersection of equidistant verticals cut off equal portions of these verticals is a parabola, is easily proved in a variety of ways. Since B*b*, C*c*, D*d*, E*e*, are all equal, and the verticals are equidistant, B*cd*E must be a straight line. So must C*dc*F; BE must be parallel to CD, and CF to DE. Therefore BF and CE are parallel, and are bisected in *m* and o by the vertical DD′. Also, if FC be produced till it meet the next vertical in *i*, *i* B is equal to D *m*. All this is very plain. Hence

$$i\,\mathrm{B}, \text{ or } \mathrm{D}\,m : d\,m = \mathrm{BF} : m\,\mathrm{F}, = m\,\mathrm{F} : o\,\mathrm{E};$$
$$\text{but} \quad d\,m : \mathrm{D}\,o = m\,\mathrm{F} : o\,\mathrm{E};$$
$$\text{therefore } \mathrm{D}\,m : \mathrm{D}\,o = m\,\mathrm{F}^2 : o\,\mathrm{E}^2;$$

and D, E, F are in a parabola, of which D *m* is a diameter, and o E, *m* F are semiordinates. We should prove, in the same manner, that BG is parallel to CF, and AG to BF, and $\mathrm{D}\,m : \mathrm{DD}' = m\,\mathrm{F}^2 : \mathrm{D}'\mathrm{G}^2$, and the points D, F, G, in the same parabola.

Thus we have demonstrated, that the equal and parallel impulse of gravity produces a motion in a parabola whose diameters are perpendicular to the horizon. This was the great discovery of Galileo, and the finest example of his genius. His discoveries in the heavens have indeed attracted more notice, and he is oftener spoken of as the first person who shewed the mountains in the moon, the phases of Venus, the satellites of Jupiter, &c. But in all these he was obliged to his telescope; and another person who had common curiosity would have seen the same things. But, in the present discovery, every step was an effort of judgment and reasoning, and the whole investigation was altogether novel. No attempt had been made, since the first dawn of mechanical science, to explain a curvilineal motion of any kind; and even the law of the composition of motion, though faintly seen by the ancients, had never been applied to any use (except by Stevinus) till this sagacious philosopher saw its immense importance. and brought it into constant service.

The process employed by Galileo in this investigation, and which has been copied by almost all the writers on the subject, is considerably different from the one now gone through. Galileo supposes the heavy body to fall in the vertical BB′ with a uniformly accelerated motion, describing spaces as the squares of the times. He supposes this motion to be compounded with the uniform motion in the direction of the tangent BR. Then, supposing that B*t* and BT are fallen through while B*r* and BR are described by the motion of projection, it follows, that because B*r* is to BR as the time of describing B*r* to the time of describing BR, we shall have $\mathrm{B}t : \mathrm{BT} = \mathrm{B}r^2 : \mathrm{BR}^2$. Therefore, completing the parallelograms B*t*C*r*, BTSR, we have $\mathrm{B}t : \mathrm{BT} = t\,\mathrm{C} : \mathrm{TS}$, and the points B, C, S are in a parabola, whose diameter is BT, and has BR a tangent in B.

Parabolic Theory of Gunnery.

PLATE CCLXXXVI. Fig. 1.

No doubt, the result of these suppositions agrees perfectly with the phenomena, and gives a very easy and elegant solution of the question. But, in the first place, it is more difficult, or takes more discourse, to prove this continued composition of motion (almost peculiar to the case) than to demonstrate the parabolic figure: and, secondly, it is not a just narration of the fact of the procedure of nature. There is no composition of such motions as are here supposed. When the body is at C, there is not a motion in the direction parallel to B*r*, compounding itself with a motion in the vertical, having the velocity which the falling body would have as it passes through the point *t*. The body is really moving in the direction CS of the tangent to the parabola, and it there receives the same infinitesimal impulse of gravity that it received at B. Its deflection, therefore, from the line of its motion, does not make any finite angle with that motion. Therefore, although Galileo's demonstration does very well for a mere mathematical process, like the navigator's calculation of the ship's place by tables of difference of latitude and departure, it by no means answers the purpose of the philosophical investigation of a natural phenomenon. The method we have followed is a bare narration of the facts; considering the motion of the body in every instant as it really is, and stating the force then really affecting its motion.

We have not scrupled to make use of the method employed by Newton in the demonstration of his fundamental proposition on curvilineal motions, first conceiving the action of gravity to be subsultory, and the motion to be polygonal, and then inferring a similar result from the uninterrupted action of gravity. But if any person is so fastidious as to object to this, (as John Bernoulli has done to Newton's method,) he may remark, that the motion B*b*, which we compared with BH, in order to produce the motion BC, is just double of the space B*t*, through which the body falls during the motion along BH. Therefore the figure will be such, that the curvilineal deflection will be one half of B*b*, or of HC, and the tangent to the curve, whatever it is, will bisect HC. Then, during the next moment, since the deflective action of gravity is supposed the same, the body will be as much deflected from its path in C, that is, from the new tangent CS, whatever direction that tangent may have, as it was in the preceding moment. This gives us *s* D equal to *r* C, and this obtains throughout. Without entering on any discussion on the progress of the deflection in the different points of the arch BC or CD, it is enough for our purpose to shew that the curve described is such that when equidistant verticals are drawn, and tangents drawn through their intersections with the curve, the portions of the verticals cut off by the tangents are everywhere equal. This also is a property of the parabola exclusively. That BCD is a parabola, of which BT is a diameter, and BR a tangent, is easily seen. For, drawing D*u* parallel to BR, it is plain that $v\mathrm{N} = 2r\mathrm{C}$, and $\mathrm{ND} = 2s\mathrm{D}$, $= 2r\mathrm{C}$. Therefore $v\mathrm{D} = 4r\mathrm{C}$, and $\mathrm{B}u = 4\,\mathrm{B}t$, and $\mathrm{B}t : \mathrm{B}u = t\,\mathrm{C}^2 : u\,\mathrm{D}^2$. And we should prove, in the same manner, that $y\,\mathrm{E} = 9\,r\,\mathrm{C}$, &c.

Plate CCLXXXVI. Fig. 1.

Having thus ascertained the general nature of the path of a projectile, we must now examine its motion in this path, determining its velocity in the different points, and the time employed in the description of the arches. For this purpose we must first ascertain the precise parabola described under the conditions of the projection, that is, depending on its direction and velocity. To do this in a way naturally connected with the acting forces, we shall consider the velocity of projection as having been generated by falling through some determinate height.

Let us therefore suppose that the body is projected from B, in the direction BR, with the velocity acquired by falling through the vertical VB. Make BT equal to VB, and BR equal to VT or 2 VB, and, lastly, draw TS parallel to BR, meeting the parabola in S.

It is plain that BR is the space which would be uniformly described with the velocity of projection in the time of falling through VB. Also B r is the space that would be uniformly described, with the same velocity, in the time of falling through B t. Therefore BR is to B r as the time of falling through VB to that of falling through B t. But, since BT is equal to VB, B r is to BR as the time of falling through B t to the time of falling through BT. Therefore BR is to B r as the time of falling through VB to that of falling through B t. But, since BT is equal to VB, B r is to BR as the time of falling through B t to the time of falling through BT. Therefore we have B t : BT $=$ B r^2 : BR^2. But, in the parabola, we have B t : BT $=$ t C^2 : TS^2, $=$ B^2 : TS^2. Therefore TS is equal to BR, or to twice VB or BT. Therefore TS^2 $=$ 4 BT^2, $=$ 4 BT $\times$ BV, $=$ BT $\times$ 4 BV. But, in a parabola, the square of any ordinate TS is equal to the rectangle of the absciss BT and the parameter of that diameter. Therefore 4 VB is the parameter of the diameter BT, and VB is the fourth part of that parameter.

If, therefore, the horizontal line VZ be drawn, it is the directrix of the parabola described by a body projected from B in any direction, with the velocity acquired by falling from V.

Cor. 1. As this is true for any other point, C, D, &c. it follows that the velocity in any point of the path is that which a heavy body would acquire by falling from the directrix to that point.

Cor. 2. Hence also we learn that the velocities in any two points, such as B and D, are proportional to the portions $v\,y$ and D t of the tangents through those points which are intercepted by the same diameters. Thus, $v\,y$ is a portion of the tangent B y, intercepted by the diameters DD′ and EE′, which also intercept a portion of the tangent D t. For these portions of tangents are in the subduplicate ratio of the lines VB and ZD. Now the velocities acquired by falling through VB and ZD are in this subduplicate ratio of the spaces fallen through.

Such is the Galilean Theory of the parabolic motion of projectiles; a doctrine valuable for its intrinsic excellence, and which will always be respectable among philosophers, as the first example of a problem in the higher department of mechanical philosophy.

We are now to consider it as the foundation of the art of gunnery. But it may be affirmed, at setting out, that the theory is of very little use for directing the practice of cannonading. Here it is necessary to approach as near as possible to the object, and the hurry of service allows no time for geometrical methods of pointing the piece after each discharge. When the gun is within 300 yards of the object, the gunner points it straight on it, or rather a little above, to compensate for the small deflection which obtains, even at this small distance. Sometimes the piece is elevated at a small angle, and the shot, discharged with a very moderate velocity, drops on the ground, and bounds along, destroying the enemy's troops. But, in all these cases, the gunner is directed entirely by practice, and it cannot be said that the parabolic theory is of any service to him.

Its principal use is for directing the bombardier in the throwing of shells. With these it is proposed to destroy buildings, to break through the roofs of magazines, to destroy troops by bursting among them, &c. Such objects being generally under cover of the works of a place, cannot be hit by a direct shot, and therefore the shells are thrown with such elevated directions, that they get over the works, and produce their effect. These shells are of great weight, sometimes exceeding 200 lb. The mortar from which they are discharged must be exceedingly strong, that it may resist the explosion of the powder able to impel this vast mass to a great distance. They are therefore most unwieldy; and it is found most convenient to have them almost solid, and unchangeable in their position. The shell is thrown to the intended distance by employing a proper quantity of powder. This is found incomparably easier than to vary the elevation of the mortar. We shall also find, that when a proper elevation has been selected, a small deviation from it, unavoidable in such service, is much less detrimental than if another elevation had been chosen. Mortars, therefore, are frequently cast in one piece with their bed or carriage, having an elevation that is not far from being the best on all ordinary occasions, and the rest is done by repeated trials with different charges of powder.

Still, however, in this practice, the parabolic motion must be understood, that the bombardier may avail himself of any occasional circumstance that may be of advantage to him. We shall therefore consider the chief problems that the artillerist has to resolve, but with the utmost brevity; and the reader will soon see, that more minute discussion would be of very little service.

The velocity of projection is measured by the fall that is necessary for acquiring it. It has generally been called the force, or IMPETUS; we shall distinguish it by the symbol f. Thus, in Plate CCLXXXVI. and Fig. 2, 3, 4, FA is the height through which the body is supposed to fall, in order to acquire the velocity with which it is projected from A. Plate CCLXXXVI. Fig. 2, 3, 4.

The distance AB between the piece of ordnance and the object, is called the AMPLITUDE, and also the range $= r$.

Let the angle EAB contained between the vertical and the direction of the object be called the ANGLE OF POSITION $= p$.

And let the angle DAB contained between that direction and the axis of the piece, be called the direction of the mortar $= d$, and let z express the zenith distance or angle EAD, contained between the axis of the mortar and the vertical line AE.

The leading problem, from which almost all the others may be derived, is the following.

Let a shell be thrown from A, (Fig. 3, 4.) with the velocity required by falling through the vertical FA, so as to hit an object B. Required the direction AD of the projection. Fig. 3, 4.

Let AH be a horizontal line, and AB the line of position of the object. In the vertical AF, take AE $=$ 4 AF, and on EA describe an arch of a circle ED d A, which shall touch the line of position AB. Draw through

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Plate CCLXXXVI. Fig. 3, 4.

the object the vertical line BD, cutting the circle in D and *d*, and join AD and A *d*. I say that AD or A *d* are the directions required. Join ED and E *d*.

For, because AB touches the circle in A, the angle ADE is equal to the exterior angle EA *a*, or DBA, and the alternate angles EAD, ADB are equal. The triangles ADB and EAD are therefore similar, and DB : DA = DA : AE, and $DA^2 = DB \times EA$. Therefore B is in a parabola, of which the vertical AI is a diameter, AD a tangent in A, and AE the parameter of that diameter. If, therefore, the body be projected from A in the direction AD, with the velocity acquired by falling through FA, the fourth part of this parameter, it will describe a parabola AVB which passes through B.

By the same reasoning, it is demonstrated that the body will hit the mark B, if projected in the direction A *d* with the same velocity, describing the parabola A *v* B.

From this very simple construction, we may draw several very instructive corollaries.

Cor. 1. When the vertical line passing through B cuts the circle EDA, it always cuts it in two points D and *d*, giving two directions AD and A *d*, either of which will solve the problem.

Cor. 2. But if the vertical through *b* only touch the circle, as it touches it in one point only, it gives but one direction, along which the body must be projected to hit the mark *b*. This direction is AG.

Cor. 3. The direction AG evidently bisects the angle EAB, and the directions AD and A *d* are equidistant from the middle direction AG.

Cor. 4. If the vertical passing through B do not meet the circle described on AE, according to the conditions specified, the object is too remote to be struck by a body projected from A with the velocity acquired by falling from F. There is no direction that will enable it to go so far on the line AB. The distance A *b* is the greatest possible with this velocity, and it is attained by taking the elevation AG which bisects the angle EAB. We may therefore call A *b* the *maximum range* on the line AB, and AG the *middle direction*.

Cor. 5. The distances on a given line of position to which a body will be projected in a given direction AD, are proportional to the squares of the velocities of projection. For the figure being similar, the range AB has the same proportion to AF, the fall necessary for acquiring the velocity. Now the falls are in the duplicate ratio of the velocities required by falling. Therefore, &c.

The converse of this problem is solved with the same facility of construction.

Let a body be projected in the direction AD, with the velocity acquired by falling through FA, it is required to find to what distance it will reach on the line AB.

Describe, as before, on AE, = 4 AF, the circle EDA, touching AB, and cutting AD in D. Through D draw the vertical DB, cutting AB in B. Then B is the point to which the projectile will reach. The proof is too evident to need discussion.

Lastly, suppose the object B to be given, and also the line of direction AD (which is a very common case, seeing that our mortars are often so fixed in their beds that their elevation can be very little altered) it is required to determine the velocity that must be given to the projectile.

Draw through the object the vertical BD, meeting the direction in D. Draw the vertical AE, and make it a third proportional to DB and DA, that is, make $AE = \frac{DA^2}{DB}$, and take $FA = \frac{EA}{4}$. Then FA is the fall which will generate the velocity required for the projection. The demonstration of this is also very evident.

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Plate CCLXXX[VI]. Fig. 2,

Notwithstanding the great simplicity of the construction of these problems, we cannot obtain numerical solutions for practice with equal simplicity, except when the line of position is horizontal, as in Fig. 2. This indeed is the most general case, and there are few situations so abrupt as to deviate very far from this case, the greatest height of a fortress commonly bearing but a small proportion to the distance of the mortar.

When AB is a horizontal plane, as in Fig. 2. the arch EDA is a semicircle.

In this case the maximum range A *b* is equal to AC, the radius of the circle, and equal to twice the height FA necessary for acquiring the velocity of the projection.

This greatest range is obtained by elevating the mortar 45 degrees from the horizon.

The ranges, with different directions, are proportional to the sines of twice the angles of elevation. For, drawing GC, DL, *d l*, perpendicular to EA, and drawing the radii CD and C *d*, we have CG equal to the range A *b* and *l d*, equal to the range AB. Now CG is the sine of the angle ACG, which is double of GAB, and *l d* is the sine of AC *d*, which is double of AE *d*, which is equal to the elevation *d* AB; and the same is true of all other elevations. We may always employ this analogy as radius to the sine of twice the angle of elevation, so is twice the height necessary for acquiring the velocity to the range of the projection on a horizontal plane.

The height to which the projectile rises above the horizontal plane is as the square of the sine of elevation. For OV the axis of the parabola is $\frac{1}{4}$th of DB or LA;—and FA, the height to which the projectile would rise straight upward, is $\frac{1}{4}$th of EA. Now $EA : LA = EA^2 : AD^2 = \text{rad.}^2 : \sin.^4 AED, = \text{rad.}^2 : \sin.^2$ elevation. Therefore $FA : VO = \text{rad.}^4 : \sin.^2$ elevation; also $VO : v\,O = \sin.^2 DAB : \sin.^2, d\,AB$, &c.

The times of the flights are as the sines of the elevation. For the velocities in the directions AD, A *d*, being the same, the times of describing AD and A *d* uniformly will be as AD and A *d*. Now AD and A *d* are as the sines of the angles AED and AE *d*, which are equal to the angles DAB and *d* AB. Now the times of describing AD and A *d* uniformly with the velocity of projection are the same with the times of describing the parabolas AVB and A *v* B.

When the object to be struck is on an inclined plane AB, ascending, as in Fig. 3. the arch EDA is less than a semicircle; and when it is on a descending plane, as in Fig. 4. EDA is greater than a semicircle. This considerably embarrasses the process for obtaining the direction, when the impetus and the object are given, or conversely. It has been much canvassed by the many authors who deliver theories of gunnery, and the parabola affords many very pretty methods of solving the problem. Dr Halley's, in the *Philosophical Transactions*, No. 179. is peculiarly elegant. Mr Thomas Simpson's also, in No. 486. is extremely ingenious and comprehensive, and has been reduced to a very elegant simplicity by Frisius in his *Cosmographia*. But neither of these methods shew so distinctly the connection between the different circumstances of the motions, or keep the general principle so much in view, as the one here given; and all the arithmetical operations which

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Plate XXVI. Fig. 3, 4.

finally result from them, are precisely similar to those deduced from our construction.

The following method suggested by the simple construction now given, is probably as easy and as expeditious as any.

Draw the horizontal line HA a, Fig. 3. and 4. cutting the vertical drawn through B in K; let C be the centre of the circular arch EDA. Join AC, and draw GC, cutting the verticals through A and B in the points f and g. Also draw CD and Cd. Let p represent the angle of position EAB, and d the angle of direction DAB, which the axis of the piece makes with the line of position AB. Also let z be the angle EAD which the axis makes with the vertical. Let r express the range AB, and f the fall FA necessary for communicating the velocity of projection. Then the parameter of the parabola at the point of projection is $4f, =$ AE, and using S to express the sine.

We have $AB : DB = S, EAD : S, DAB, = S, z : S, d.$
$DB : DA = S, DAB : S, DBA, = S, d : S, p.$
$DA : AE = S, DEA : S, EDA, = S, d : S, p.$
Therefore $AB : AE = S, z \times S, d : S^2, p.$
That is $r : 4f = S, z \times S, d : S^2, p.$
And $r \times S^2, p = 4f \times S, z \times S, d.$

Hence are derived formulæ, which solve all the questions contained in the problem.

$$\text{I. } r = \frac{4f \times S, z \times S, d.}{S^2, p.}$$

$$\text{II. } f = \frac{r \times S^2, p.}{4 S, z \times S, d.}$$

$$\text{III. } S, d = \frac{r \times S^2, p.}{4f \times S, z.}$$

The answers to the questions expressed in the two first cases are obtained by a single operation. In the first case, the maximum value of r, which corresponds with the elevation AG, is a third proportional to AE and AD, and will be had by the analogy $\sin.^2 p : \sin. \frac{1}{2} p = 4f : r$.

We also may remark, that the ranges made with the same velocity, and on the same declivity, are as the products of the sines of d and of z.

But these formula do not afford so ready an answer, when d is the thing wanted, as one would expect from their simplicity. When d is unknown, z is also unknown. In this case we must remark, that $S, z \times S, d$ is equal to $\frac{\cos. \overline{z \backsim d} - \cos. \overline{z+d}}{2}$, and that $z+d=p$.

This changes our formula into $r \times \sin.^2 p = 4f \times \frac{\cos. \overline{z \backsim d} - \cos. \overline{z+d}}{2}, = 2f \times \overline{\cos. z \backsim d - \cos. p}, = 2f \times \cos. \overline{z \backsim d} - 2f \times \cos. p$. Therefore we have

$$r \times \sin.^2 p + 2f \times \cos. p = 2f \times \cos. \overline{z \backsim d}.$$

Having obtained the arch $z \backsim d$, and having $z+d=p$, we easily obtain d, it being $= \frac{p + z \backsim d}{2}$. The process is much expedited by the help of a table of natural sines. We must remember, that when the projection is made on an ascending plane, the quantity $2f \times \cos. p$, is to be added to $r \times \sin.^2 p$; but that it is to be subtracted from it if the projection is made on a declivity.

But a plainer method may be taken, although not so obviously deduced from the general principle. The position of the object B being known, its horizontal distance AK is known. Call this h. The middle direction AG is also known. The line fA is also known, being $=2f$. Now $fC = 2f \times \tan. fAC, = 2f \times \text{cotan. } p$. Call this b. Then Cg is $=h+b$, or $=h-b$, according as the projection is made on an ascending or a descending plane. Now we have

$$fA : Cg = \cos. p : \cos. \overline{d-z}, \text{ or}$$
$$2f : h \pm b = \cos. p : \cos. \overline{d-z}.$$

Then to $\frac{1}{2} p \left(= \frac{1}{2} \overline{d+z}\right)$ add $\frac{1}{2} \overline{d-z}$, and we obtain d.

This is, in fact, the process to which we are ultimately led by every method that is taken for the solution of this case of the problem.

The construction suggests another process, which may be more acceptable to some readers. The angle fAG is $\frac{1}{2}$ EAB. Therefore $fG = 2f \times \tan. \frac{1}{2} p$, and $2f \times \tan. \frac{1}{2} p - AK = gG$, = the versed sine of $z \backsim d$, CA, or $\frac{2f}{\sin. p}$ being radius.

There are two questions more that must be solved before the artillerist can have all the information he requires. In throwing of shells, it is of peculiar importance that the fuse of the shell burn during the whole time of the flight, but no longer; and it would be best of all were it ended when the shell is about six feet from the ground. This requires an exact knowledge of the time of the flight.

The time of the flight is the same with that of falling through DB. We must therefore calculate DB in feet.

Then $t = \frac{\sqrt{DB}}{4}$; $t^2 = \frac{DB}{16}, = \frac{r \times \sin. d}{16 \sin. z}$. From the sum of tho logarithms of the range (measured in feet) and the sine of the direction, take the sum of the logarithm of 16 and the sine of the zenith distance, and half the remainder is the time of the flight, measured in seconds.

If the best or middle direction had been chosen, which is generally not far from being the case, DB is equal to BA or r. Therefore in this case we have $t = \frac{\sqrt{r}}{4}$.

Lastly, with respect to the velocity and momentum with which the projectile makes its stroke, this is easily deduced from the property of the parabolic motion. We know the velocity of projection, or the velocity at A, namely, that which is acquired by falling through FA. In like manner, the velocity at B is that acquired by falling through F α, (B α being drawn parallel to the horizon). Therefore, $\sqrt{FA} : \sqrt{F\alpha}$ = velocity at A : velocity at B.

CHAP. II.

On the Determination of the Initial Velocity of Projectiles from the explosive force of Gunpowder.

Robins' theory of the force of gunpowder.

In our article Gunpowder, we have already noticed Mr Robins' investigations respecting the explosive force of gunpowder, and we have suggested some important corrections upon the data which he employed. We shall now proceed to give an account of the solution of the important problem of determining the initial velocity of a ball, when the elasticity of the powder at the instant of its firing is given, and when the density of the ball, the quantity of the charge, and

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Robins' theory of the force of gunpowder.

the dimensions of the piece of artillery from which it is thrown, are known.

The solution of this problem depends upon the two following principles.

1. That the action of the powder upon the ball ceases as soon as it is out of the piece.

2. That all the powder is converted into an elastic fluid before the ball is sensibly moved from its place.

The first of these principles is sufficiently manifest from the consideration, that the flame will very suddenly extend itself in every direction when it reaches the mouth of the gun, and therefore its force on the bullet will be completely extinguished.

The second principle, though less obvious, is equally certain. If the powder was fired successively, and not all at once, it occurred to Mr Robins, that by using two or three bullets instead of one, a greater quantity of powder would be fired, since a heavier weight would require a longer time to pass through the barrel. Hence two or three balls should be impelled with a much greater force than one. This, however, is by no means the case. Mr Robins found from experiment, that the velocities with which different numbers of balls were discharged were reciprocally in the subduplicate ratio of the number of balls; that is, if one ball was discharged with a velocity of 1700 feet per second, the same charge would impel two balls with a velocity of from 1250 to 1300 feet per second, and three balls with a velocity of from 1050 to 1110. But when bodies, containing different quantities of matter, are successively impelled through the same space, with the same power acting at each point of that space with a given force, then the velocities communicated to these different bodies should be reciprocally in the subduplicate ratio of their quantities of matter. Hence, since the velocities are in the subduplicate ratio of the number of balls, the action of the powder must, in all these cases, have been nearly the same, and consequently the truth of the principle is established.

Plate CCLXXXVI. Fig. 5.

Let us now suppose that AB, Fig. 5. is the axis of the gun, DCGE the part of the cavity filled with powder, and that the hinder surface of the ball lies at GE. Then if we take FH to represent the force with which the ball is impelled at the point F, and if through H we draw a hyperbola KHNQ to the asymptotes AI, AB forming a right angle, the ordinate MN will represent the force with which the ball is impelled at M; for since the densities of the elastic fluid at the points F and M are as AM to AF, or as FH to MN, the forces will be in the same ratio. Take EL to FH as the force which impels the ball at F is to the weight of the ball, and draw LP parallel to EB. Then the equal lines LF, RM, &c. will be to the corresponding ordinates FH, MN as the gravity of the ball is to the force with which it is impelled at the points F and M. But by Prop. 39. Book I. of Newton's *Principia*, the areas FLPB, FHQB are as the squares of the velocities which the ball would acquire when acted upon by its own gravity through the space EB, and when impelled through the same space by the force of the gunpowder. Hence we shall have

$$V=\sqrt{\frac{\text{FHQB}\times(\text{Vel. of falling through FB})^2}{\text{FLPB}}}$$

If we therefore put

V = velocity of the ball.
L = length of the charge of powder.
B = length of the bore AD.
S = specific gravity of the ball.
D = the diameter of the bore, and
W = the weight of the ball in ounces, we shall have

$$V=27130\sqrt{\frac{10\,L}{SD}\times\text{Log.}\frac{B}{L}},\ \text{or}$$

$$V=100\sqrt{\frac{223\,LD^2}{W}\times\text{Log.}\frac{B}{L}}$$

Thus making $L = 2\frac{5}{8}$ inches.
$B = 45$ inches.
$S = 1.345$ for a leaden ball.
$D = \frac{1}{4}$ of an inch.

Then we shall have

$V=27130\sqrt{\frac{7}{2269}}\times\text{log.}\frac{120}{7}=1674$ for the velocity of the ball per second; or if the weight of the ball $W = 1\frac{9}{20}$ oz. or $\frac{29}{20}$ oz. then,

$V=100\sqrt{\frac{1115\times189}{29\times32}}\times\text{log.}\frac{120}{7}=1674$ feet, as formerly.

Having thus determined theoretically the initial velocities of projectiles, Mr Robins was anxious to compare his theory with experiment. He was thus led to the invention of the ballistic pendulum, by which the real velocities may be measured with such a degree of exactness, that in a velocity of 1700 per 1″, the error will never exceed the 500th part.

CHAP. III.

On the Methods of determining Experimentally the Velocities of Projectiles at any Distance from the Gun from which they are Discharged.

Robins' ballistic pendulum.

Plate CCLXXX[illegible] Fig. 12.

The ballistic pendulum, which Mr Robins invented for measuring the initial velocity of projectiles, is shewn in Plate CCLXXXV. Fig. 12. where ABCD represents the body of the machine consisting of three poles B, C, D, joined at A. On the sockets R, S screwed upon two of these poles, rests the horizontal axis EF, which suspends a pendulum GHIK, made of iron, with a broad surface at its extremity. A thick piece of wood GHIK is fastened by screws to the broad surface of the iron. A little below the bottom of the pendulum is a brace OP, joining the two poles B, C; and on this brace is fastened a contrivance MNU, made somewhat like a drawing pen, with two edges of steel, bearing on each other in the line UN, the pressure of these edges being regulated by a screw Z. To the bottom HI of the pendulum is fastened a narrow ribbon LN, which passes between the steel edges, and which hangs loosely down, as at W, through an opening cut in the lower piece of steel.

Hutton's improvements on the ballistic pendulum.

Dr Hutton made some considerable improvements on the ballistic pendulum. At first, he used a narrow tape divided into inches and tenths, to which he adapted a contrivance different from that of Mr Robins. From the bottom of the pendulum proceeded a tongue of iron, which was raised or depressed by means of a screw. This tongue was cloven at the bottom to receive the end of the tape, and the tips were pinched together by a screw. Immediately below this, the tape was passed between two slips of iron, which could be brought to any degree of approach by two screws. These pieces were made to slide vertically up and down a groove in a heavy block of wood, and could be fixed at any height by a screw.

This method of measuring the chord of the arc of vi-al Ve- ...ies of ...tiles.

bration by the tape, was however often attended with uncertainty; and Dr Hutton adopted the following simple contrivance. He took a block of wood, having its upper surface formed into the arc of a circle of nearly the same radius as the extreme length of the pendulum. In the middle of this arch was a shallow groove three or four inches broad, running along the middle of the block through its whole length. This groove was filled with a composition of soft soap and wax, of about the consistency of honey, or a little firmer, having its upper side smoothed off with the general surface of the broad arch. A sharp spear proceeded from the bottom of the pendulum, so as just to enter and scratch the surface of the composition in the groove, without having its motion sensibly retarded. From the trace which was thus left, the length of the cord of the arc of vibration was easily measured.

The pendulum being thus constructed, is used in the following manner The ball is discharged against the block of wood GHIK, which, in consequence of the impulse, vibrates through an arc of a certain extent, which of course increases with the velocity of the ball. The extent of the arc of vibration is measured by the length through which the ribbon LN is pulled out through the edges UN. Hence, if the weight of the pendulum is known, and also the distance of its centre of gravity and oscillation from its axis of suspension, it is easy to determine the extent of the arc of vibration, the velocity with which it is struck by a body of a known weight entering it at a given point. In the investigation of the theorem for computing the velocity of the ball, Mr Robins committed a trifling mistake, which he corrected in the *Philosophical Transactions* for 1743, but which the editor of his works omitted to insert in the New Principles of Gunnery, published in 1761. The theorem of Robins is

$$v=\frac{c}{r}\times\frac{pg}{bi}+\frac{i}{o}\times\frac{o}{\sqrt{2i}}$$

The theorem as corrected by Euler, is

$$v=\frac{c}{r}\times\frac{pg}{bi}+\frac{o+i}{2o}\times\sqrt{\frac{o}{2}}$$

The formula given by Antoni is

$$v=c\sqrt{32.18\times\frac{\overline{pgo+bi^2}\times\overline{pg+bi}}{bir}}$$

which is $v=5.6727c\sqrt{\frac{\overline{pgo+bi^2}\times\overline{pg+bi}}{bir}}$

The formula given by Dr Hutton is

$v=\frac{5.6727c}{bir}\sqrt{\overline{pgo+bii}\times\overline{pg+bi}}$, almost the same as Antoni's, which he reduces to the following very simple formula:

$$v=5.6727gc.\frac{p+b}{bir}\sqrt{o},$$

which is within $\frac{1}{5000}$dth part of the true quantity, and will always give the velocity within less than half a foot, even when the velocities are greatest. In these formulæ,

v = the initial velocity of the ball at the instant of impact.

b = weight of the ball.

p = weight of the pendulum.

g = distance to its centre of gravity.

o = the distance of its centre of oscillation.

i = the distance to the point of impact, or the point struck by the ball.

c = the chord of the arch of vibration.

r = its radius or distance to the ribbon.

Initial Velocities of Projectiles.

Mattei's machine for measuring initial velocities.

The machine of Mattei for measuring initial velocities near the mouth of the gun, which we have already briefly described, was employed by Antoni. It consists of a horizontal wheel AB, mounted upon a vertical axis, and put in motion by the descent of a weight Q suspended to the rope GG, and which can be raised into a state of activity by the winch fixed to the axis of the pulley P. A circular band of writing paper. AE, BF, about six inches high, is fixed round the circumference of the wheel AB, so as to form a drum 10 feet in diameter. A butt or block of elm is placed about two or three feet from the drum to receive the balls. The gun being fixed immoveably at the distance of 20 feet, so that its axis produced would pass through an exact diameter of the drum perpendicular to GG, the machine is put in motion by the descent of the weight Q. The motion soon becomes uniform, and the velocity of the drum is measured by a small eccentric wheel IL upon the axis CD, which at every revolution gives a vibratory horizontal motion to a tongue of wood, at the extremity of which is suspended a common pendulum, which is shortened or lengthened till its vibrations are isochronous to those of the tongue. The time in which the wheel performs a revolution will be shewn by the length of the pendulum. When the pendulum and the tongue have acquired an isochronous motion, the gun is discharged, and the wheel stopped. The hole made in the drum at the first entrance of the ball will be easily distinguished from the other hole which it made at its exit, by the edges of the holes being turned to the point by which the ball went out of the drum. A thread is then stretched in the direction in which the ball was fired, so as to pass through the centre of the first hole, and the point where the line cuts the drum is marked. The distance between this mark and the second hole is the distance through which the circumference of the drum has moved while the projectile was passing through a space equal to its diameter.

In order to find the uniform velocity of the shot in a second of time, call d the diameter of the wheel, c its circumference, t the time in which the wheel performs one revolution, m the distance through which a part of the circumference of the drum moves while the ball is traversing the distance D, and v the initial velocity of the shot in a second of time: then $m:d=c:\frac{cd}{m}=$ the space passed through by the shot with a uniform velocity during one revolution of the wheel: then as $t:1=\frac{cd}{m}:\frac{cd}{tm}=v.$

In using this machine, Antoni used wads of parchment torn in several places, that they might not injure the drum of paper. An account of the experiments themselves will be given in the next Chapter.

Methods of determining initial velocities by the penetration of butts.

Antoni has given an account of other three methods of measuring the initial velocities of projectiles. The first consists in measuring their respective penetrations into a homogeneous butt of a known consistency. If we call b the consistency of the butt, d the diameter of the shot, p the depth of its penetration, and v the initial velocity, we shall have $v=\sqrt{\frac{bp}{d}}$. In order to find b, the consistency of the butt, fire a piece of small calibre, with an iron shot one inch in diameter, and measure its

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initial velocity by the methods already described, and let it be 1000 feet, then $v = 1000$. Let the same piece be then loaded as before, and fired into the butt, and let its penetration be 12 inches, or 1 foot, $= p$. Then since $b\,p = d\,v^2$, we shall have $p \times 1 = \frac{1}{12} \times 1000^2$, or $p \times 83333$. Substituting then, in the formula, $b\,p = d\,v^2$, we have $83333\ p = d\,v^2$. The consistency of the butt being thus found, place the great gun, the initial velocity of whose shot is required, and having fired several rounds in a horizontal direction against the butt, let the mean of the different depths of penetration be $7 = p$, and let d, the diameter of the shot, be equal 4 inches, then we have $83333 \times 7 = \frac{4}{12} v^2$, and $v = \sqrt{\frac{83333 \times 7 \times 12}{4}} = 1323$, the initial velocity required.

Method of determining initial velocities by analysing the curve. PLATE CCLXXXVI. Fig. 7.

The second method proposed by Antoni of determining initial velocities, consists in analysing and resolving into its simple movements the curve described by the projectile on quitting the piece. In order to effect this, a gun AB, Fig. 7. mounted on its carriage, and laid on an even and solid platform, is placed with its axis in a horizontal direction AC, so that the shot, at its first graze, may touch the earth in the point C of the horizontal line DF. The vertical distance KG is obviously the space through which the shot has descended by the action of gravity, which may be called s, and the horizontal distance AK or DG is the space which it has passed through in the same time, in virtue of the impulsive or projectile force. Then since $s = \frac{32.18\ t^2}{2}$, and $t = \sqrt{\frac{2\,s}{32.18}}$, we have, by substituting KG for s, $t = \sqrt{\frac{2\ \text{KG}}{32.18}}$ = the time in which the shot is impelled from A to K. Having obtained DG accurately from the mean of several trials, call it r, and considering it as uniformly passed over, say, as $t : r = 1 : \frac{r}{t}$, the initial velocity or the space through which the shot would move in a second, without considering the air's resistance. Let KG = four feet, then we have $t = \sqrt{\frac{2 \times 4}{32.18}} = \frac{1}{2}$ a second; and if DG = 700 feet, we have $\frac{r}{t}$, or $v = \frac{r}{\sqrt{\frac{2 \times 4}{32.18}}} = 1400$ feet, the initial velocity required.

As the initial velocity thus determined is not absolutely correct, on account of the resistance of the air, a more accurate result may be obtained, by placing a butt LMN nearer the gun. Let a line be drawn on the butt at M, where it is cut by the horizontal line of direction AM, and by firing several shot at the butt, the vertical distance MH $= s$ will be ascertained. By measuring the distance DL, and using the formulæ already given, the initial velocity v will again be found. The nearer the gun is brought to the butt, the more correct will the initial velocity be found. Both these methods may be applied to guns of all lengths and calibres.

Method of deducing the initial velocities from the thickness of the metal.

The third method of determining initial velocities, is by deducing them from the thickness of the metal of the fire arm when it is in equilibrio with the pressures of the elastic fluid in every point of its length. This method, however, is not applicable to guns of large calibre fired with the common charges of powder, but only to fusils and pieces of small calibre. Antoni informs us, that in Piedmont musket barrels are proved, by charging them with 17 drachms of common cannon powder, over which is put a very high wad of hard tow, which is with difficulty pressed into the barrel, and which is afterwards rammed down with all the force which the armourer can exert. A leaden bullet, weighing $18\frac{1}{2}$ drachms, is then put in, and wadded as before. The barrels being placed with their breach upon a strong beam of wood, are each fired twice. Many of them burst, sometimes at the breach, and sometimes in the middle of the bore, and sometimes near the muzzle; but as the bursting never happened more frequently on one part than another, the officers and manufacturers did not consider it as necessary to make any change in the thickness of the metal. Hence in guns of this kind, the thickness of the metal may be considered as proportional to the pressure of the elastic fluid in every part of their length.

As this method is not likely to be of much use, we shall merely refer the reader to Antoni's *Treatise on Gunpowder*, translated by Thomson, p. 87, 88, 165, &c.

CHAP. IV.

Comparison of the Initial Velocities of Bullets, as computed from the Theory, with the actual Velocities, as determined by the Ballistic Pendulum.

In determining the initial velocity of bullets, Mr Robins used a musket barrel, nearly as thick at the muzzle as at the breach, and its thickness was made equal to the diameter of its bore. It was always charged with a laddle, as in the case of cannon, and the wadding was never greater than was necessary to confine the powder to its proper place. In order to prevent the impulse of the flame from acting upon the pendulum, the mouth of the musket should be sixteen or eighteen feet from it, when the charge is half an ounce of powder. With larger charges, Mr Robins has often found the impulse to be sensible at the distance of twenty-five feet.

His first set of experiments was made with a musket 45 inches long; the diameter of the ball was $\frac{3}{4}$ths of an inch, and the cavity containing the powder was $2\frac{5}{8}$ inches, which, as the barrel exceeded the bullet by about the 40th of an inch, contained exactly 12 pennyweights of powder. This barrel we shall call A.

The weight of the whole pendulum was 52 lb. 3 oz. The distance of the centre of gravity from the axis of suspension was 52 inches; 200 of its small swings were performed in 253 seconds, and therefore the distance of its centre of oscillation from the axis of suspension, was $62\frac{2}{3}$ inches.

The following results were obtained with this pendulum and the barrel A.

Number of Experiments.	Barrel employed.	Quantity of Powder	Chord of its Ascending Arch measured on the Ribbon.	The same by the Theory.	Error of the Theory.
		Dwts.			
1	A	12	18.7	19.0	+.3
2	A	12	19.6	19.0	—.6
3	A	6	13.6.	13.4	—.2

Another set of experiments was made with the same barrel, but with a pendulum exceeding a little the

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weight of 56 lb. 3 oz. and the following results were obtained.

Number of Experiments.	Barrel employed.	Length of the Cavity containing the Powder, or Line AF in Fig. 5.	Quantity of Powder.	Chord of the Ascending Arch measured on the Ribbon.	The same by the Theory.	Error of the Theory.
		Inches.	Dwts.	Inches.	Inch.	Inches.
4	A	$2\frac{5}{8}$	6	11.9	12.1	+.2
5	A	$2\frac{5}{8}$	6	12.2	12.1	—.1
6	A	$1\frac{1}{4}$	6	13.2	13.6	+.4
7	A	$1\frac{1}{4}$	6	13.9	13.6	—.3
8	A	$2\frac{5}{8}$	12	16.7	17.2	+.5
9	A	$2\frac{5}{8}$	12	17.5	17.2	—.3
10	A	$2\frac{5}{8}$	12	16.9	16.8	—.1
11	A	$2\frac{5}{8}$	12	17.0	16.8	—.2
12	A	$2\frac{5}{8}$	6	11.7	11.5	—.2
13	A	$2\frac{5}{8}$	6	11.1	11.5	+.4
14	A	$2\frac{5}{8}$	12	16.7	16.3	—.4

In calculating the theoretical results for the experiments 10—14, an allowance was made for the quantity of bullets lodged in the board, which increased the weight of the pendulum.

The next experiments made by Mr Robins were with another barrel C, which had the same bore with the last, but which was only 12.375 inches long. The pendulum was rather lighter than 56 lb. 3 oz.

Number of Experiments.	Barrel employed.	Extent of the cavity containing the Powder.	Quantity of Powder.	Chord of the ascending Arch measured on the Ribbon.	The same by the Theory.	Error of the Theory.
		Inches.	Dwts.	Inches.	Inches.	Inches
15	C	$2\frac{5}{6}$	12	12.7	12.8	+ .1
16	C	$2\frac{5}{6}$	12	12.6	12.8	+ .2
17	C	$2\frac{5}{6}$	12	12.4	12.8	+ .4
18	A	$2\frac{5}{6}$	12	17.0	17.3	+ .3
19	A	$2\frac{5}{6}$	12	17.2	17.2	.0
20	A	$2\frac{5}{6}$	12	17.1	17.2	+ .1
21	A	$2\frac{5}{6}$	12	17.2	17.2	.0
22	A	$2\frac{5}{6}$	6	12.4	12.2	— .2

Another barrel B of the same bore with A and C, but 24.312 inches long, was now used, with a pendulum a little heavier than 56 lb. 3 oz. A correction was made for the increase of weight, as formerly.

Number of Experiments	Barrel employed.	Extent of the Cavity containing the powder.	Quantity of Powder.	Chord of the ascending Arch measured on the Ribbon.	The same by the Theory.	Error of the Theory.
		Inches.	Dwts.	Inches.	Inches.	Inches.
23	A	$2\frac{5}{6}$	12	17.1	17.2	+ .1
24	A	$2\frac{5}{6}$	9	15.2	15.0	— .2
25	A	$2\frac{5}{6}$	9	15.4	15.0	— .4
26	C	$2\frac{5}{6}$	12	11.5	12.8	+1.3
27	C	$2\frac{5}{6}$	12	11.5	12.8	+1.3
28	C	$2\frac{5}{6}$	6	8.7	9.	+ .3
29	C	$2\frac{5}{6}$	12	12.3	12.5	+ .2
30	B	$2\frac{5}{6}$	12	14.4	14.4	0.0
31	B	$2\frac{5}{6}$	12	14.4	14.4	0.0
32	B	$2\frac{5}{6}$	6	10.3	10.5	+ .2
33	A	$1\frac{3}{4}$	8	14.7	14.5	— .2
34	A	4	12	15.7	15.3	— .4

Mr Robins suspects, that in experiments 26 and 27 a mistake had been made in the weight of the powder, or that the barrel had been damp.

Another barrel D was now used, 7.06 inches long, and 0.83 in diameter. Its bullet, which weighed $33\frac{1}{2}$ dwts. was exactly fitted to the bore without any windage, so that it went in with difficulty.

No of Expts.	Barrel employed.	Length of the Cavity containing the Powder.	Quantity of Powder.	Chord of the ascending Arch measured on the Ribbon.	The same by the Theory.	Error of the Theory.
		Inches.	Dwts.	Inches.	Inches.	Inches.
35	A	$2\frac{5}{6}$	12	9.2	9.2	.0
36	A	$2\frac{5}{6}$	12	9.5	9.2	— .3
37	A	$5\frac{1}{4}$	24	11.7	11.3	— .4
38	A	$7\frac{1}{2}$	36	13.2	12.6	— .6
39	A	$2\frac{5}{6}$	12	9.3	9.1	— .2
40	A	$1\frac{3}{4}$	8	7.6	8.1	+ .5
41	C	$2\frac{5}{6}$	12	6.1	6.6	+ .5
42	C	$2\frac{5}{6}$	12	6.5	6.6	+ .1
43	B	$2\frac{5}{6}$	12	8.0	8.2	+ .2
44	B	$2\frac{5}{6}$	12	8.3	8.2	— .1
45	A	$2\frac{5}{6}$	12	9.5	9.1	— .4
46	A	$2\frac{5}{6}$	12	9.1	9.1	.0
47	A	$2\frac{5}{6}$	6	7.2	6.5	— .7
48	A	$2\frac{5}{6}$	6	6.7	6.5	— .2
49	C	$2\frac{5}{6}$	12	6.8	6.7	— .1
50	C	$2\frac{5}{6}$	12	7.5	6.7	— .8
51	C	$2\frac{5}{6}$	6	4.7	4.8	+ .1
52	C	$2\frac{5}{6}$	6	5.0	4.8	— .2
53	D	$2\frac{1}{4}$	12	7.0	7.2	+ .2
54	D	$2\frac{5}{6}$	12	7.1	6.8	— .3
55	D	$2\frac{5}{6}$	6	4.7	4.8	+ .1
56	D	$2\frac{5}{6}$	6	4.8	4.8	.0
57	A	$2\frac{1}{16}$	6	6.4	6.5	+ .1
58	A	$2\frac{1}{16}$	6	6.4	6.5	+ .1
59	A	$2\frac{1}{16}$	6	6.6	6.5	— .1
60	A	$2\frac{1}{16}$	6	6.7	6.5	— .2
61	A	$2\frac{1}{16}$	12	9.0	9.1	+ .1

Mr Robins supposes, that the error in the 50th experiment was owing to the wind. All the preceding experiments were made and registered, before they were compared with the theory.

Antoni's experiments on Initial Velocities.

A set of valuable experiments on the initial velocities of bullets were made by Antoni, with the machine invented by Mattei.

The first series was made with a musket 3 feet 6 inches in the length of its bore, and with a charge of powder of 7 drams.

Nature of the Powder.	Moist Weather	Mean state of the Atmosphere.	Very dry Weather.
	Feet.	Feet.	Feet.
Common war powder	1392	1542	1618
Fine do.	1569	1736	1829
Fowling powder	1566	1703	1784
Firework powder	1566	1706	1779

The following experiments were made under a mean state of the atmosphere, with guns of different lengths and calibres.

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Nature of the Guns.	Kind of Powder.	Weight of Powder.	Initial Velocity.
A musket with a bore 1 ft. 10 inch. long	Fine war powder	7	1390
	Fowling do.	7	1367
	Firework do.	7	1372
Rifled carabine	Fine war powder	7	1956
	Fowling do.	7	1920
	Firework do.	7	1934
A wall piece carrying a leaden bullet $2\frac{1}{2}$ oz. in weight	Fine war powder	20	1956
	Fowling do.	20	1928
	Firework do.	20	1923
A musket with a bore 3 ft. 6 inch. long	Fine war powder	7	1736

In order to ascertain the effect produced by a difference in the weight of shot, and in the windage, three bullets were fired from a wall-piece, and two from the musket 3 feet 6 inches in length of bore.

Weight of Balls.		Quantity of fine War Powder.	Initial Velocities.
Wall-piece	$3\frac{1}{2}$ oz.	23 drams	1770
	3	23	1855
	3 oz. but of the same diameter as the first ball	23	2068
Musket	1 oz.	7	1736
	$\frac{7}{8}$	7	1834
	Carabine ball.	7	1863

The following experiments were made in a mean state of the atmosphere, to shew how the initial velocities vary with different charges of fine war powder:

Weight of Powder in drams.		Initial Velocities.
Musket with a bore 3 ft. 6 in.	5	1399
	7	1736
	10	1984
Wall-piece with a bullet $2\frac{1}{2}$ oz.	$11\frac{1}{2}$	1504
	18	2056
	25	2060

The following results were obtained with four muskets of different lengths. The ball was 1 oz. in weight, and the charge was seven drams of fine war powder:

Length of Barrel from the Ball to the Muzzle.		Initial Velocities.
Feet.	Inches.	
0	11	1037
1	10	1390
3	8	1736
4	8	1815

CHAP V.

On the Actual Ranges of Projectiles in a resisting Medium.

Ranges of Projectiles in a resisting Medium.

HITHERTO we have considered only the state of projectiles immediately after they have quitted the mouth of the gun or piece from which they have been discharged. We shall now proceed to consider the effects which are produced by the resistance of the air; and we shall again have occasion to admire the singular address with which Mr Robins has investigated this branch of the subject.

The resistance opposed to a body moving in a medium of unifom density was always considered by philosophers as proportional to the square of the velocity; that is, if a ball moved with four times the velocity in one part of its path that it did in another, the resistance to the greater velocity would be 16 times as great. Now, if we take a ball $\frac{3}{4}$ of an inch in diameter, moving with a velocity of 1600 feet in a second, it will be found, from theory. (see Newton's *Principia*, Prop. 38.), that its resistance will be $4\frac{1}{6}$ pounds avoirdupois, the weight of water being taken to that of air as 850 to 1.

In order to compare this result with experiment, Mr Robins used his ballistic pendulum, with which he could easily measure the velocity of a projectile at any point of its path. He charged a musket barrel three times in succession with a leaden ball $\frac{3}{4}$ of an inch in diameter, and with about half its weight of powder, and fired it against the pendulum at 25, 75, and 125 feet distance from the mouth of the piece respectively. The following were the results:

Distance from the Muzzle.	Tract of air passed through.	Velocity in a second.
	Feet.	
25	50	1670
75		1550
125	50	1425

Hence, in passing through 50 feet of air, the bullet lost a velocity of 120 or 125 feet per second; and as it passed through that space in $\frac{1}{32}$ or $\frac{1}{30}$ of a second, the medium quantity of resistance must have been about 120 times the weight of the ball, or 10 lb. avoirdupois, since the ball weighed $\frac{1}{12}$ of a pound. It follows, therefore, that the theoretical is to the observed resistance as $4\frac{1}{6}$ to 10.

The following results were obtained with the same piece:

Distance from the piece.		Velocity.
25 feet	Medium of three trials	1690
175	Medium of five trials	1300

In this experiment, the ball lost a velocity of 390 feet in a second, in traversing 150 feet of air; and the velocity computed from these data is 11 and 12 lbs. avoirdupois, even greater than before.

The following experiments were made in smaller velocities. The same barrel, and balls of the same size, but less powder, were now used.

Distance from the piece.		Velocity.
25 feet	Medium of five trials	1180
250	Medium of five trials	950

The ball, therefore, in passing through 225 feet of air, lost a velocity of 230 feet in a second; and as it passed through that space in $\frac{1}{4}$ths of a second, the resistance to the middle velocity will be 2 lbs. 10 oz. avoirdupois, whereas the theoretical resistance will be only $\frac{1}{11}$ths of this.

From these experiments, it is manifest, that the theory of the resistance of air in slow motions, as established by Sir Isaac Newton and others, is quite incorrect when applied to the rapid motions of military projectiles. The parabolic theory of gunnery is, therefore, in every respect erroneous. The path of military projectiles is neither a parabola, nor approaching to a parabola, unless when their velocities are very small; and instead of their path lying in the same place, it is in reality doubly incurvated, the ball being frequently driven to the right and left of its original direction by the action of some force acting obliquely to the progressive motion of the body, occasioned no doubt by the whirling motion of the shot about its axis.

In computing the paths of bodies moving rapidly through the air, Mr Robins lays down the following principles which he has deduced from numerous experiments.

First, That the resistance varies as the squares of the velocities, when the velocities do not exceed 1100 feet per second; and that a 12 pound shot, moving with a velocity of 25 feet per second, is half an ounce avoirdupois. Hence we shall have its resistance for different velocities thus:

Velocity.	Resistance.
25 feet per second	½ oz.
100	8 oz.
500	12½ lb.
1000	50 lb.
1700	144½ lb.

Second, That if the velocity be greater than 1100 or 1200 * feet per second, then the resistance will be three times as great as it should have been by a comparison with the smaller velocities. Thus the 12 lb. shot above-mentioned, instead of being resisted by 144 lbs. will now suffer triple that resistance, or 433½ lbs.

In proceeding to give an account of Mr Robins method of computing the resistance, we must first explain the terms which he employs.

1. The *potential random* of a projectile is the horizontal distance to which it would be thrown in a non-resisting medium, at an angle of 45°. If v be the initial velocity of the projectile in a second, in feet, then the potential random or $p = \frac{2\,v^2}{64\frac{1}{3}\text{ feet}}$, or $v = \sqrt{\frac{64\frac{1}{3}p}{2}}$ when the potential random is given.

2. The *potential range* is the horizontal distance to which the projectile would be thrown at any angle different from 45°.

3. The *actual range* is the horizontal distance to which the projectile is actually thrown.

In computing the effects of resistance, he assigns a certain quantity F, adapted to the resistance of the particular projectile. This quantity F expressed in yards, in iron shells, or bullets, is $d \times 300$ when d is the bullet's diameter in inches. When the bullet has a different specific gravity from iron, then F must be increased or diminished in the ratio of the specific gravities. Mr Robins then gives the three following propositions, which are suited to velocities below 1100 or 1200 feet in a second. The application of the principle to greater velocities will be shown in the corollary to Prop. I.

Prop. I.

To determine the potential range, and consequently the potential random and initial velocity of a given shell or bullet, when its actual range is given, and when its elevation does not exceed 8° or 10°.

Enter the following Table with the quotient arising from dividing the actual range by F, and the corresponding number in the 2d column, multiplied by F, will be the potential range required; and as the ranges at different elevations are proportional to the sines of twice the angle of elevation, (see Chap. I. p. 574. col. 2.) the range at 45°, the potential random is also given. Then, as the velocity is that which is due to a height equal to one half of the potential random, (See p. 574.) the initial velocity is likewise given. Thus we have $v = \sqrt{\frac{64\frac{1}{3}p}{2}}$.

Actual ranges expressed in F.	Corresponding potential ranges expressed in F.	Actual ranges expressed in F.	Corresponding potential ranges expressed in F.	Actual ranges expressed in F.	Corresponding potential ranges expressed in F.
0.01	0.0100	1.55	2.7890	3.3	13.8258
0.02	0.0201	1.6	2.9413	3.35	14.4195
0.04	0.0405	1.65	3.0994	3.4	15.0377
0.06	0.0612	1.7	3.2635	3.45	15 6814
0.08	0.0822	1.75	3.4338	3.5	16.3517
0.1	0.1034	1.8	3.6107	3.55	17.0497
0.12	0.1249	1.85	3.7944	3.6	17.7768
0.14	0.1468	1.9	3.9851	3 65	18.5341
0.15	0.1578	1.95	4.1833	3.7	19.3229
0.2	0.2140	2.	4.3890	3.75	20.1446
0.25	0 2722	2.05	4.6028	3.8	21.0006
0.3	0.3324	2.1	4.8249	3.85	21.8925
0.35	0.3947	2.15	5.0557	3.9	22.8218
0.4	0.4591	2.2	5.2955	3.95	23.7901
0.45	0.5258	2.25	5.5446	4.0	24.7991
0.5	0.5949	2.3	5.8036	4.05	25 8506
0.55	0.6664	2 35	6.0728	4.1	26 9465
0.6	0.7404	2.4	6.3526	4.15	28.0887
0.65	0.8170	2.45	6.6435	4.2	29.2792
0.7	0.8964	2.5	6.9160	4.25	30.5202
0.75	0 9787	2.55	7.2605	4.3	31.8138
0.8	1.0638	2.6	7.5875	4.35	33.1625
0 85	1.1521	2.65	7.9276	4.4	34.5686
0.9	1.2436	2.7	8.2813	4.45	36.0346
0.95	1.3383	2.75	8.6492	4.5	37.5632
1.0	1.4366	2.8	9.0319	4.55	39.1571
1.05	1.5384	2.85	9.4300	4.6	40.8193
1.1	1.6439	2.9	9.8442	4.65	42.4527
1.15	1.7534	2.95	10.2752	4.7	44.3605
1.2	1.8669	3.0	10.7237	4.75	46.2460
1.25	1.5845	3.05	11.1904	4 8	48.2127
1.3	2.1066	3.1	11.6761	4.85	50.2641
1.35	2.2332	3.15	12.1816	4.9	52.4040
1.4	2.3646	3.2	12.7078	4.95	54.6363
1.45	2.5008	3.25	13.2556	5.0	56.9653
1.5	2.6422				

* Mr Robins has noticed the remarkable fact, that the velocity at which the projectile begins to follow a new law of resistance, is nearly the same as the velocity of sound. It follows, however, from Dr Hutton's experiments, that there is no such *saltus* from the law of the squares of the velocities; but that the increase of the resistance above this law takes place gradually from the slowest motion, and never rises so high as to be three times that quantity.

The following examples will make this proposition easily understood. An 18 pounder, with a five inch iron shot, and a charge of 2 lb. of powder, ranged 975 yards, at an elevation of 3° 30′. In this case, $F = d \times 300 = 1500$, and $\frac{975}{1500} = 0.65$, which gives in the 2d column of the Table 0.817, consequently $0.817F = 1225$ yards equal the potential range required, which increased in the ratio of the radius to the sine of twice the angle of elevation, gives 10050, for the potential random. The original velocity is then

$$v = \sqrt{\frac{64\frac{1}{3}p}{2}} = 984 \text{ feet in } 1'',$$ where p is the potential random, or 10050 yards, or 30150 feet.

In order to find the actual range from the potential range at a small angle, enter the second column of the Table with the quotient of the potential range divided by its correspondent F, there will be found opposite to it in the first column, a number which, multiplied by F, will give the actual range required.

If the potential random deduced from the potential range exceeds 13,000 yards, then it ought to be corrected for the treble resistance already mentioned. In order to find the correct potential random, take a 4th continued proportional to 130,000, and the potential random is found by this proposition; and this 4th proportional is the potential random, corrected for the treble resistance. In like manner, when the true potential random is given greater than 13,000 yards, we must take two mean proportionals between 13,000 and this random, and the first of these proportionals must be assumed, instead of the random given in all the operations described under this proposition.

For example, a 24 pounder charged with 12 lbs. of powder, ranged about 2500 yards at an angle of 7° 15′. In this case, F is 1700, and $\frac{2500}{1700} = 1.47$, opposite which, in the 2d column, is 2556, which gives the potential range 4350 yards, and the potential random 174,000; but as that is more than 13,000, we must take a 4th continued proportional to 13,000 and 17,400, which is 31,000 yards, the correct potential random required, whence the velocity is nearly 1730 feet in a second.

Prop. II.

The actual range of a given shell or bullet, at an angle not exceeding 45°, being given, to determine its potential range at the same angle, and thence its potential random and original velocity.

Let A be the angle of elevation, then multiply F by $\cos. \frac{3A}{4}$, and the product will be E corrected for the given angle. Use this corrected value of F instead of F in the way described in Prop. I. and the potential range will be had, consequently the potential random and original velocity.

Thus a mortar charged with 30 lb. of powder, throws a shell $12\frac{3}{4}$ inches diameter, and 231 lb. weight, to the distance of 3450 yards, or two miles, at an elevation of 45°. The value of F corresponding to this shell is $12\frac{3}{4} \times 300$, or 3825 yards; but as the shell is only four-fifths of a solid globe, the true value of F will be $\frac{4 \times 3825}{5} = 3060$, which when multiplied by $\cos. \frac{3A}{4}$ gives 2544 for F corrected. Now the quotient of the potential range divided by E, or $\frac{3450}{2545}$, is 1.384, which when sought in the 1st column of the Table gives 2,280, which being multiplied by corrected F, gives 5800 yards for the potential range required. This is also the potential random, as the elevation is 45°, and the original velocity of the shell will be 748 feet in a second.

In order to find the actual range from the potential range, divide corrected F by the potential range; and entering the 2d column of the Table with this quotient, the number in the 1st column multiplied into corrected F will be the actual range sought.

Prop. III.

The potential random of a given shell or bullet being given to determine its actual range at 45°.

Make q = the given potential random divided by F corresponding to the shell or bullet.

d = the difference between the tabular logarithms of 25 and of 9, the logarithm of 10 being supposed unity. Then the actual range sought will be

$$3{,}4\,F + 2\,d\,F - \frac{d^2}{10}F \text{ when } q \text{ exceeds } 25, \text{ and}$$

$$3{,}4\,F - 2\,d\,F - \frac{d^2}{10}F \text{ when } q \text{ is less than } 25.$$

In this solution q may be any number not less than 3, nor greater than 2500.

The following Table computed in this way shews the relation between the potential randoms and the actual range at 45°, within the limits of the proposition.

Potential Randoms.	Actual Range at 45°.	Potential Randoms.	Actual Range at 45°.
3 F	1.5 F	50 F	4.0 F
6 F	2.1 F	100 F	4 6 F
10 F	2.6 F	200 F	5.1 F
20 F	3.2 F	500 F	5.8 F
30 F	3.6 F	1000 F	6.4 F
40 F	3.8 F	2500 F	7.0 F

It is singular to observe that so enormous are the effects of the air's resistance, that when the potential random increases from 3 F to 2500 F, the actual range increases only from $1\frac{1}{2}$ F to 7 F.

In order to examine the justness of the approximations laid down in Prop. II. and III. Mr Robins has calculated a table of the actual ranges at 45° of a projectile, resisted as the square of its velocity.

Potential Randoms.	Actual Range at 45°.	Potential Randoms.	Actual Range at 45°.
.1 F	.0963 F	6.5 F	2.169 F
.25 F	.2282 F	7.0 F	2.237 F
.5 F	.4203 F	7.5 F	2.300 F
.75 F	.5868 F	8.0 F	2.359 F
1.0 F	.7323 F	8.5 F	2.414 F
1.25 F	.860 F	9.0 F	2.467 F
1.5 F	.978 F	9.5 F	2.511 F
1.75 F	1.083 F	10.0 F	2.564 F
2.0 F	1.179 F	11.0 F	2.651 F
2.5 F	1.349 F	13.0 F	2.804 F
3.0 F	1.495 F	15.0 F	2.937 F
3.5 F	1.624 F	20.0 F	3.196 F
4.0 F	1.738 F	25.0 F	3.396 F
4.5 F	1.840 F	30.0 F	3.557 F
5.0 F	1.930 F	40.0 F	3.809 F
5.5 F	2.015 F	50.0 F	3.998 F
6.0 F	2.097 F		

anges of projectiles in resisting Medium.

This Table was computed by methods different from those hitherto described, and is sufficiently correct to serve as a standard with which the results of the other rules may be compared.

Antoni's comparison of the actual and potential randoms.

The following Table contains the comparison of the actual potential randoms, from trials made by Antoni on the banks of the Po, in June 1764, the barometer standing at 29 inches.

	Initial Velocity.	Elevation.	Actual Ranges. Yards	Potential Ranges. Yards.
Rifled carabine, bullets weighing ⅛th of an oz.	1956	15°	901	19903
		24°.20	938	29854
		45°	895	39806
Musket, the bullet weighing 1 oz.	1736	7°.15	948	7845
		15°	1305	15691
		24°.20	1335	23537
		45°	1181	31383
Wall-pieces: Balls weighing 3 oz.	1855	15°	1433	17897
		24°.20	1753	26734
		45°	1629	35794
Wall-pieces: Balls weighing 3½ oz.	1770	15°	1699	16307
Wall-pieces: Balls weighing 3 oz. but equal in diameter to 3½ oz. balls.	2068	15°	1630	22268

Antoni's method of finding the curve described by projectiles.

In order to determine experimentally the curve described by projectiles, Antoni recommends the following method. Choose a piece of ground on which the guns may be placed at the different heights, A, C, D, E, and fire some rounds from A, the position and charge of the gun remaining always the same. Having marked the first graze of the shot at I, fire from C, D, F, with the same elevation, direction, and charge, and mark the grazes at L, B, and Q. The perpendiculars IH, LK, BM, and QF, will be the abscissæ of the curve described by the shot and horizontal lines; AH, CK, DM, and EF, will be the corresponding ordinates, from which the curve may be deduced, or traced mechanically.

PLATE LXXXVI. Fig. 8.

The same result may be obtained by firing the gun from different points of a horizontal plain against the face of a mountain.

CHAP. VI.

Mr Robins' Practical Maxims relative to the Effects and Management of Artillery, the Flight of Shot and Shells.

Maxim I.

Robins' practical maxims.

In any piece of artillery whatever, the greater quantity of powder it is charged with, the greater will be the velocity of the bullet.

Maxim II.

If two pieces of the same bore, but of different lengths, are fired with the same charge of powder, the longer will impel the bullet with a greater celerity than the shorter.

Maxim III.

If two pieces of artillery, different in weight, and formed of different metals, have their cylinders of equal bores and equal lengths; then, with like charges of powder and like bullets, they will each of them discharge their shot with nearly the same celerity.

Practical Maxims. Robins' practical maxims.

Maxim IV.

The ranges of pieces at a given elevation, are no just measures of the velocity of the shot; for the same piece fired successively, at an invariable elevation with the powder, bullet, and every other circumstance as nearly the same as possible, will range to very different distances.

Maxim V.

The greatest part of that uncertainty in the ranges of pieces, which is described in the preceding maxims, can only arise from the resistance of the air.

Maxim VI.

The resistance of the air acts upon projectiles in a twofold manner; for it opposes their motion, and by that means continually diminishes their celerity; and it, besides, perpetually diverts them from the regular course they would otherwise follow; whence arises those deviations and inflections mentioned in Maxim XI.

Maxim VII.

That action of the air by which it retards the motion of projectiles, is in many instances an immense force; and hence the motion of these resisted bodies is totally different from what has been generally supposed.

Maxim VIII.

This retarding force of the air acts with different degrees of violence, according as the projectile moves with a greater or lesser velocity; and the resistances observe this law: that to a velocity which is double another, the resistance (within certain limits) is fourfold, and to a treble velocity ninefold; and so on.

Maxim IX.

But this proportion between the resistances to two different velocities does not hold, if one of the velocities be less than that of 1200 in a second, and the other greater. For in that case the resistance to the greater velocity is near three times as much as it would come out by a comparison with the smaller, according to the law explained in the last maxim.

Maxim X.

To the extraordinary power exerted by the resistance of the air, it is owing that when two pieces of different bores are discharged at the same elevation, the piece of the larger bore usually ranges farthest, provided they are both fired with fit bullets, and the customary allotment of powder.

Maxim XI.

The greatest part of military projectiles will, at the time of their discharge, acquire a whirling motion round their axis, by rubbing against the inside of their respective pieces; and this whirling motion will cause them to strike the air very differently from what they would do, had they no other but a progressive motion. By this means it will happen that the resistance of the air will not always be directly opposed to their flight; but will frequently act in a line oblique to their course, and will thereby force them to deviate from the regular tract they would otherwise describe. And this is the true cause of the irregularities described in Maxim IV.

Practical Maxims.

Robins' practical maxims.

Maxim XII.

From the sudden trebling the quantity of the air's resistance, when the projectile moves swifter than at the rate of 1200 feet in a second, (as has been explained in Max. IX.) it follows, that whatever be the regular range of a bullet discharged with the last-mentioned velocity, that range will be but little increased, how much soever the velocity of the bullet may be still farther augmented by greater charges of powder.

Maxim XIII.

If the same piece of cannon be successively fired at an invariable elevation, but with various charges of powder, the greatest charge being the whole weight of the bullet in powder, and the least not less than the fifth of that weight; then, if the elevation be not less than 8° or 10°, it will be found that some of the ranges with the least charge will exceed some of those with the greatest.

Maxim XIV.

If two pieces of cannon, of the same bore but of different lengths, are successively fired at the same elevation, with the same charge of powder, then it will frequently happen, that some of the ranges with the shorter piece will exceed some of those with the longer.

Maxim XV.

In distant cannonadings, the advantages arising from long pieces and large charges of powder are but of little moment.

Maxim XVI.

In firing against troops with grape-shot, it will be found, that charges of powder much less than those generally used are the most advantageous.

Maxim XVII.

The principal operation in which large charges of powder appear to be more efficacious than small ones, are the ruining of parapets, the dismounting of batteries covered by stout mortars, or battering in breach; for in all these cases, if the object be but little removed from the piece, every increase of velocity will increase the penetration of the bullet.

Maxim XVIII.

Whatever operations are to be performed by artillery, the least charges of powder with which they can be effected are always to be preferred.

Maxim XIX.

Hence, then, the proper charge of any piece of artillery, is not that allotment of powder which will communicate the greatest velocity to the bullet, (as most practitioners have hitherto maintained,) nor is it to be determined by an invariable proportion of its weight to the weight of the ball; but, on the contrary, it is such a quantity of powder as will produce the least velocity necessary for the purpose required; and instead of bearing always a fixed ratio to the weight of the bullet, it must be different according to the different business which is to be performed.

Maxim XX.

No field piece ought at any time to be loaded with more than $\frac{1}{4}$, or the utmost $\frac{1}{3}$ of the weight of its bullet in powder. Nor should the charge of any battering piece exceed $\frac{1}{3}$ the weight of its bullet.

Practical Maxims.

Robins' practical maxims.

Maxim XXI.

The depth to which a bullet penetrates in a solid substance is a much more definite criterion of its comparative velocity than the distance to which it ranges when fired at an elevation. For when the velocity of the bullet is doubled, it penetrates into an uniform substance near four times as deep, and with three times the velocity near nine times as deep; * so that, with different velocities, the penetrations vary in a much greater proportion than the velocities themselves.

Maxim XXII.

Hence then in all contests about the greater or less velocity which a bullet acquires from different quantities of powder, or from different lengths of pieces, or different methods of loading; the most decisive experiment is to try the penetration of the bullet into some uniform substance, placed at a small distance from the muzzle of the piece; since that bullet which, in repeated trials, penetrates deepest, may be concluded to have been discharged with the greatest celerity.

For farther information on the subject of gunnery, see Tartaglia's *Colloquies concerning the Art of shooting in great and small Pieces of Artillery*, translated by Lucas, Lond. 1588. Collado's *Practica Manuale D'Artiglieria*, Venice, 1586. Bourne's *Art of shooting in great Ordnance*, 1693. Eldred's *Gunner's Glasse*, 1646. Galileo's *Discursus et Demonstrationes Mathematicæ*, 1638. Anderson *on the genuine Use and Effects of the Gun*, 1674. Blondel, *L'Art de jetter les Bombes*. Greave's *on the Force of Guns*, in the *Phil. Trans.* 1685, vol. xv. p. 1090. Halley, *Phil. Trans.* 1686, vol. xvi. p. 3; 1695, vol. xix. p. 68. Newton's *Principia*. John Bernoulli, *Mem. Acad. Par.* 1711; and *Act. Lips.* 1713. Brook Taylor, *Phil. Trans.* 1726, vol. xxxiv. Keill, *Journal Literaire de la Haye*, 1719, p. 151. D. Bernoulli, *Comment. Petrop.* vol. iv. p. 136. Mariotte *on the Recoil of Fire Arms*, in the *Mem. Acad. Par.* vol. i. p. 233. Cassini *on the Recoil*, Id. 1703. Cassini *on the Effect of different Charges, Id.* 1707. Guisnée on the *Galilean Theory, Id.* 1707. Ressons, *Id.* 1716, p. 79; and 1719 and 1720. Maupertuis, *Id.* 1731, p. 297. Jurin. *Phil. Trans.* 1742, p. 172. St Remy's *Memoirs of Artillery*, vol. i. p. 69. Robins' *New Principles of Gunnery, Id.* translated by Euler, and retranslated into English by Brown. Euler, *Mem. Acad. Berlin*, 1753, p. 34. Krafft, *Acta Petropol.* vol. iv. i. 154, ii. 175. Leutmann, *Comment. Petrop.* iv. p. 265. Deidier, *Mem. Acad.* 1741. D'Arcy, *Mem. Acad.* 1751, p. 45. D'Arcy, *Essais sur la Theorie de l'Artillerie*, 1760. Borda, *Mem. Acad.* 1769, p. 116. Montalembert, *Mem. Acad.* 1755, p. 463; *Id.* 1759, p. 358. Lambert, *Mem. Acad. Berl.* 1765, p. 102; *Id.* 1773, p. 34. Cassali, *Comment. Bonon*, vol. v. 1. Bernoulli, *Mem Acad. Berl.* 1781, 347. Sulzer, *Mem. Acad. Berl.* 1755. Tempelhoff, *Mem. Acad. Berl.* 1788, p. 216. Moreau, *Journal Polytechnique*, vol. iv. xi. 204. Devalliere, *Mem. Acad. Par.* 1772. Mattei, see *Antoni's Work*. Butet, see Antoni's *Treatise on Powder*, and *on Fire Arms*, translated by Thomson. Hutton, *Phil. Trans.* 1778, and *Tracts* vol. ii. iii. Rumford, *Phil. Trans.* 1781, p. 229; *Id.* 1797, p. 222. Franceur, *Mecanique*. Grobert, *Journal des Mines*, 1804, No. 92. or Tilloch's *Phil. Magazine*, vol. xxii. p. 220. Glenie's *History of Gunnery*.

* Dr Hutton has found that the penetrations are in a much lower proportion.

unpowder. GUNPOWDER, is a compound of nitre, sulphur, and charcoal. The chemical action which these few elementary bodies exert on each other, has many times determined the fate of nations. More human beings have fallen victims to its power than at present exist upon the face of the globe, and it is now considered as the most effective agent in modern warfare.

istory of unpowder. The history of this surprising substance is clouded with much obscurity, and this we deem sufficient for not entering minutely into this branch of our subject.

Polydore Virgil, and Thevet, attribute the discovery of gunpowder to a monk named Constantine Anelzen, who was a chemist of some celebrity in his time. Others assert, with much probability, that it was discovered by Bartholdus Schwartz, about the year 1320.

The Venetians are said to have used gunpowder during a war with the Genoese, in the year 1330. In 1346, cannon and gunpowder were used at the battle of Cressy; and about the same time at the siege of Calais.

Long before any of these periods, gunpowder is said to have been discovered by Roger Bacon. In a work written by him in 1280, he points out the composition of gunpowder; and was so much aware of its importance, as to recommend its explosive powers as the means of destroying armies.

The Chinese, and probably other nations of the East, with whom most of the arts have originated, appear to have been acquainted with a variety of these explosive compounds long before they were known to Europe. It appears almost impossible, that, in countries where nitre is found in the soil, the commonest people should have been ignorant of the action between carbon and nitre. If sulphur were not present, still the effects would be remarkable.

The preparation of gunpowder is divided into three principal departments. 1st, The choice and purification of the materials; 2d, The adjustment of the proportions, by which a maximum of explosive power may be produced; and 3d, The incorporation of the materials, which is a mechanical process not of less importance than the other departments.

ethod of oosing the tre. In the choice of nitre, no rule is so important as the form and size of the crystals. It is necessary first to examine whether the nitre affords any foreign matter different from nitric acid and potash. It sometimes contains nitrate or muriate of lime, magnesia, and perhaps muriate of potash. First dissolve a small portion of the nitre, and filtre the solution. To a little of this, add a few drops of a solution of sulphate of silver. If a bluish white precipitate falls down, which turns darker coloured by exposure to the light, then the nitre contains muriatic acid, combined with some of the bases above mentioned; namely, lime, magnesia, potash, and probably soda. Take another portion of the solution of nitre, and drop into it a solution of oxalate of ammonia. If a white precipitate falls down, it shows the presence of lime. To a third portion of the solution add a little pure ammonia, then if any precipitate is found the nitre contains magnesia.

In particular experiments, the tests above mentioned might be used to separate the foreign matter; but for general use, this would be too expensive; and the only practicable method of purifying nitre, is by frequent solution, evaporation, and careful crystallization. When the crystals are transparent, clear, and well formed into distinct prisms, the nitre may be looked upon as pure. It is well to test it after every fresh crystallization, to know when it may be relied upon. If nitre should contain any alkaline sulphate, the test for this substance will be a solution of nitrate of barytes. If a precipitate is produced, add more of the same substance carefully till no more is precipitated. By this means the sulphate of the alkali becomes a nitrate, which is nitre.

French method of purifying nitre. The French method of purifying nitre for the manufacture of gunpowder is very simple, and has been practised with success. The nitrate or muriate of lime, or the same acids with magnesia and even common salt, are more easily soluble in cold water than the nitre itself; but particularly the earthy salts, which are most injurious. This property presents an easy means of separating them from the nitre.

The French, for this purpose, first coarsely pound the crude nitre, and put it into a copper, adding to it 20 per cent. of cold rain water. The mixture is then stirred, and allowed to remain for 6 or 7 hours. The liquid part is now drained off, and 10 per cent. more water added, which, after stirring as before, is allowed to remain one hour, and then drained off as formerly. Lastly, 5 per cent. of water is to be added, and drained off as before, leaving the whole to drain completely. By this means the deliquescent salts are carried off, and also a portion of nitre, which may afterwards be separated for common purposes.

The drained mass is now to be dissolved, by adding to it 50 per cent. of pure water at 212°. This solution is next to be placed in shallow leaden vessels in a cool place, in order to allow the nitre to crystallize, which very soon takes place. During the crystallization the solution is frequently agitated, to prevent the crystals from being too large. It is an object to have the prisms not thicker than needles, in order to promote their more speedy desiccation, previous to its being reduced to powder, for mixing with the sulphur and charcoal. As the crystals are deposited, they are removed into baskets to drain. They are ultimately placed in wicker wooden vats with double bottoms, the superior bottom being perforated, so as to allow the water to drain through into the cavity below. This nitre is deemed sufficiently pure for making gunpowder.

Method of choosing the sulphur. The choice of the sulphur for making gunpowder, is easy to those who are experienced. It should be of a lively yellow colour. Its specific gravity should not be great. It should appear porous, but not shining. When a bit of it is burned upon a piece of clean glass or porcelain, it should leave no residuum.

If it does not answer these characters, it should be melted at a low heat, and skimmed from time to time. If this is not sufficient, it should be sublimed at the lowest possible heat. The sulphur which is extracted from pyrites, is never sufficiently pure for this purpose. That from Italy and Sicily, which is naturally sublimed by the heat of volcanoes, is the most pure.

Method of choosing the charcoal. In the choice of charcoal, it was once deemed an object even to make use of peculiar kinds of wood; but now any kind of wood properly charred is employed. The charcoal which is formed during the distillation of the pyrolignic acid, is now generally preferred.

Having pointed out the proper materials, it will now be necessary to shew the manner of intimately mixing them together; for certainly we cannot with propriety call gunpowder a compound. Since that sort of contiguity essential to their readily exploding, depends upon mechanical and not chemical union, it will not be wondered that gunpowder should differ so much in its qualities even with the best proportions. All the ex-

Gunpowder.

plosive chemical compounds, such as fulminating gold and silver, are uniform in their effects, because their formation is the result of chemical union.

Method of combining the materials.

The first business in preparing gunpowder, is to pound the materials, and pass them through fine sieves. Then for 100 pounds of powder, weigh 75.4 nitre, 11.8 sulphur, and 12.8 charcoal. These powders are to be intimately mingled, till the mass assumes a uniform colour; that is, till no specks of yellow, white, or black appear; for the nitre, after its crystals have been dried and powdered, becomes as white as flour. Water is now to be added, and the mass agitated till it assumes the form of a stiff but kneadable paste. In this state, it has been formerly kneaded or beaten in mills, called turning mills. This apparatus consists of large mortars, with pistols or stampers of lignum vitæ. These are still worked in some manufactories, but in the works of government they are laid aside, on account of the danger arising from the heat of percussion. The machine substituted for this seems much better. It consists of a large stone in the form of a grindstone, which is made to roll upon its edge in the circumference of a circle. A vertical shaft turns in the centre of the circle. A horizontal shaft works in the centre of the stone, the height of which is equal to the radius of the circle, in the periphery of which the stone is to roll, the end of this horizontal shaft being fastened into the vertical shaft. It will be evident that when the latter turns round, the rolling stone will go round just as a cart wheel is carried round by drawing the cart forward. The edge is a little rounded on the face, and works in a circular bed or trough, containing the paste to be worked or kneaded. The stone now goes round upon the paste, squeezing it flat. The point of contact is constantly preceded by a scraper, which goes round with the stone, and which constantly turns the paste, previously flattened, into the track of the stone, so that a new surface is always presented to its action. The size of this apparatus is sufficient to work from 50 to 60 pounds at once. It is driven by a steam engine, a water wheel, or by horses.

Process of working the paste.

The paste being sufficiently worked, which cannot be too much, is now sent to the corning house, where a separate mill is used for forming the paste into corns or grains.

Method of granulating the powder.

This process is performed in sieves with parchment bottoms, perforated with holes. These sieves are placed upon a revolving horizontal plane. The paste, in a certain state of dryness, is put into the sieves, and a piece of lignum vitæ in the shape of an oblate spheroid laid upon it. A rotatory motion is given to the spheroid at the time the sieves are revolving. This forces the paste in small grains through the holes in the parchment, which is received below.

The granulated matter consists of particles of very different sizes, and some reduced to dust. These are passed through wire sieves of different sizes, to give the different sized grains in which it is sold. Those which pass through the finest sieve, and which are called dust, are made up into paste, and worked over again.

Operation of polishing.

The proper grains are next to be glazed or polished. This is performed in a very expeditious manner, by putting the grains into a revolving cylinder, working like a barrel churn. This vessel should not be more than half full at once. The grains, by rubbing one against another, become smooth, and approach a spherical form.

Of drying.

The next operation, which has been attended with the greatest danger, is the drying. This has generally been effected by placing the powder upon shelves on three sides of a small room, on the other side of which is an iron stove; the fire being fed from the back of the wall. When we recollect that the stove itself is frequently hot enough to explode gunpowder, it is surprising that more safe methods have not been adopted. Steam appears to be the most proper agent to be employed, not only for the sake of avoiding danger, but it is better calculated to dry the powder more effectually, without any fear of the powder being injured in its quality. It is recommended that powder be not dried too quick, or with too great a heat, for fear of volatilizing the sulphur. All these precautions are unnecessary with steam, as sulphur only evaporates at 220°; and steam would not raise it so high as 212° without pressure. The shelves on which the powder is laid to dry might be made of cast iron, and hollow. The inner cavity might have a sloping bottom, so that when the steam came into it from a boiler below, the water, after condensation, might run back into the boiler. There would, of course, be no waste of water, which should be rain water. The steam might be formed from a fire at a sufficient distance, to avoid the risk of any accident. This method would not be less desirable in an economical point of view. The powder should be kept on the stove till the time of barrelling, for which the finest dry weather is always preferred.

Operation of drying.

A very great improvement has lately been made in preserving gunpowder, by using barrels of copper instead of wood. These barrels are first made water and air tight; and then the lid screws on so as to exclude completely all communication with the atmosphere. This has been of the greatest importance, particularly in the navy.

Having given the direct practical method of forming gunpowder, we shall now give some account of its chemical properties, from which alone we can get at any true theory of its effects.

Chemical properties of gunpowder.

The ingenious Mr Robins appears to have been the first who has examined gunpowder scientifically. He very properly conceived that its power consisted in the evolution of an abundance of some elastic fluid liberated in an instant, and strongly increased in its force by the heat attendant on the explosion. Having convinced himself that a permanently elastic fluid was generated during the explosion of gunpowder, his next business was to ascertain what proportion this bore to the whole weight of the powder. For this purpose, he exhausted the receiver of an air-pump, the capacity of which was equal to 520 cubic inches. In this he suspended a hot iron capable of firing gunpowder, and a mercurial gauge to ascertain the force of the air generated. On letting 27 grains of powder fall on the iron, the mercury indicated an increase of elastic fluid, which raised it two inches; and upon repeating the experiment, he found this result confirmed. The barometer at this time was 30 inches, so that the quantity of elastic fluid generated was equal to $\frac{1}{15}$th of an atmosphere. He guesses the temperature of the receiver to be such as to increase the volume $\frac{1}{5}$th of the whole. He then calculates the weight of this volume of gas, allowing its specific gravity to be the same with common air, to weigh 131 grains, for every ounce of 437.5 grains of gunpowder, which is $\frac{131}{437}$, or nearly $\frac{3}{10}$ of the whole.

Experiments of Mr Robins.

From determining the specific gravity of gunpowder, he found that the bulk of the powder to the volume of gas generated, was as 1 to 244.

He next supposes that the heat generated by the explosion of the powder, would have the same effect in expanding the generated elastic fluid which a red heat

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Chemical properties of gunpowder.

would produce. He then ascertained, by an experiment, that air was increased in volume by a red heat 4.1 times nearly. This would make the volume of the powder to that of generated air as 1 to 1000 nearly. The force which would arise from such an increase of volume, Mr Robins finds adequate to the effect of the powder in practice, and in a very ample manner agreed with his theory.

We have to lament that these experiments were not made with more precision. The gases generated were considered by Mr Robins as common air, the specific gravity of which is 1. These gases, however, being a mixture of carbonic acid, carbonic oxide, and azotic gases, should have been taken at a mean not less than 1.25. There is also some uncertainty about the allowance made for the heat of the receiver; and the volume was not increased by that circumstance so much as $\frac{1}{5}$th of the whole, which he supposes to be the case. The very little which was known of gaseous chemistry at the time Mr Robins made his experiments, does not admit of our wondering that no more was established by his labours. The constituents of nitre were then little known; and therefore the nature of the gases resulting from the decomposition of gunpowder could not be ascertained. He was satisfied with calling the gaseous product air, and supposed it to have only the properties of common air. In order to apply the chemical facts at present known to explain the nature of gunpowder, we shall compare the proportions of the ingredients used by different manufacturers, with those proportions which theory would point out, in order to produce a *maximum* effect.

An intelligent account of making gunpowder has been given by Mr Coleman, of the royal gunpowder mills at Waltham Abbey. (*Phil. Mag.* vol. ix.) In some observations at the end of the paper, Mr Coleman has taken a very proper view of the theory of gunpowder, by giving some calculations relative to the resulting products. He has taken into the account the water, which he rates at 4 per cent. It has not been ascertained, that water undergoes any change in the decomposition of gunpowder; nor, indeed, is it very probable that any such effect takes place. He has also given too little oxygen for sulphurous acid. He states it to be 80 per cent. when it is actually 50. It appears from experiments made in the firing of gunpowder, that very little of the sulphur enters into combination with the oxygen, and we believe not after the carbon is kindled. The residuum is always very near a complete sulphuret of potash; and the quantity of sulphur used in the composition is seldom more than is just sufficient to form the sulphuret. This is rendered highly probable, from the fact of gunpowder possessing the same strength with very different proportions of sulphur. Indeed, M. Chaptal has made very good gunpowder without sulphur. It is however different in a mechanical point of view, and on that account would not answer in practice. It is therefore highly probable, that the sulphur does not form sulphurous acid when the explosion takes place, since oxygen seems to unite with the carbon alone. The potash, when deserted by oxygen and the nitrogen, assumes the form of a fine dust of powder, and the sulphur the form of vapour. These combine, forming a sulphuret of potash, which appears in white fumes, and adheres to surrounding bodies. The moment this white efflorescence is touched with the tongue, the exact taste of sulphuret of potash is perceived. If the carbon were very defective in quantity, and the sulphur in the usual proportion, some sulphurous acid would doubtless be formed, and the smell of it would be very perceptible, in the fumes resulting from its decomposition; but no smell of this kind is perceived in the explosion of ordinary gunpowder.

Proportions of the ingredients.

The following Table contains some of the proportions used by different manufacturers in this and other countries.

Varieties of Gunpowder.	Nitre.	Charcoal	Sulphur.
Mr Coleman, of the Royal Mills at Waltham Abbey,	75	15	10
Generally used in France, .	76	12	12
War powder of France, . .	75	12.5	12.5
Result of experiments by M. Chaptal, ...	77	14	9
Used in China, ...	75.7	14.4	9.9
Result of Mr Napier's method of approximating the true proportions, ...	80	15	5
Average, ...	76.45	13.81	9.73

Doubtless all these varieties are very good powder, which would not have been the case had the charcoal been as uncertain in its proportions as the sulphur.

It will be admitted on all hands, that the best gunpowder must result from such materials as explode the quickest, leaving the least possible residuum, and affording the greatest possible volume of elastic fluid. Now, if sulphur did, by its combination with oxygen, form an elastic fluid, the resulting gas, which is sulphurous acid, is nearly 1.5 times heavier than carbonic acid, and therefore contributes less force in a given weight. It will be found, when nitre is deflagrated with charcoal, that carbonic oxide is formed as well as carbonic acid, which contributes more elastic force than the same weight of carbonic acid.

There is one good reason to be given for the use of the sulphur, although it does not contribute to the production of any elastic fluid. The carbonic acid which is generated, would doubtless combine with the potash, if it were not for the presence of the sulphur; and thus so much elastic fluid would be lost. That this is the case, we know from the fact, that carbonate of potash is always formed when nitre is decomposed by charcoal alone. This would be the case to a certain extent with gunpowder made without sulphur; some carbonate of potash would be formed.

It will appear from these facts and observations, that the proportions for gunpowder will be those in which the carbon will just consume the oxygen of the nitre, and the sulphur as much as will exactly saturate the potash. This will be effected by an atom each of nitre and sulphur, and three atoms of carbon, or nitre 95.5; charcoal 16.2; and sulphur 15. These will give in the 100 nitre 75.4; of charcoal 11.8; and sulphur 12.8. These proportions agree with the best in practice. The bodies which result from the decompositions of this compound, will be in 126.7 parts, 60 of sulphuret potash; 40.8 of carbonic acid; 12 9 of carbonic oxide; and 13 of azot.

The three latter are elastic fluids, equal to 66.7 out of 126.7, or $\frac{4}{7}$ of the whole nearly. Mr Robins made the gaseous product $\frac{7}{10}$ of the whole. This last number, when the specific gravity of the gas is taken right, will differ very little from our calculation.

In the 66.7 by weight, (suppose grains,) we have

Gunpowder.

Carbonic acid	40.8 =	87 cubic inches
Carbonic oxide . . .	12.9 =	42
Azot	13. =	40.6
Total		169.6

Now Mr Robins found that 27 grains of powder generated as much air as made $\frac{1}{17}$ of an atmosphere in a space equal to 520 cubic inches. This at the pressure of the atmosphere, which was at the time equal to 30 inches, would make 34.6 cubic inches. The increased temperature which the receiver got by the explosion, might reduce this to 30 or 31. We find from our calculation that 126.7 of gunpowder generates 169.6 cubic inches of gas. Then as 126.7 : 27 : : 169.6 : 35.7 cubic inches, which is only three cubic inches different from Mr Robins' experiment. This might arise from his powder not consisting of proper proportions.

In the present improved state of chemical science, when the nature of the bodies constituting gunpowder are so well understood, as well as the compounds resulting from their action on each other, the proportions above given may be taken as the best for practice. The charcoal should, in particular, not be less in proportion to the nitre, as the smallest portion less than a whole atom would be the same as to leave out the whole atom, in which case there would be no carbonic oxide formed. If, for instance, instead of the proportions 95.5 nitre, 16.2 charcoal, and 15 sulphur, the carbon was 16, then there would be 4.2 of carbon left in the residuum, and no carbonic oxide would be formed; since bodies cannot unite but in definite proportions.

The reason why carbonic oxide is formed during the decomposition of nitre by charcoal, will be obvious from nitric acid having five atoms of oxygen. Four of these unite with two of carbon to form two atoms of carbonic acid, while the odd atom of oxygen is compelled to take another atom of carbon to form carbonic oxide. The writer of this article found the presence of the latter substance a fatal objection to getting pure carbonic acid by deflagrating nitre with charcoal.

Method of choosing gunpowder.

The goodness of gunpowder is known to those experienced in it by its appearance. It should not be strictly black, but of azure grey inclining to red. The grains should appear uniform, both to the eye and to the touch. If some rub to powder sooner than others, it shows that the mass is not well mixed.

When it is fired on clean paper, or on a clean board, it should not soil it, or leave black spots. The smoke arising from it will form a circle or ring, more or less perfect as the explosion is more or less rapid, and is a good test of its strength.

Description of the Eprouvette for determining the strength of

The best and most certain test of the strength of gunpowder is the *eprouvette.* This is a machine in which the powder acts against a weight in order to raise it to a given height. The powder in these machines, however, acts by a sudden impulse, and not as it acts in a gun, which is by gradual pressure during the whole time the charge is passing through the barrel. Hence the common powder powers are very imperfect, and have been long deemed insufficient. The French method of trying powder is more to be depended upon, but it is more tedious, and takes up too much time for practice.

Each of the magazines for powder have a small mortar, exactly of the same size, and capable of containing a ball of 7½ inches in diameter. The mortar is elevated to an angle of 45°; and when the powder is of the required strength, 3 ounces of it is capable of projecting the ball of the above size 55 French fathoms.

Methods of determining the strength of gunpowder.

Mr Robins proposed a much more certain apparatus for trying the strength of powder, which has since been executed and reduced to practice by Dr Hutton. It is founded on the principle that the momentum of the gun and the charge must be equal, or that the force of the powder, which is equally exerted upon both, will generate velocities in each, which will be inversely as their quantities of matter. Thus, if the weight of the charge were 1, that of the gun being 100, then their velocities will be reciprocally as these numbers. For this purpose, Dr Hutton's machine consists of a brass cannon of about one inch bore.* It is suspended in such a way, that the arch of its recoil can be easily ascertained. The gun is generally charged with two ounces of powder. The arch of recoil gives the velocity with which it is propelled, and hence the force of a given quantity of powder. No wadding is used in this method, the powder being merely collected into as compact a mass as possible. In these experiments, it should always be ascertained whether the whole of the powder be fired.

Plate CCLXXXI. Fig. 10, 11.

The strength of powder might be very conveniently and correctly ascertained, by firing a bullet into some uniform medium, such as sand or clay. The medium may first be tried, by letting a ball fall from a given height into it, and observing the depth to which it has penetrated. Since these depths are the spaces through which the ball has passed to lose motion, which is supposed to have been uniformly retarded, they will therefore be as the squares of their velocities. Hence, when the space has been determined by the falling body of which the velocity was known; the first velocity of the projected body may be determined, the space through which it has penetrated being known.

Since the force of gunpowder is exerted in a manner similar to the action of condensed air, which is analogous to the action of a spring, there appears nothing more necessary to be known than the volume of elastic fluid set free, and its temperature, to know what is its velocity of expansion when no matter has to be moved.

Mr Robins first ascertained the volume of air formed by a given quantity of gunpowder, and then supposed that this elastic fluid was exposed to a heat equal to redness, by the explosion of gunpowder. He also found by experiment, how much the volume of a given bulk of air was increased by a red heat. The first production of air gave him a force of about 244 atmospheres, or that the original volume of gunpowder was multiplied by that number. The red heat he found would multiply this volume by about 4.1. This gave about 1000 times for the increase of volume. The force of its first action would therefore equal so many atmospheres, or 1000×15 pounds upon a square inch. When this force begins to move, it decreases with the dilatation, and exactly in the same ratio. Mr Robins not only ascertained the velocity given to the bullet by a given weight of powder, but he fired the powder alone, which having no weight to move, would expand itself with the greatest velocity. He found that, under these circumstances, the velocity of expansion was 7000 feet in one second.

Plate CCLXXXI. Fig. 12.

In these experiments, the charge, at a small distance, was fired at a piece of wood, constituting the bob of a pendulum. This pendulum had a ribbon attached to it, which was slightly held between two surfaces, so that when the pendulum vibrated, the length of the

* See the Description of this Plate at the end of the Volume.

Gunpowder Plot.

ribbon drawn out, measured the cord of the arch of vibration, by which the velocity of the striking body was known. See the *Description of Plates*.

Rumford's notions.

Count Rumford has advanced some new notions respecting gunpowder, deeming the reasons for its power given by Mr Robins insufficient, viz. the gases and the heat. He attributes the power of the powder to the vapour of the water it contains, and supposes the heat to be the result of friction. His views of the subject have not been countenanced by other philosophers, as they appear to be contrary to experience. Mr Robins, and more recently Mr Coleman, found that powder was the strongest in its most dry state, if none of the materials were injured, and that it became weakened by the slightest quantity of moisture.

Notwithstanding all the caution used in purifying the nitre, all powder has a great tendency to absorb moisture from the atmosphere. This may go on to a considerable extent, without any permanent injury to the powder, its power being restored by drying. If, however, the water absorbed be sufficient to effect a solution of nitre, the latter afterwards crystallizes, and appears like hoar-frost upon the grains of the powder: This is called the starting of the saltpetre, when the powder is not capable of being restored to its original strength by drying; for the nitre is, to a certain extent, detached from the other two ingredients. Powder is sometimes so much injured by dampness, as to be of no value, except in so far as the nitre can be recovered from it by solution. (c. s.)

GUNPOWDER Plot. This conspiracy, one of the most iniquitous and daring treasons recorded in history, was the memorable offspring of religious bigotry. It had its origin in the disappointed zeal of the Catholics, and has contributed more than any thing to fix upon themselves that very intolerance, of which they have given so many and such dreadful examples.

After the death of Mary, who was regarded as a martyr to their cause, they rested their last hope on the favour and protection of her son. Of these they pretended to have received the most unequivocal assurance; and mere toleration was among the lowest of their anticipations. James quickly undeceived them; and though certainly less hostile to their religion than jealous of the papal supremacy, he shewed a confirmed resolution of at all times enforcing against them the enactments of the two preceding reigns. Their surprise and rage at this conduct were excessive. They saw nothing before them but submission or revenge; and they chose their part. Robert Catesby, a gentleman of ancient family, and whose character in other respects suited little with the desperation of a zealot, formed the terrible scheme of at once avenging and retrieving their lost ascendancy. He imparted his thoughts to a few zealous Catholics, among whom were Piercy, Rookwood, and Sir Everard Digby. A meeting was held, to consult what measures would best accomplish their purpose. Piercy, in the true spirit of fanaticism, proposed to assassinate the king, and to be himself the instrument; but Catesby, with deeper purpose, laid before them a wider plan of vengeance. He represented to them the inefficacy and the danger of striking a single victim, which would but mark out themselves for a more dreadful atonement. He shewed them that the whole of their enemies might be struck at once, by running a mine below the House of Parliament, and when all should be assembled at the opening of the session, blowing them up in one common ruin, and consigning them, as he chose to express himself, "from flames above to flames below." The scheme was received with enthusiasm. A few more Catholics were taken into the plot; and, with the others, had their consciences absolved by the Jesuits Garnet and Tesmond. Among these was the famous Guy Fawkes, who had been sent for from Flanders, and was well fitted, by his zeal and intrepidity, to take a prominent share in this extraordinary enterprize.

The plot being now fully concerted, a house adjoining the House of Parliament was hired in Piercy's name, and the operation commenced towards the end of the year 1604. Nothing could exceed the industry with which it was forwarded. A store of provisions was taken in to prevent the necessity of interruption; and the conspirators came armed to the work, determined to succeed, or perish in the attempt.

Between the houses was a partition wall, three yards thick. This, after much labour, they succeeded in piercing; but just as the work opened to the other side, they were alarmed by an unaccountable noise from below. Fawkes, who passed himself for Piercy's valet, went out to enquire into the cause, and learned, to their inexpressible satisfaction, that the sounds they had heard proceeded from a coal vault under the House of Lords, where coals were at that moment selling off, and that the vault itself would be let after the sale. The conspirators seized with eagerness the opportunity, bought up the remainder of the coals, and hired the place. Thirty-six barrels of gunpowder were procured from Holland, conveyed into the vault, concealed under coals and faggots, and the doors boldly thrown open, as if to challenge inspection.

Matters being thus far in preparation, there remained but one obstacle to the completion of the enterprize. The Duke of York and the Princess Elizabeth, on account of their youth, would be absent from parliament, and escape destruction. It was resolved, therefore, that when the explosion should have done its work, Piercy, who, as a gentleman pensioner, had access to the Palace, should carry off or assassinate the Duke, while Sir E. Digby, having assembled his friends on pretence of a hunting match, was to seize the princess, then at Lord Harrington's house in Warwickshire, and proclaim her queen.

Every thing was now arranged for the dreadful issue. The day approached (the 5th of November) appointed for the meeting of parliament. The conspirators looked forward to a certain triumph, when, fortunately for the country and for Protestantism, the indiscretion of a Catholic laid open the treason.

Ten days before the sitting of parliament, Lord Monteagle, a Catholic, son of Lord Morely, received from a person unknown the following letter. It had been put into the hand of his servant, with express injunctions to be delivered only to himself. "My Lord, out of the love I bear to some of your friends, I have a care of your preservation. Therefore I would advise you, as you tender your life, to devise some excuse to shift off your attendance at this parliament. For God and man have concurred to punish the wickedness of this time. And think not slightly of this advertisement; but retire yourself into your country, where you may expect the event in safety. For though there be no appearance of any stir, yet I say they will receive a terrible blow this parliament, and yet they shall not see who hurts them. This council is not to be contemned, because it may do you good, and can do you no harm. For the danger is past as soon as you have burned the letter. And I hope God will give you grace to make

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good use of it." Neither Monteagle nor Salisbury, to whom he carried the letter, was inclined to regard it seriously. James was the first to penetrate its meaning. The words quoted by Salisbury, to prove to him the folly or insanity of its author, viz. "the danger is past *as soon* as you have burnt the letter," James interpreted to signify, not that the danger would be past when the letter was burnt, but that it would pass in a space of time as short as the burning of the letter might occupy. This, compared with the preceding threat of a "terrible blow," the authors of which would be concealed, suggested to the king the agency of gunpowder. It was determined, therefore, to have an inspection of all the rooms and vaults below the houses of parliament. This duty was performed the day before the meeting by the Lord chamberlain, who, besides noticing the prodigious pile of fuel, did not fail to observe also the dark, intrepid, and suspicious countenance of Fawkes, who, still passing himself for Piercy's servant, loitered about the cellar. This being reported to the council, a more particular search was deemed advisable. Accordingly, Sir Thomas Knevet, justice of peace for Westminster, went with proper attendants at midnight, and seized Fawkes, just as he had completed his preparations, and was leaving the vault. He was dressed in a cloak and boots, and held in his hand a dark lantern. Matches being found upon him, and the powder discovered under the fuel, the guilt became apparent, and he no longer sought to conceal it. He broke out in a tone of defiance and contempt, expressing in the strongest manner, his extreme regret that so many heretics had escaped his vengeance, and declaring that he could attribute only to the devil the frustration of so good a work. He met the council with the same scornful intrepidity, and obstinately refused giving any account of his accomplices; but, after two days solitary confinement in the Tower, and the rack being just set before him, his courage was shaken, and he made a full disclosure of the treason. Upon the first notice that Fawkes was arrested, Catesby, Piercy, and Winter fled hastily into Warwickshire, where they joined the party of Sir E. Digby. Sir Everard having failed in his attempt to seize the Princess, was already pressed, and almost beset by the sheriffs. After being driven for some time from place to place before their enemies, they made a resolute stand at the house of Holback, in Staffordshire; but here part of their powder having accidentally exploded, they were thrown into the utmost confusion, the gates were flung open, and the armed multitude rushed in upon them from all sides: Catesby and Piercy, fighting back to back, fell by the same shot; Winter, Digby, and Rookwood, were taken alive, and, with the Jesuits Garnet and Oldcorne, suffered by the executioner. More were afterwards convicted; and some owed their lives to the clemency of James.

Stourton and Mordaunt, two Catholic lords, having been absent from parliament, were suspected of connivance, and fined, the former in £4000, and the latter in £10,000. The Earl of Northumberland fell under the same suspicion. It was discovered, that, as captain of the band of Gentlemen Pensioners, he had excused his cousin Piercy, upon his admission into that corps, from taking the customary oaths. He was stripped of his employment, imprisoned during the king's pleasure, and fined in £30,000.

Such was the issue of this memorable treason,—a treason scarcely more memorable for the desperate zeal and devoted bigotry of its conductors, than for the magnitude of its purpose, and the deep atrocity of its guilt.

Gun… ‖ Gusta…

It has not the excuse of precipitation or passion. Though undertaken perhaps in the freshness of imagined injury, it was meditated for years, and with increasing zeal and approbation. Neither was it the offspring of ignorance and depravity; its leaders were the most esteemed and most enlightened of their religion. Hence may be traced in the minds of Protestants a jealousy and a prejudice, which, even in these times, yield, with much reluctance, to the better views and more tolerant spirit of enlightened Christianity. (*v*)

GUNSHOT Wounds. See Surgery.

GUNTER'S Line. See Arithmetic, vol. ii. page 423, 424; and Logarithmic Scales.

GURNIGHEL, is the name of a mountain in the canton of Bern, and situated to the north of the chain of the Stockhorn, on the confines of the country of Schwartzenbourg, and six leagues to the south of Bern. It is principally remarkable for its baths of sulphurous waters, which are situated on the north-west side of the mountain, at the side of a fine wood of firs, and which are accessible to carriages, notwithstanding the great height of their situation. One of the springs, called Stockwasser, issues from the ground about a quarter of a league from the baths. Its temperature is + 6° of Reaumur. Fourteen ounces of this water contains, according to M. Morell of Bern, carbonic acid gas, mixed

With hepatic gas	$3\frac{1}{2}$ cubic inches.
Carbonate of magnesia . .	$2\frac{3}{4}$ grains.
Lime	$1\frac{1}{2}$ grain.
Sulphate of lime	$8\frac{1}{8}$ grains.
Sulphate of magnesia . . .	$\frac{1}{24}$ grain.
Sulphate of soda . . .	$\frac{3}{29}$ grain.
Iron	$\frac{3}{40}$ grain.

A second spring, which is called Schwartzbrunlein, has a strong sulphurous odour. It is at first very limpid, but it is rapidly decomposed by the air, and becomes as white as milk. It is more powerful than the other spring, and great quantities of it are sent in bottles hermetically sealed to Berne at the price of about 11 sous. The lodging-house is commodious, though by no means sumptuous. The expence of board is about 6 or 7 French livres per day. From the house there is a fine view over the whole of the canton which is comprehended between the Jura and the mountains of Emmenthal, and also of the town and lake of Neufchatel. See Ebel's *Manuel*, &c.

GUSTAVUS Adolphus, commonly called the Great, King of Sweden, was born at Stockholm in the year 1594. He was educated with particular care, and instructed in all the learning and accomplishments which are calculated to form a statesman and a hero. His genius was great, his memory prodigious; and he discovered an uncommon docility and desire of acquiring knowledge. In the year 1611, he ascended the throne of Sweden, being then only 18; but the vigour of his character, and his various acquirements, compensated the disadvantage of his youth; and the choice which he made of his ministers and counsellors, evinced his ability to conduct the government of the kingdom, at the head of which he was placed.

Soon after his accession, he was involved in war with the Danes, the Russians, and the Poles, from which he extricated himself with great valour and prudence; having increased his hereditary dominions by the acquisition of Livonia, which he wrested from the two last mentioned powers. In the year 1630, he was invited by the German Protestants to join the league against the Emperor; and by his powerful assistance, and the good conduct of his arms, he greatly contributed to the ultimate success of their cause. On his departure from Sweden, he called together the states of the kingdom; and having caused them to do homage to his daughter Christina, then only four years old, he took leave of them in a discourse, in which he explained, at length, the motives that prompted the enterprize he was about to undertake.

In the month of June 1630, Gustavus landed on the coast of Pomerania, with an army of 15,000 men. At first, his operations were greatly impeded by the jealousy and discord that reigned among the Protestant Princes of Germany, who seemed to be actuated rather by their own selfish interests, than by any enlarged view to the general good. However, he soon expelled the imperial troops from Pomerania, and forced the Elector of Brandenburg to embrace his true interest, by affording every facility to the enterprize of the Swedes. The King then resolved to hasten to the relief of Magdeburg, which was besieged by the imperial generalissimo Count Tilly; but his views were frustrated by the strange conduct of the Elector of Saxony, who refused to permit him to pass the Elbe; and he had the mortification to receive intelligence of the fall of that important fortress, accompanied with circumstances of atrocity, which have stamped indelible infamy on the name of Tilly. The haughty and cruel conduct of the imperial commander soon brought the Elector of Saxony to a sense of his situation and true interest; and having joined his forces to those of the King of Sweden, they encountered the enemy under Tilly, at Breitenstein, near Leipsic, on the 7th of September 1631. A battle ensued, which terminated in the total discomfiture and rout of the Imperialists. The victorious King now advanced along the Maine, as far as the Rhine; forced the city of Mentz to capitulate; drove the Spaniards out of Germany, and freed the Palatinate. He then turned his arms against Bavaria; and Tilly, who endeavoured to dispute with him the passage of the Lech, was again defeated, and perished in the attempt.

His loss was supplied by Wallenstein, who was now placed at the head of the imperial armies; and commenced his operations by driving the Saxons out of Bohemia. Meanwhile Gustavus, pursuing his victorious career, had advanced into the heart of Bavaria, and made himself master of Munich. As he approached the Austrian dominions, Wallenstein hastened to their relief, and compelled the king to retire. The two armies met at Nuremberg, and formed entrenched camps opposite to each other, where they remained inactive during two months. It was the policy of Wallenstein to avoid a battle, in hopes that the Swedish army would be weakened by famine and disease. At length the latter made a vigorous attempt to storm the entrenchments of the Imperialists; but, for the first time since their landing in Germany, they received a severe check; and, after a fruitless exhibition of valour, Gustavus found himself compelled to retire, the whole of the neighbouring country being completely exhausted of provisions. He was followed into Saxony by Wallenstein; and the two armies again met at the village of Lutzen, near Weissenfels. Here a sanguinary battle took place on the 6th of November 1632, which was fought with great skill, and with the most obstinate courage, on both sides. The intrepidity and discipline of the Swedes, however, at length prevailed, and the Imperialists were driven from the field. But the victory was dearly purchased. Besides a great loss of men, the conquerors had to lament the death of their adored king, who was killed by a musket shot while gallantly leading on his cavalry to a charge against the broken ranks of the enemy. After the battle, his body was found lying near a large stone, which, in commemoration of this circumstance, was called the *Schwedenstein*, (Swede stone,) and which still indicates the spot where the great vindicator of the religious liberties of Germany terminated his victorious career. Thus fell Gustavus Adolphus, in the thirty-eighth year of his age. The ball which inflicted the mortal wound entered his back, and passed through his body. This circumstance, among others, excited a suspicion of treachery; and the Duke of Saxe-Lawenburgh, one of his generals, who immediately afterwards left the Swedish service, has been expressly pointed out by some historians as the assassin of his royal commander. There is, however, no positive evidence of his guilt, and the fact is to this day doubtful.

Gustavus left behind him the character of a good Christian, a great king, a prudent statesman, and a consummate general. Amidst the operations of war, he did not neglect the cultivation of the sciences. He enriched the university of Upsal, established a royal academy at Abo, and founded an university at Dorp in Livonia. Before his time, there were no regular troops in Sweden; but he formed and executed the project of having 80,000 men, constantly well armed, clothed, and disciplined. He was acknowledged to be the greatest captain of his time, and the bravest soldier in his army; and the military art is indebted to his genius for several great improvements. He formed his cavalry into smaller subdivisions, which enabled them to move with greater ease and rapidity; his order of battle was composed of two lines, (instead of one, according to the usual practice,) in order that the second might advance, in the event of the first being broken; and he was the first who demonstrated, in modern times, the importance of a well-disciplined infantry in the field. His own army was a perfect pattern of good order. The morals of his soldiers were to him an object of equal attention with their courage and military discipline. Temperance was commanded as a duty by the Swedish laws of war; excesses of every kind were severely punished; and every regiment mustered, morning and evening, around its chaplain, to perform their devotions in the open air; the king himself being always present upon those occasions. He endured all the hardships and privations of war with the meanest of his army; and never spared his person in the hour of danger.

He not only extended his dominions, and raised the reputation of Sweden abroad, but also turned his attention to the constitution of his country, which he would probably have improved had he lived to return into his own kingdom. By his regulations, however, the succession to the crown, which had been previously limited to the male line, devolved upon his daughter Christina, who was only six years old at the period of her father's death. See Harte's *Life of Gustavus Adolphus;* Schiller's *History of the Thirty Years War;* and the *Gen. Biog. Dict.* (z)

GUSTAVUS I. and III. See Sweden.

GUTTA Serena. See Surgery.

GUTTEMBERG. See Printing.

GUZERAT, or Gujhat, a large province in Hindostan, situated principally between the 21st and 24th degrees of North Latitude, is about 320 miles in length, and 180 at its average breadth. Its southwest portion approaches the form of a peninsula, Guzerat. lying between the gulfs of Cutch and Cambay; but it stretches far inland towards the north-east, having the province of Cutch on the west, Malwah and Khandesh on the east, Aurungabad on the south, and Agimere or Ajimeer on the north. It was one of the 11 soubahs,* into which Akbar divided Hindostan; and is understood to have, at that time, extended southward as far as Damaun. It contained nine circars, namely, Guzerat proper, or Ahmedabad; Putten; Nadowt; Behrodeh, or Baroda; Behroatch, or Baroche; Chumpaneer; Kodehra; and Sorat. These were subdivided into 198 pergunnas, of which thirteen contained sea ports. The whole Soubah furnished 67,375 cavalry, and 8900 infantry; and, in the reign of Aurungzebe, the amount of its revenue was equivalent to £1,800,000 sterling.

History. Guzerat was subdued in 975 by the Afghans or Patans, a hardy race, from the mountainous regions between Persia and Hindostan, who established the extensive empire of Ghizni, and maintained their authority till the end of the thirteenth century, when the Moguls commenced their ravages. In the fifteenth century, it was governed as an independent kingdom, by a dynasty of Rajpoot princes, who had adopted the Mahommedan religion, and removed the seat of government from the ancient capital Nehrwallah to Ahmedabad. In 1572, it was reduced by the emperor Akbar; and was, at that period, in a flourishing state as a maritime and commercial country. In the beginning of the 18th century, after the death of Aurungzebe, many of the more distant provinces renounced their allegiance to the Mogul emperor; and the governor of Ahmedabad and Cambay following these examples, assumed the sovereignty of that part of Guzerat. About the middle of the 18th century, it was conquered by the Mahrattas under Ragonauth Row; and its nabob Mohman Khan, took refuge in Cambay, where he held a small territory subject to the payment of an annual tribute to the Mahrattas. The capital was taken from the Mahrattas by general Goddard in 1779; but for political reasons was ceded to Futty Singh, a Hindoo chieftain, and at the end of the war in 1783 was restored to the Mahratta government. The more civilized and cultivated districts are at present possessed by the East India Company, the Guicowar and the Peishwa. The territories of the Company comprehend a considerable extent of country on both sides of the Gulf of Cambay; and include the populous cities of Surat, Baroche, Cambay, and Gogo. The sea-coast, from the Gulf of Cambay to the river Indus, is occupied by different independent chiefs, who are generally addicted to piracy, and are kept only in awe by the naval superiority of the British. The northern, western, and even central quarters of the province, have been but recently explored, and are overrun, or rather occupied, by numerous tribes of armed banditti, who are thieves not so much by profession as by nation.

Aspect. The province of Guzerat, in its general aspect, is flat and unvaried. In many places, not the smallest stone is to be seen; and there is scarcely a rising ground in the whole district to the west of Powagur, the name of the mountain by which it is separated from the interior of Hindostan. It is more hilly towards the eastern frontier, and much covered with jungle. Much of the more level tracts is either an arid sandy country, or a saline swamp of a singular description, which, even when dried up, remains in a great measure sterile and unproductive. In those places, also, where the surface is apparently smooth to the eye, it is much intersected by ravines, of considerable extent and depth, which in the rainy season are filled with rapid torrents, and cannot be crossed without the assistance of rafts or boats. It is, nevertheless, especially in its western districts, full of the richest prospects, and is inferior to no part of Hindostan in beauty or fertility.

Mountains. The only mountain in the province is that of Powagur, a steep and rocky height, resembling the Table Land of the Cape of Good Hope, but apparently more lofty. On its summit is a strong hold, deemed impregnable, and supposed to be the Tiagura of Ptolemy.

Rivers. Guzerat is watered by several large rivers, of which the most considerable are the Myhi, which takes its rise near Amjerrah, the capital of Rajode, and, running in a south-west direction, falls into the bottom of the Gulf of Cambay; the Nerbudda, supposed to be the Narmada of the Greeks, which rises in the mountain of Pindara, near the north-east corner of Berar, and proceeding westwards about 640 miles, terminates its course on the east coast of the Gulf of Cambay; and the Taptee, which descends from the mountains of Burhanpour, and after a course of above 320 miles, nearly parallel to that of the Nerbudda, falls into the sea below Surat. These larger rivers are ordinarily extremely gentle and pellucid; but begin to swell some time before the rain falls in the low countries; and then become furiously rapid, frequently sweeping away whole villages, with the inhabitants and their cattle. In the rainy season, the mountain torrents swell the smallest streams in a wonderful manner, so as to make them rise in a few hours 20 or 30 feet above their usual level. In the dry season, nevertheless, a great scarcity of water is experienced in many places, especially in the sandy soil to the north of the Myhi river, where the periodical rains are speedily absorbed, and wells must be dug to the depth of 80 and 100 feet.

Climate. The rainy season sets in with the south-west monsoon before the middle of June, accompanied with tempestuous weather, and continues with more or less violence about four months. The greatest quantity of rain always falls in July; yet, in the province of Guzerat, there is not so much rain during the wet season as there is at Bombay, and the southern part of the Malabar coast. In December, January, and February, the mornings and evenings are cold and sharp, and sometimes ice has been seen at Surat in the month of January. At this period the thermometer is frequently under 60° at sun-rise, and seldom exceeds 70° at noon; and the weather throughout the whole day is temperate and agreeable. But, in the succeeding months, during the prevalence of the hot winds, though the morning may be tolerably cool, the thermometer gradually rises from 70° to 100°; and in the plains near Cambay, has been observed at 116° in the soldiers' tents. During the hot and dry months, the surface of the country is covered with sand or dust; and, in the rainy season, becomes a thick mire, and often a sheet of water.

Soil and productions. The soil is generally sandy or marshy; but, in the cultivated districts, is a reddish light earth, or a rich black mould, both of which are highly fertile and productive. Except for the richer crops, manure is seldom required; and the dung of the cow-house is then the

* Akbar divided Hindostan into eleven soubahs, or grand divisions; each of these into smaller provinces called circars; and each of these again into districts or pergunnas. A twelfth was afterwards added, formed of countries west of the Indus.

principal substance employed. In some of the pergunnas, particularly in Brodera and Jamboseer, the fields are inclosed, and the country enriched with plantations of mango, tamarind, and banian trees. The different kinds of grain are generally sown in June, and reaped in September. Wheat and barley are raised in many districts. Rice is a principal article of cultivation; and a great variety of Indian grains is every where produced. Of these may be mentioned the juarree, or cush-cosh, (*holcus sorchum* of Linnæus,) a fine, large plant, resembling maize or guinea corn, growing to the height of eight or ten feet, each stalk bearing several ears, the largest of which will frequently contain 2000 seeds; bahjeree, (*holcus spicatus* of Linnæus,) resembling the last, but inferior in size, and only used by the poorer classes; codra, chena, buntee, bowtah, growing to the height of two or three feet, and yielding grain of a nutritious quality; various pulses, especially tuar, (*cytisus cajan*) resembling split peas; mutt and gram, (*dolichos biflorus*) chiefly used for nourishing cattle. Cotton is a staple commodity; and that of the Ahmood pergunna is of so superior a quality, that it generally brings the highest price in the markets of Bengal and China. Sugar, tobacco, and indigo, flourish luxuriantly in the province; and might be cultivated with great profit. Hemp and flax grow well in the northern districts; but are often raised chiefly for the sake of the oil contained in the seed, and an intoxicating drug called Chang made from the leaves. Mustard seed is raised in considerable quantities, and is greatly esteemed in pickles. Occasionally may be seen, in gardens, large crops of poppies, (the seeds of which are very commonly mixed by the natives in cakes and confections,) ginger, turmeric, fenugreek, and betel leaf, extensive fields of capsicum or chilies, and large tracts of yellow cossumba, (*carthamus*,) which yield a valuable red dye. In those places where there is no cocoa nuts, various shrubs and plants are cultivated for producing oil, especially the sesamum, and ricinus, palma Christi. The water melons, especially those of Baroche, are superior to any in India. The white, red, and curling mulberry, flourishes in the gardens; and the cuttings require only to be put into the ground in the rainy season, where they take root, and grow up without farther trouble. The bamboo grows wild in most districts, is frequently planted in hedges around the villages, and in seasons of scarcity sometimes furnishes an article of food. Mango, tamarind, and banian trees are to be found in most parts of the province. One of the last mentioned, (the banian or *ficus Indicus*) the most magnificent tree of the kind in India, grows on an island in the river Nerbudda; and has nearly 1350 trunks, all traced to one parent stem, forming a canopy of verdant foliage, impenetrable even to a tropical sun, extending over a circuit of 2000 feet.

Animals. Many milch cows and buffaloes are reared in the villages; and ghee, or clarified butter, forms a principal article in the markets of Guzerat. Many horses also are bred in the province; and those of Cutch and Cottywar are held in great estimation. The oxen of Guzerat are accounted the finest in India. They are perfectly white, with black horns, a delicately soft skin, and eyes not inferior in lustre to those of the antelope. They will travel 10 or 12 miles a-day successively for a considerable time, under a load of 200 or 300 lbs.; and are fed upon straw, grass, cotton seed, or oil cake. Those which are reared in the northern districts are of superior size, strength, and docility; and some of them are capable of travelling in a hackery (or light cart) 30 or 40 miles a day. A more ordinary breed is employed in agriculture, and in the conveyance of merchandize; and others, of all different colours, as in other parts of Hindostan, are to be found in the province. The uncultivated and wood tracts abound in wild animals of various kinds. Lions, though not generally supposed to be found in the country, have been seen even in the vicinity of Cambay; and tigers are very common, sometimes so large as to weigh 250 lbs. Leopards, hyænas, wolves, foxes, jackals, and wild hogs, are the ordinary inhabitants of the swamps and jungles. Deer, elks, guanas, antelopes, hares, cameleons, porcupines, &c. are the most common kinds of game. Monkeys and squirrels are every where abundant, and remarkably tame. The former particularly often inhabit the towns, where they are generally protected, and in some places are revered as sacred animals. They are sometimes rendered instruments of a bloodless, but sufficiently malicious revenge among neighbours. A handful of rice, or other grain of which the monkeys are fond, is thrown upon the roof of the house of the obnoxious person, about the commencement of the wet season; and, in order to get at the grain which has slipped under the tiles, these mischievous animals soon uncover the whole habitation, at a time when labourers being generally occupied in repairing the houses, it may be impracticable for the hapless owner to have his home secured from the heavy torrents, which are beginning to fall. Of the birds of prey, the most common are hawks and brahminee kites, which last are so remarkably voracious, as sometimes to dart upon a dressed fowl, or other food, while the servants are carrying it from the kitchens, (which are frequently at a little distance from the house,) to the dining-table. There are bats of an extraordinary size, (nearly six feet between the tips of the extended wings,) called flying foxes, and extremely disagreeable in smell and aspect. Peacocks, doves, and green pigeons, assemble in flocks around the villages, and are almost as tame as poultry in a farm-yard. Partridges, snipes, woodcocks, wheatears, &c. are very abundant; and there is a great variety of water-fowl in the lakes and rivers, particularly storks, cranes, quails, flamingoes, pelicans, ducks. The sahras and cullum (*ardea virgo* of Linnæus) are very stately birds, generally six feet high, of an azure hue, with crimson coloured heads. But the florican, or curmoor, (*otis houbara* of Linnæus,) is at once the most elegant of Indian birds, and exceeds all other wild fowl in delicacy of flavour. It is distinguished by its lofty carriage, variegated plumage, and especially by a tuft of black feathers falling gracefully from its head. Lizards are abundant in Guzerat, and many of them are extremely beautiful. Serpents are found in great numbers and varieties; and some of the largest kinds, which are accounted harmless, and are held sacred by the natives as guardians of the spot which they frequent, are allowed to occupy the gardens. One of the most venomous is the cobra de capello, or coluber naja, which is very common in Guzerat. There are many varieties of water snakes, (some of them spotted with the most beautiful colours,) which seize upon the frogs, lizards, young ducks, and water rats, and are in their turn devoured by the larger water fowls. Locusts, though less destructive than those of Arabia and Africa, are frequent visitors in the province; and leave every vegetable substance over which they pass stripped and browned, as if scorched with fire. The large locust, called "the creeping leaf," and which has been described under the article GUIANA, is common in Guzerat.

Guzerat.

Towns and commerce.

The principal towns in the province are Ahmedabad, Surat, Cambay, Baroche, Baroda, Dhuboy, Gogo, and Chumpaneer. They are generally in a ruinous condition, presenting, in their decayed palaces, tottering minarets and mouldering aqueducts, many vestiges of their former splendour. Their commerce has never been so flourishing as it was under the Mogul government, even in the times of its most violent convulsions. The principal trade of the province is carried on with Bombay. The chief exports are cotton, piece-goods, and grain; and the imports consist mostly of sugar, raw-silk, pepper, cocoa nuts, cochineal, woollens, and bullion. Almost all castes in Guzerat, excepting the Brahmins and Banyans, occasionally follow the occupation of weaving; which, together with the labours of agriculture, employs the greatest number of the more industrious of the lower classes. Fortifications were formerly very numerous in the province; and are still preserved in the more remote quarters. The natives every where live in towns or villages for security against banditti, and wild beasts. A single farm house, or separate cottage, is rarely to be seen; and, at night, the cattle are always brought within the hamlet, which is commonly surrounded by a mud-wall or bamboo hedge. The larger towns are usually situated near an extensive lake, the banks of which are adorned with Hindoo temples and caravansaries, and its surface covered by the various kinds of lotus. The houses, especially in the villages, are rarely built of brick, and provided with tiled roofs, but chiefly constructed of mud, and thatched with straw or reeds.

Inhabitants.

As many parts of Guzerat have never been subdued by any invader, the natives there retain their original character unchanged; but, in the maritime districts, in consequence of the many sea ports and commercial advantages, which have attracted strangers of all descriptions, the province contains a greater variety of castes and religions, than any other in Hindostan. It is commonly believed among the natives, that the province was originally peopled by the rude castes which still exist, and which are known by the names of Cooles and Bheels; but neither record nor tradition remains respecting their religion or government in their primeval state. In the town of Rajpeepla, however, the Rajpoot successor is still formally invested with the nominal sovereignty by a family of Bheels descended from their original chieftains. When the Rajpoots acquired the ascendancy, the most powerful of their princes resided at Neherwallah, (or Putten,) on the northern frontiers; and three dynasties are said to have successively occupied the throne, from which many of the modern Gracia families pretend to trace their descent.

Gracias.

The Gracias are a numerous class of landholders in some parts of the province; and, in others, only possess a sort of feudal authority over certain villages and districts. They are described as consisting of four castes or families,—the Coolees, the Rajpoots, the Seid Mahommedans, and the Mole Islams or modern Mahommedans. The places principally occupied by the Gracias are Rajpeepla and Mandwee, the former south, and the latter north of the Nerbudda river; Meagam and Ahmode, between the Nerbudda and the Myhi; and Mandowee or the Taptee. Many tribes of them also reside in a kind of independent state on the rugged banks of most of the rivers, and in different parts of the peninsula. Criminals, who fly to their haunts for refuge, are readily incorporated among them; and all of them are habitual plunderers, forming one half of the population north of the Myhi. Of all the banditti who infest the province, the most cruel and untameable are the Coolees, who maintain amidst their fastnesses an armed independence, and plunder without distinction all who travel without an escort, or whom they are able to master. They are taught to despise all approaches to civilization; and are said to hold cleanlinesss in the utmost contempt, as a mark of cowardice. They are well mounted, and often roam in troops to a distance from their own settlements, to plunder villages or surprise travellers. Their own villages, at the same time, are large and populous, their fields inclosed, and their lands in general in a state of good cultivation.

Guzerat. Inhabitan Coolees.

Rajpoots.

The Rajpoots are of a high caste, and are well bred to the use of arms. They are athletic in their persons, faithful to their engagement, magnanimous and brave above most other natives of India, and make the most excellent soldiers They chiefly inhabit the districts north of the Nerbudda; and the great body of them occupy the province of Ajimeer, where they have never been subdued by the Mahommedans, and where they preserve in their strongholds and fastnesses the original manners of the Hindoo race. Their country is said to resemble greatly the more habitable mountainous tracts of Swisserland, and to afford some of the grandest and most picturesque scenery in India.

Bheels.

The Bheels are like the Coolee, savage robbers, but generally poorer; and inhabit chiefly the districts around Turcaseer. The high Moguls or Mahommedans, especially those who inhabit the towns along the coast, are a polite and respectable people. In all the larger towns are found a singular race, who are Mahommedans in religion, but Jews in features, manners, and dispositions. They are called Borahs, and form every where a distinct community.

Borahs.

They profess a total uncertainty of their own origin; but Boorhanpour, in Khandesh, is the rendezvous of the sect, and the residence of their moulah or high priest. They are noted for their address in bargaining, their minute parsimony, and constant attention to gain. They are the principal traders in the commercial cities, and are found straggling over the whole province, and the other western parts of Hindostan, as itinerant pedlars. In Guzerat is found, also, the greater part of the Gabres or Parsees, or worshippers of fire, who inhabit the continent of India, and who preserve the slender remains of the religion of the Magi: (See Gabres.) Of the proper Hindoos there are many castes and sects in Guzerat. The different families of Brahmins, settled in the province, amount to 84 in number, and are named after the places of their ancestors nativity or inheritance. Each of these has several subdivisions, and innumerable distinctions, which prevent the members of one from intermarrying with another.

Banyans.

The Banyans, or Vaneeya, are very numerous in Guzerat, and are also separated into many subdivisions. They are all merchants, and frequently travel to very distant countries, where they remain for several years, in the prosecution of traffic, and then return to their families with the gains of their adventure. Their language, the Guzeratee, which is nearly allied to the Hindee, is well known in all the great Indian markets, and forms the chief medium of mercantile intercourse in that continent. A singular custom among the Guzerat merchants may here be noticed, namely, that, when any of them finds himself failing in trade, he sets up a blazing light in his house or shop; absconds, till his creditors have examined into the state of his property; and wears the tail of his waist-cloth tucked up, till they have acquitted him of all suspicion of dishonesty. Persons, who take this step in time, so as not to injure their creditors much, Guzerat. Inhabitants. are held in great esteem, and are so frequently observed to be subsequently prosperous, that some have been known, in hopes of future good fortune, to set up the sign of bankruptcy without any necessity. The class of Bhauts, or Bharots, abound more in this province than in any other part of India. They are a very honourable tribe, and are principally occupied as historians, heralds, soothsayers, recorders of births and deaths, itinerant bards or minstrels, trading or begging on their way. In this last capacity, they repeat verses (which are either of their own composition, or selected from the Hindoo legends) with a pleasing modulation of voice, and gracefulness of action; and one of them is generally connected with the household of every Hindoo rajah or Mahratta chief, attending them on days of public ceremony, enumerating their titles, and proclaiming their praises. They also become guarantees of treaties between princes, securities for bonds between private persons, or cautioners for the payment of revenues from districts, and farmers of the taxes. They receive an annual stipend, or a per centage from the districts, villages, or individuals whom they thus guarantee; and, upon signing the agreement, add the figure of a dagger as their seal, and as an emblem of the fatal consequences attending a breach of contract. Should any party fail in the obligation, the Bhaut, who had offered himself as guarantee, proceeds to the house of the defaulters, and there destroys himself or one of his family, imprecating the vengeance of the gods upon the heads of those, who had compelled him by their misconduct to commit the deed of desperation. To be the object of these imprecations, is accounted by the Hindoos the most direful of all catastrophes; and hence the security of a Bhaut is the strongest and most sacred of all bonds. They are frequently also engaged in agriculture; but, as a privileged class, are exempted from all payment of taxes; and, when any attempts have been made to subject them to assessments, they do not fail to murder some of their tribe, with the usual imprecations on those who have infringed their rights.

Bhauts.

Charons. The Charons are nearly allied to the Bhauts in manners and customs; and, being generally possessed of large droves of carriage cattle, they carry on an inland traffic in grain to a considerable distance. They are frequently hired for the protection of travellers; and, when attacked by banditti, they take a solemn oath to die by their own hands, if any injury be done to the persons under their care. So great is the veneration in which they are held by the superstitious natives, that this threat of suicide is generally effectual in restraining the most ferocious plunderers. Ungreas. The Ungreas, whose profession is that of money-carriers, are of all casts, and generally athletic and well armed. Though extremely poor, they are remarkable for their honesty in conveying the largest sums. They conceal the money in their quilted clothes; and though rewarded for their services only with a small pittance, they will fight with the utmost desperation in defence of the property with which they are entrusted. Puggies. In the northern and western parts of the province, is a class named Puggies, whose business it is to trace the steps of a thief, and they are so expert in the office, that, if set upon the pursuit early in the morning, after the theft has been committed, before many people have been moving about the vicinity, they seldom fail to point out the village where the thief has taken refuge. Dheras. The Dheras of Guzerat are similar to the Pariars of Malabar, and are obliged to live apart from the other inhabitants. They live on all kinds of carrion, and are much addicted to pilfering and intoxication. They are compelled by ancient custom to serve the state and travellers as carriers of baggage; and also to act as scavengers for the removing of filth from the roads and villages. Koonbees. The Koonbees, which is the name given in Guzerat to the Hindoos of the pure Sudra, or fourth cast, form the great body of the agricultural peasantry; and are supposed to have emigrated originally from Ajimeer, or Hindostan Proper. They hold portions of government land; and are called Patells, in distinction from the Gracias. They are peaceable, industrious subjects under every change of rulers; and, as they seldom repair to the cities, their manners are altogether simple and inoffensive. They rarely leave the village where their fathers lived and died, but continue in the same place, to plough the fields, and reap the harvest, and tend the cattle, while their women are employed in spinning cotton, grinding corn, and preparing the usual repast of milk, pulse, and other vegetables. Too large a proportion of the produce of their lands is collected for the government and subordinate chiefs; but still a sufficiency generally remains for the supply of their wants, which are extremely few and simple. In the more remote districts particularly, their mode of living is remarkably primitive. A hut built of mud, and thatched with straw, is the ordinary habitation of the villager. A few earthen pots for cooking, a large jar of unburnt clay for holding grain, another of burnt clay, for holding water, and a glazed jug for holding oil, form the chief part of his furniture. A couple of yards of cotton cloth tied round the middle, and sometimes a turban on the head, composes the whole clothing of the men; and a long piece of similar cloth, put on in graceful folds, is the usual dress of the females.* They testify great hospitality to strangers, who are usually presented at the entrance of the villages with fruit, milk, butter, fire-wood, and earthen utensils; and sometimes compelled, at their departure, to take with them one day's provisions. They are a contented people, and their condition tolerably comfortable in seasons of peace; but they have no idea of liberty, and are subjected to every species of suffering in time of war. But wherever British influence extends, their comforts are increased, and their security better provided for. In the north-western quarters, many barbarous practices prevail among them; and among the Coolees and Rajpoots particularly, besides what may be called the prescribed cruelties of their religion, it is not uncommon for many persons of both sexes to cut off their noses, as a security against the malignant influence of witches. Female Infanticide. The unnatural practice of putting to death the female infants, which prevailed among the Jahrejahs, a race of Rajpoots in the peninsula of Guzerat, was abolished in 1808, by the humane exertions of Jonathan Duncan, Esq. late governor of Bombay, and of Colonel Walker, British resident in the province;† and within the districts acquired by the East India Company, many other degrading customs are gradually disappearing. The province of Guzerat, in short, presents among its different inhabitants instances of the extremes of civilization, exhibiting all the rudeness of the pastoral and al-

* It is a universal practice among all the Mahommedans of both sexes, and the Hindoo males throughout Guzerat, to smoke tobacco; except the Brahmins, who take snuff very freely.

† See Cormack's *Account of the Abolition of Female Infanticide in Guzerat.*

most of the savage state, along with the wealth and luxury of commercial cities. It affords equally striking specimens of the extremes of population, which is thinly scattered over the western districts, but unusually crowded in the vicinity of Surat, and some of the other cities. The whole number of inhabitants in this extensive province is estimated at six millions, in the proportion of one Mahommedan to ten Hindoos. See Rennel's *Memoir of a Map of Hindostan*; Milburn's *Oriental Commerce*; Hamilton's *East India Gazetteer*; and Forbes's *Oriental Memoirs*. (q)

GWALIOR, GUALIOR, or GUALIAR, is the name of a strong fortress of Hindostan, in the district of Gohud, and province of Agra. This fort stands on a hill about 1 $\frac{6}{10}$ mile long, 300 yards wide at its greatest breadth, and 342 feet high at its north end. The sides of this hill are nearly perpendicular, and a stone parapet is carried all the way round close to the brow of it. At the north end of the hill, and near the middle of the fort, are two remarkable pyramidal buildings of redstone, in the ancient Hindoo stile of architecture. The only gate to this fort is at the northern extremity of the east side, from which there is an ascent to the top of the rock by several flights of steps. The garrison is supplied with excellent water, from several natural cavities in the rock; and about half way up the rock, on the outside, there are many artificial excavations, containing the figures of men and animals carved out of the solid rock.

The town is situated on the east side of the hill. It is large and populous, and contains many good stone houses. The stone is obtained from the neighbouring hills, which surround the fort like an amphitheatre, at the distance of from one to four miles. They chiefly consist of schistus, with apparently a large portion of iron, and their surface is rugged, and nearly destitute of vegetation. The small river Soonrica rises to the eastward of the town, and beyond it is the tomb of Mahommed Ghous, a learned man; it is a handsome stone building, with a cupola covered with blue enamel. Within the inclosure of this monument is another tomb erected to the memory of Tan-Sein, a great musician. The leaves of the tree which overshadows this tomb, are supposed by the vulgar to give great melody to the voice when chewed. About 700 yards from the northern extremity of the fort, is a conical hill, having on its summit two high pillars joined by an arch, which is supposed to be of very ancient workmanship.

The town of Gwalior carries on a considerable trade in cloth with Chanderi, and also in indigo. About 14 miles from Gwalior, on the road to Narwar, is a mine of iron, near the village of Beerch, which is worked to advantage.

Gwalior was always considered by the natives as impregnable, till it was taken by escalade by Major Popham, on the 3d August 1780. In the time of the Mogul government, it was a state prison, where the obnoxious members of the family were secured, and a large collection of lions, tigers, and wild beasts was kept here for their amusement. It was appropriated to the same purpose by Madajee Sindia, who, on account of its security, also made it a grand depot for artillery and military stores.

When the Mogul empire was dismembered, this fort came into the possession of the Ranah of Gohud, from whom it was taken by the Mahrattas. After the British took it in 1780, it was given up to the Ranah. Sindia invested the fort, and after a siege of many months, he succeeded in taking it by corrupting part of the garrison. In 1804, it was ceded to the British; but, by the treaty of 1805, it came into the possession of Dowlet Row Sindia. Distance from Agra 80 miles; from Delhi 197; and from Calcutta 480. East Long. 78° 14′, and North Lat. 26° 18′. See Hamilton's *Gazetteer*.

GYMNASTIC EXERCISES. See ATHLETÆ, vol. iii. p. 45—48.

GYMNOSOPHIST is a word of Greek origin, and literally signifies a philosopher who goes naked. It is particularly applied to the sages of India, who are understood to have wandered from place to place, either wholly without clothing, or only partially covered. Hence the *sapientes Indiæ* are described by Quintus Curtius, under the designation of *genus horridum et agreste*.

Though the Gymnosophists are usually considered as belonging exclusively to India, they were not in ancient times confined to that part of the world. There were likewise African Gymnosophists. These last inhabited a mountain in Ethiopia, near the river Nile; and they appear to have lived in celibacy and solitude, subjecting themselves to various penances and privations, after the manner of hermits or monks in more modern times. They were understood to hold an immediate intercourse with the immortal gods. If any one had killed his neighbour by accident, he had recourse to those recluses for absolution, and received it, upon the performance of certain ceremonies which they required. They were skilful in the medical art, and Lucan ascribes to them several important discoveries in astronomy. Indeed, it may be inquired, whether there were not Gymnosophists (using that term in a more general sense) in every nation, the early history of which has come down to us in any thing like detail, or with any measure of certainty; and whether the Brahmins of India, the Priesthood in Egypt, the Persian Magi, and the Druids of Great Britain, were not all branches of the same philosophical school, holding certain doctrines in common, though distinguished from one another by the degree of improvement to which they had respectively attained, or the political and moral circumstances of the countries to which they belonged.

One principal tenet of the Gymnosophists appears to have been that of the metempsychosis, or transmigration of souls; whether we understand by this term the passage of the soul from one human body to another, or the transmission of the immortal spirit through the bodies of different animals, till having been defæcated and refined in its progress, it enters at length into the immediate and beatific presence of the Supreme Divinity. The doctrine of the metempsychosis was afterwards taught with greater celebrity by Pythagoras; and, as the philosopher just named is known to have travelled into India, there is reason to believe that he borrowed it from the Gymnosophists. In many features of their character, however, the *sapientes Indiæ* appear to have resembled the stoics. They undervalued and despised the goods of fortune, and lived chiefly in the woods and desert places, supporting themselves upon the spontaneous productions of the earth. Hence they are called, by Clement of Alexandria, *alobii*, or *hylobii*; and he relates of them, that they inhabit neither cities nor villages, but eat acorns, and drink water out of their hands. They abstained from marriage and the society of women. They held that every man was sufficient for himself, neither dependant upon others for the supply of his wants, nor requiring their assistance. They cherished a spirit of lofty independence. When

Gymnosophist || Gypsies.

Alexander the Great sent one of his captains to a body of the Gymnosophists, inviting them to a conference, they replied, that it was not their practice to visit any one, but that if the Macedonian king had any thing to communicate, they were ready to receive him. They maintained the lawfulness, and even the duty of suicide, and attached a degree of infamy to a lingering and anticipated dissolution. "Apud hos," says Quintus Curtius, "occupare fati diem, pulchrum; et vivos se cremari jubent. Quibus aut segnis ætas, aut incommoda valetudo est, expectatam mortem pro dedecore vitæ habent. Nec ullus corporibus, quæ senectus solvit, honos redditur. Inquinari putant ignem, nisi qui spirantes recipit." *De Reb. Gest. Alexand. Magn.* lib. viii. c. 9.

Apuleius *Florid.* lib. i. thus describes the Gymnosophists: "They are all devoted to the study of wisdom, both the elder masters and the younger pupils: and what to me appears the most amiable thing in their character, is, that they have an aversion to idleness and indolence; accordingly, as soon as the table is spread, before a bit of victuals be brought, the youth are called together from their several places and offices, and the masters examine them what good they have done since the sunrise. Here one relates something he has discovered by meditation; another has learnt something by demonstration; and as for those who have nothing to allege why they should dine, they are turned out to work fasting." (*h*)

GYMNOTUS Electricus. See Electricity, vol. viii. p. 477, 478, and Plate CCXLVI. Fig. 2.

GYNANDRIA. See Botany, vol. iv. p. 74, 77, 312.

GYPSIES. Towards the earlier part of the fifteenth century, the attention of various European nations was attracted towards a wandering tribe of people, entirely different in appearance and manners from the established inhabitants, and speaking a language peculiar to themselves. None could account for their origin; neither could the route by which they had been introduced be explained: they took up a temporary abode in places most congenial to their disposition, and were gradually dispersed throughout the continent, and among the principal islands. During their first introduction, and the periods immediately succeeding it, the strangers received various appellations, resulting either from corrupted dialects, or the opinions of those among whom they dwelt. But by common consent, conjoined with some imperfect traditions regarding their history, the name of Egyptians, or Gypsies, has been long bestowed upon them.

In so far as we are enabled to collect, these people have undergone no alteration with the lapse of centuries; they are a rude, illiterate, uncultivated race at this day; time and climate have been alike ineffectual in producing a change; they are the same in Siberia, in Turkey, in India, and in Europe: and if their vices have not increased, neither has there been any amelioration in their character. M. Olivier found a race of gypsies in Aleppo, and Lieutenant Pottinger saw tribes resembling them in Beloochistan. The gypsies are of a dark complexion, symmetrically formed, and rarely subject to deformity; they have beautiful white teeth, and the women fine black eyes, but the men are characterised by a scowling aspect. They are not remarkable for strength; they are swift of foot, but decidedly deficient in courage. The swarthiness of their colour is undoubted, and the earlier historians call them "black horrid looking men;" but the complexion of those who are kept cleaner than usual, is evidently lighter: besides, there can be little doubt that an alteration in this respect may be slowly effected by the temperature of the atmosphere, or in the course of successive generations.

Gypsies reputed to be cannibals.

The gypsies testify an indifference to the quality of their food, unknown among the least civilized tribes of Europe. Carrion is a dainty to them; a murrain among cattle, whereby they may obtain abundance of flesh from animals dying of disease, is a joyful and profitable event; and they are even disposed to eat it almost raw. They have been accused of cannibal appetites; and as the existence of cannibals in several parts of the world is beyond dispute, we are not entitled to deny the fact with respect to gypsies. In the year 1782, after having for a length of time disturbed the tranquillity of Hungary, where they are numerously disseminated, many were brought to trial, and convicted of various crimes, among which were robbery, murder, and feeding on human flesh. It is recorded, that they confessed having killed three people, and ate their bodies in great festivity, among other delicacies, at a wedding; that they preferred young persons from sixteen to eighteen years of age, and burnt their bones for fuel. The band to which these malefactors belonged, had subsisted 21 years, during which 84 individuals had perished by their barbarity. But the punishments inflicted on the criminals, were too shocking to admit of description. Thirteen were put to death at Frauenmark, in August; 15 at Kameza, in September; and at Esabrag 13 more, including 18 women who were beheaded. Many others were condemned, but respited, and 150 remained in chains. Yet whether these gypsies were actually guilty of such enormities, or whether they were the victims of persecution on slight grounds of suspicion, appears to us problematical. Amidst the numerous accusations of European cannibalism, few if any have been satisfactorily proved; and although the Asiatic gypsies are indirectly charged with the same depraved propensity, it is only on very slight evidence. Thus they have an immoderate desire for ardent spirits; and tobacco is so grateful, that they will be content to abstain from every thing else for a whole day, for a single leaf of it.

Habitations.

Gypsies have no settled abode, and never dwell in cities. They live in huts, or even in excavations of the earth, generally on the side of a hillock, that has a southern exposure. A roof is formed of rafters, overlaid with turf, and a woollen cloth is often drawn across the aperture left for a door. Some of the more miserable only shelter themselves in forests, or behind hedges in the warmer climates. A fire occupies the middle of the hut, around which the children lie naked; and indeed the whole tribe, although delighting in finery, go very scantily clothed. But if a single gaudy article can be obtained, the rest is disregarded; whence a man is sometimes seen on the continent in an old red silk coat, or a woman adorned with glaring ribbons, while their other apparel consists of rags. Linen is a scarce commodity among them, for the females can neither sew nor spin.

Professions.

None of the gypsies are agriculturists. Where they have, by unusual fortune, and by abandoning their nomadic life, become proprietors of spots of ground, the cultivation of it is left to others. Their own professions are gold washing in Hungary, at which they are very expert, farriery, rude occupations in smith work, and, in Britain, they are for the most part employed in the lowest branches of that art. Their tools and materials are alike indifferent. Nothing is done but on a small

Gypsies.

scale; and it is observed, that the artificer always sits down cross-legged to his work, which is considered as denoting the eastern origin of his race. They were formerly employed abroad in the execution of criminals, wherein they displayed a skill in the art of torturing their fellow-creatures, corresponding with their own innate pusillanimity. Many dealt in horses, but they practised such ingenious deceptions, and to so great an extent, that a royal ordinance prohibited this part of their profession. Their females form a considerable portion of the dancing girls of India. They combine music with their allurements; and most of them, both in that peninsula and Turkey, as likewise in Spain, subsist on the wages of prostitution. Every where the character of their dances is the same; and, in Spain, one of them called Maguindry is prohibited under severe penalties. The men and women sometimes bring forward dramatic exhibitions, for the performance of which they are called before the houses of the wealthy. The women, as is well known, pretend to skill in divination, and tell the fortunes of the credulous from palmistry, physiognomy, or moles on the skin; hence the origin of the beautiful engraving of *La Zingara*. So long ago as the year 1531, we find an English statute narrating, "that before this time many outlandish people, calling themselves Egyptians, using no craft nor feat of merchandize, have come into this realm, and gone from shire to shire, and place to place, in great companies, and used great, crafty, and subtile means to deceive the people, bearing them in hand, that they, by palmistry, could tell men and women's fortunes, and so, many times by craft and subtilty, have deceived the people of their money, and also have committed many heinous felonies and robberies, to the great hurt and deceit of the people they have come among." It is singular, that at Tobolsk in Siberia, their practice and professions are the same. "They watch every traveller," according to Commodore Billings, "and pretend to explain the mysteries of futurity, by palmistry or physiognomy. The peasant dreads their power, and, from motives of fear, contributes to their support, lest they should spoil his cattle or horses." Thus, in the western parts of Europe, and the eastern parts of Asia, at an interval of nearly three centuries, the gypsies are distinguished by corresponding features, scarcely modified by the people among whom they seek an asylum.

Religion.

This tribe is utterly unacquainted with science and literature. The scanty knowledge of their forefathers remains with them unimproved. A few of those in Spain, however, pretend to knowledge in medicine or surgery; and the females in the neighbourhood of Calcutta visit that and other towns, and prescribe for the complaints of their own sex. They have no settled principles of religion; they are Turks with Turks, and Christians with Christians. It does not appear that they celebrate any religious rites, or entertain the common sentiments of mankind in regard to a future life, or places of reward and punishment. The son of a more civilized Transylvanian gypsey having died at school, and being about to receive Christian burial, the officiating priest inquired, whether the survivors believed that the deceased would rise again at the last day? "Strange supposition!" they answered, "to conceive that a carcase, a lifeless corpse, should be reanimated, and rise again; it is no more likely to happen, in our opinion, than to the horse we flayed a few days ago." Their children, however, are circumcised in Turkey, and baptised in Europe.

Marriages.

Their marriages, which take place at a very early age, are void of ceremony, and rather resemble temporary connections than a union for life. One of their own number performs the part of priest, and thus gives it the sanction of publicity. The youth then forsakes his father, along with his bride, and if capable of mechanical exercises, he provides a pair of tongs, a stone for an anvil, a hammer and a file, to commence the profession of smith, after the fashion of his predecessors. In India a scene of riot and intoxication precedes the establishment of the parties, and certain mystical ceremonies attend the marriage. The men are extremely jealous of their wives, who are kept in strict subservience, and are in danger either of corporal punishment, or absolute dismissal, if they happen to displease them. Both sexes are extravagantly attached to their offspring; and, in some countries, it frequently happens that the readiest method of obtaining payment of the father's debts is by arresting his children. No education is given to the young, unless it be instruction in obscenity, and in the art of stealing dexterously. Infants of five or six months old are supplied with spirits in India, and their mothers, while indulging a fatal propensity to the same beverage, suckle them until they have seen as many years. In Europe these people are remarkably healthy, and escape those epidemical maladies which sweep away thousands around them; and even when they labour under dangerous diseases, they pertinaciously refuse medical assistance. They make loud lamentations at funerals, and carry the body of the leader of their horde with great respect to the grave.

Language.

The language of the gypsies, though it has necessarily undergone many changes from their successive migrations, and the corruptions unavoidable from living among others, is peculiar to themselves in Europe; but it contains many affinities with a dialect of particular casts in Hindostan. This fact receives the stronger corroboration, from having been first recognized by some young men, natives of the coast of Malabar, who were prosecuting their studies at Leyden. Numerous expressions were compared by them, and the same has since been carried to a greater extent, by literary men residing in India. Etymologies are in general to be distrusted, for they frequently lead to the most ludicrous and absurd mistakes; but we cannot deny, on the other hand, that the affinities of languages spoken by nations separated far asunder, may be found so strong and decided, that we shall find it difficult to deny them a common origin. On this subject Grellman remarks, "with respect to the construction and inflexion of the two languages, they are evidently the same, that of Hindostan has only two genders—the gypsey the same. In the former, every word ending in *j* is feminine, all the rest are masculine; in the latter it is the same. That makes the inflexions entirely by the article, and adds it to the end of the word; the gypsey language proceeds exactly in the same manner. Finally, likewise, excepting a few trifling variations, this identical similarity is evident in the pronouns." Many other instances of mutual correspondence may be produced, almost all tending to a similar purport, as may be seen at large in the writings of those authors who discuss this subject.

The gypsies of Europe acknowledge a chief or leader, who usually assumes the dignified title of wayvode or prince, duke, count, or lord, according to the countries frequented by them. The most exalted of these titles is given to one who presides over the gold washers in Hungary, and the dignity is elective, but with some regard to descent from a former wayvode, and also to the stature and apparel of the individual chosen, who is commonly about the middle age. He is merely lifted up three times with the loudest acclamations, amidst a numerous concourse of the tribe; his wife is treated with similar ceremony, while the dignity of both is recognized by all present. The titles assumed by these people are of ancient date: they appear in the fifteenth century; and in the commencement of the sixteenth, King James IV. of Scotland grants a pass and recommendation to the king of Denmark, in favour of the tribe of Anthony Gawino, an Earl from Little Egypt. He specifies that this miserable train had visited Scotland by command of the Pope, and having conducted themselves properly, they wished to go to Denmark: He therefore solicited the extension of his royal uncle's munificence towards them; adding, at the same time, that these wandering Egyptians must be better known to him, because the kingdom of Denmark was nearer to Egypt! In Hindostan, the gypsies have a chief who has very little direct authority over them, but he controuls the establishment of sets who profess dramatic exhibitions, and draw a tribute from their profits. They even acknowledge a rude judicial procedure before a court of five persons, or a general assembly, and any individual, for petty offences, has to pass the ordeal of applying a hot iron to his tongue. If conviction follows, the culprit is generally sentenced to pay a fine in liquor, of which his judges participate; or, as a mark of the highest ignominy, he may be condemned to have his nose rubbed on the ground.

...aved ...cter of ...ypsies.

Almost in every country throughout the globe, the gypsies have long been the objects of reproach and detestation. From their first appearance, they have been wandering outcasts, and universally refused a settlement in towns, or in their immediate neighbourhood. The dislike manifested towards them, though attended with less barbarous consequences, may be assimilated to the detestation which has accompanied the Jews, since the destruction of Jerusalem. Those atrocious cruelties, however, that stain the annals of nations, cannot with confidence be charged on this nomadic tribe. If their crimes are numerous, they are of a petty description, directed against the property more than the persons of their fellow creatures. The gypsies have no where manifested virtuous principles, or any desire to excel; the depravity of the parents passes to the children, who inherit, along with it, the detestation of the people among whom they seek an abode. In foreign states, many attempts have been made to reclaim them, but there, as well as in our own island, they have been for the most part indiscriminately condemned to exile. Neither has the politic and patriotic views of the governments thus directed, been attended with the success which they merited.

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In the year 1782, the Empress Maria Theresa promulgated an edict, prohibiting gypsies from dwelling in tents, and enjoining them to settle in fixed abodes. They were forbidden to wander about, to allow their childen to go naked, to deal in horses, and to wear cloaks whereby thefts might be easily concealed. They were also commanded to abstain from feeding on carrion, to frequent the churches, and to conform to the manners of the inhabitants of the territory where they resided. Their usual name was to be abolished, and in future they were, instead of gypsies, to be called *new boors*, and occupy themselves in the active prosecution of agriculture. These regulations, wisely conceived, being ineffectual, severer enactments followed. It was decreed, that no gypsey should be permitted to marry, unless he could shew himself in a situation to maintain a wife and family; and that those who had children should be forcibly deprived of them, in order that the rising generation should have the benefit of a better mode of education. The latter part of this ordinance was carried into effect, and in certain districts, all the children above five years of age were conveyed away in waggons from their parents. But it is not evident that such compulsory measures were beneficial; and the failure of others in the eastern extremities of Russia, nearly at the same period, though more gentle, prove that it will be extremely difficult to reclaim the gypsies to habits of industry. Experience daily proves, that mankind, who have roamed at liberty, are averse to a settled residence, and that the controul of those living in society is an arduous undertaking, while their management is easily accomplished should they be only in an isolated state. With the diminution of their own hordes, a gradual incorporation will take place with those around them, and probably is insensibly doing so at this moment where they are least numerous. No accurate computation can be formed of the extent of the united tribes of gypsies dispersed throughout the world; for they are unequally distributed, and only partially known. Grellman conjectures, that those in Europe may amount to 700,000 or 800,000; of whom Twiss conceives 40,000 to belong to Spain: there are many in the Turkish empire, but few in the island of Britain, particularly north of the Tweed.

Number of the gypsies.

History.

The history of the gypsies is an enquiry not less obscure than difficult; and it must be allowed, that even yet we have no conclusive authorities relative to its earliest period. Analogies certainly prove the eastern parentage of their tribes; but why they left their native soil, or how they penetrated into Europe and its more distant islands, we are unable to discover. It is commonly believed, that they migrated from Egypt; an opinion which has probably received greater corroboration from their name than from other circumstances. But neither their size, complexion, manners, or appearance, correspond with those of any Egyptians described in ancient or modern history; hence, if we are to draw any argument from their name, we must say it arises from Egypt, being the last point of their departure from the East. Those observers who have most profoundly studied their history, find a striking resemblance between the gypsies and the natives of Hindostan: Should this hypothesis be correct, they may have reached the isthmus of Suez by the north of India, and crossed it into Egypt; a progress by no means impracticable, but which does not satisfactorily account for their immediate access to Europe. The time of their first appearance in this quarter of the globe is unknown; but towards the beginning and middle of the fifteenth century, they attracted general attention as a strange people. They are recorded to have frequented Germany in the year 1417; Switzerland in 1418; and they are spoken of as being in Italy in 1422. It is said that they were originally known in France by the name of Bohemians; and arrived at Paris on the 17th of August 1427. They travelled in hordes, generally of 70 or 100 persons, probably finding it expedient not to accumulate too much; and each horde had a leader, who assumed a title which, however, has more the character of the West than the East. Rapidly spreading over Europe, they were at first believed to be pilgrims, chiefly from the Holy Land; and, hence they both received protection and indulgence, and were treated with marks

Gypsies.

of veneration wherever they went; but their real disposition speedily betrayed itself; they proved a lawless gang of depredators, deceiving the credulous, plundering their benefactors, and rendering themselves obnoxious to all civilized nations. Every arm was lifted against them; they were driven from place to place; and at length the very name of being a gypsey, was esteemed a crime deserving capital punishment. It is not unlikely, that the severity of the enactments directed against them, had the effect of dividing and spreading their hordes still farther, to avoid the penalties of a permanent residence. But the barbarous and unsettled condition of the different European states, was a powerful obstacle to the establishment of a vigorous police; and it is only in recent times, that the kingdoms, in which we dwell at peace, have been freed from vagabonds and beggars, who, invading the cottages of the peasantry, demanded alms in a manner that their inhabitants durst not refuse.

British statutes regarding them.

Gypsies are always included in the statutes respecting vagabonds; and in the year 1531, they were commanded at once to depart from England within sixteen days. The laws of Scotland exhibit repeated instances of the light in which they were subsequently viewed; for an ordinance of the Privy Council of 1603, converted to a perpetual act in 1609, decreed, that the whole race should quit the kingdom under pain of death. Nevertheless they found means to evade compliance; they continued roving about the country; and, as is well known, one of them having seduced the affections of a Countess of Cassilis from her husband, persuaded her to elope with him. In the criminal records, several of the same name as this adventurer appear to have been brought to trial for petty offences, and for being found in Scotland. Four gypsies named Faa, were condemned to be hanged in 1613, though they seem to have had permission to remain. Two more of this name were tried in 1616; and in 1624, Captain John Faa, and five other men of his name, were sentenced to death. Their execution was followed by the condemnation of Helen Faa, widow of Captain John, Lucretia Faa, and nine females more, all to be drowned for being reputed Egyptians, for remaining in the kingdom, and having committed petty thefts. But this barbarous sentence was commuted to perpetual banishment. The terror of these trials quieted Scotland for nearly a century; and, excepting a few itinerant gypsies, universally denominated tinkers, none are now to be seen. They are also gradually disappearing from England, where they seem inclined to be turbulent; and some years ago, we believe, that, on the apprehension or punishment of one of their gang, they threatened to set fire to the town of Norwich. In a country so industrious as Britain, the residence of men who live in a state of idleness cannot be permanent: and they will either depart, or their habits will be assimilated to those around them, while they themselves are slowly absorbed in the great mass of the people.

See Peysonnel *Observations sur les peuples barbares qui ont habité les bords du Danube;* Thomasius *De Cingaris;* Muratori *Rerum Italicarum Scriptores,* tom. xviii.; Swinburne's *Travels in Spain;* Twiss's *Travels in Spain;* *Asiatic Researches,* vol. vii.; Grellmann's *Dissertation on the Gypsies;* Laborde's *View of Spain;* Olivier *Voyages,* tom. ii.; and Pottinger's *Travels.* See also *Free* Masonry. (*c*)

GYPSUM. See Mineralogy.

GYRATION, Centre of. See Mechanics.

H.

Habeas Corpus.

HABEAS CORPUS, is a writ in the English law, of which there are various kinds, for removing prisoners from one court into another, for the more easy administration of justice. Such are the *habeas corpus ad respondendum, satisfaciendum, prosequendum, testificandum, deliberandum*, &c. when a prisoner is removed from an inferior court to be charged with a new action in the courts above; or when he is to be charged with process of execution; or when it is necessary to remove a prisoner in order to prosecute or bear testimony in any court, or to be tried in the jurisdiction wherein the fact of which he is accused was committed. There is also the common writ *ad faciendum et recipiendum*, otherwise called an *habeas corpus cum causa*, which issues out of the courts of Westminster Hall, commanding the inferior judge to produce the body of the defendant in a process, together with the day and cause of his caption and detainer, to *do and receive* whatsoever the king's court shall consider in that behalf.

But the most important writ of this kind, and the most efficacious for vindicating the personal liberty of the subject in all cases of illegal confinement, is that of *habeas corpus ad subjiciendum*. This is a high prerogative writ, and therefore, by the common law, issuing out of the court of King's Bench, not only in term time, but also during the vacation, by a *fiat* from the chief justice, or any other of the judges, and running into all parts of the king's dominions. Like all other prerogative writs, it must be applied for by motion, and does not issue of mere course, without shewing some probable cause why the extraordinary power of the crown is called in to the assistance of the party. And this is the more reasonable, because, when once granted, the person to whom it is directed can return no satisfactory excuse for not bringing up the body of the prisoner. This also, it will be observed, induces an absolute necessity of expressing, upon every commitment, the reason for which it is made; in order that the court, upon an *habeas corpus*, may examine into its validity, and act according to the circumstances of the case.

The law of England has always been extremely careful in asserting and preserving the personal liberty of individuals, which ought never to be abridged at the mere discretion of the magistrate, without the explicit permission of the laws. The great charter provides, that no freeman shall be taken or imprisoned, but by the lawful judgment of his equals, or by the law of the land; and many subsequent old statutes expressly direct, that no man shall be taken or imprisoned by suggestion or petition to the king, or his counsel, unless it be by legal indictment, or the process of the common law. The writ of *habeas corpus* affords an ample and effectual remedy in all cases of illegal confinement; yet this remedy was in danger of being rendered nugatory during the early part of the reign of Charles I. the court of King's Bench having determined, that they could not upon an *habeas corpus* either bail or deliver a prisoner, though committed without any cause assigned, in case he was committed by the special command of the king, or by the lords of the privy council. This illegal judgment drew on a parliamentary enquiry, and produced the petition of right, 3 Car. I. which enacted, that no freeman shall be imprisoned or detained without cause shewn, to which he may make answer according to law. The evasions of this enactment, however, which were attempted in the following years, particularly in the case of Mr Selden, gave rise to the statute 16 Car. I. c. 10. § 8 whereby it was provided, that if any person be restrained of his liberty by order or decree of any illegal court, or by command of the king's majesty in person, or by warrant of the council board, or of any of the privy counsel; he shall, upon demand of his counsel, have a writ of *habeas corpus*, to bring his body before the court of King's Bench or Common Pleas, who shall determine whether the cause of his commitment be just, and thereupon do as to justice shall appertain. But other abuses now crept into daily practice, which in some measure defeated the benefit of this great constitutional remedy; and in the case of Jenks, who in 1676 was committed by the king in council for a turbulent speech at Guildhall, new shifts and devices were made use of to prevent his enlargement by law. These abuses gave birth to the famous *habeas corpus act*, 31 Car. II. c. 2. which has frequently been considered as another *magna charta* of the kingdom; and by which the methods of obtaining this writ are so plainly pointed out and enforced, that, so long as this statute remains unimpeached, no subject of England can be long detained in prison, except in those cases in which the law requires and justifies such detainer.

Sometimes, when the state is in real danger, a temporary suspension of the *habeas corpus* act is thought necessary; but, fortunately, it is not left to the executive power to determine when the danger of the state is so great as to render this measure expedient. For the Parliament only, or legislative power, whenever it sees proper, can authorise the crown, by suspending the *habeas corpus* act for a short and limited time, to imprison suspected persons without giving any reason for so doing. This, however, is an experiment which ought never to be resorted to, except in cases of extreme emergency. See Blackstone's *Comment.* B. III. ch. 8, and Jacob's *Law Dict.* by Tomlins, in which the reader will also find the substance of the provisions contained in the *habeas corpus* act. (z)

HABIT. See Moral Philosophy, and Association of Ideas, vol. ii. p. 570, col. 1.

HACKNEY. See Middlesex.

Haddington.

HADDINGTON is a royal burgh of Scotland, and the county town of East Lothian or Haddingtonshire. It is situated on the small river Tyne, and consists of four streets which cross each other nearly at right angles. One of these has two branches, viz. the Fore and the Back Street, the first of which crosses the place of intersection. The streets are in general spacious and clean. The houses, particularly those in the Fore Street, are neat and well built; and in the suburbs are some elegant little villas. At the end of the Fore Street, at its junction with the Back Street, is a neat town house, erected from the designs of the late Mr Adam. The old abbey, which contains the parish church, is one of the principal ornaments of the town. This venerable pile was formerly the church of the Franciscan monastery, and was erected during the reign of Alexander II. In February 1355–6, the town and monastery, along with the church of the Minorites, were burned by Edward III. The parish church, which has lately been much improved and embellished, occupies the west end, and the rest of the building is in ruins. In the aisle, which forms the burying-place of the Maitland family, is a marble statue of the Duke of Lauderdale lying on a bed of state, and also the monument erected to John Maitland, Baron of Thirlstane, Lord High Chancellor of England, which contains an inscription from the pen of James VI. The Episcopalian chapel, built by private subscription, is neat and commodious. About a ¼ mile to the east of the town, near the suburb called Nungate, are the ruins of a nunnery, founded in 1178 by Adda, widow of Prince Henry, and mother of Malcolm IV. The bridge over the Tyne, which connects this suburb with the town, is built of stone, and consists of three arches. Several remains of the ancient fortifications of the town are still visible. Haddington had formerly a house of dominicans or black friars, who were introduced into Scotland in the reign of Alexander II.

Haddington sends a member to parliament along with Jedburgh, Dunbar, Lauder, and North Berwick. It is governed by a provost, three bailies, a dean of guild, a treasurer and 12 councillors, and has seven incoporated trades. The principal manufacture carried on in Haddington was one of coarse woollen cloth; but it has some time ago been abandoned. The manufacture of starch was attempted by Mr Wilkie, jun. of Gilchriston, a public spirited individual, but it did not succeed. A new flour mill, driven by steam, has been built in the Nungate; and an extensive distillery is at present erecting on the bleachfield by Mr Dunlop, one of the partners of the distillery at East Linton. The town has also suffered considerable injury, from the removal of the extensive barracks in its immediate vicinity. The country around Haddington is extremely rich and beautiful, and is ornamented with many gentlemen's seats, the principal of which are Amisfield, one of the seats of the Earl of Wemyss; Clerkington, the seat of Mr Hepburn; Leadington, the seat of Lord Blantyre; Coulston, the seat of Lord Dalhousie; Alderston, the seat of Mr Stewart; and Letham, the seat of Mr Buchan Hepburn.

The following is the population of the burgh and parish in 1811.

Number of inhabited houses	671
Do. of families	1041
Do. employed in agriculture	379
Do. in trade and manufactures	389
Males	2002
Females	2368
Total population	4370

See *Statistical Account of Scotland*; *Transactions of the Antiquarian Society of Scotland*, vol. i.; and Chalmers' *Caledonia*, vol. ii. p. 412.

HADDINGTONSHIRE. See Lothian, *East*.

HADLEIGH, or Hadley, is a market-town of England, in the county of Suffolk, situated on the river Breton. Its principal ornament is its church, which is a handsome structure with a spire steeple, situated in the middle of the town. The altar piece of the church is very handsome. Guthrum or Gormo, the Danish chieftain, who was defeated by Alfred, embraced Christainity, and reigned over the East Angles for 12 years, was interred here in 889. The tomb, however, which is shewn as his, is supposed by Mr Gough to be of much later date. Twelve alms-houses for 24 aged persons were founded here in 1497 by William Pykenham, dean of Stoke College, who was rector of Hadleigh. This town formerly carried on a great trade in cloth; but its principal business is now that of spinning yarn for the weavers of Norwich. In 1811, the town and parish contained 509 inhabited houses, 529 families, and a population of 2592. See *Beauties of England and Wales*, vol. xiv. p. 211.

HADRAMAUT. See Arabia, vol. ii. p. 275, &c.

HADSJAR. See Arabia, vol. ii. p. 275, &c.

HAERLEM, or Haarlem, a town in the United Provinces, 12 miles west of Amsterdam, and 15½ north of Leyden, is a place of considerable antiquity, and has experienced many vicissitudes in its history. In 1249, the citizens having signalized themselves in the crusades, were rewarded with great privileges by William, king of the Romans, and Comte of Holland. At different times, especially in 1347 and 1351, it was almost entirely consumed by fire. In 1492, it was seized and pillaged by the faction of the Caes-en-brool, but was recovered by Albert, duke of Saxony, who punished the insurgents, and deprived the inhabitants of their privileges. At the request of Philip II. of Spain, it was erected into a bishop's see by Pope Paul V.; but, in 1571, the citizens embraced the Protestant faith, and submitted to the Prince of Orange. It was besieged in 1572 by Frederick of Toledo, son of the Duke of Alva, and for the space of eight months made a most desperate resistance. Even the women of the place formed themselves into regular battalions, and shared in all the duties of the garrison. At length, worn out by famine and fatigue, they agreed to surrender, upon condition that the lives of the garrison and of the citizens should be spared; but the articles of capitulation were perfidiously violated, and two thousand of the soldiers and inhabitants were massacred in cold blood. In 1577, it was finally united with the States.

Haerlem is a large and handsome town, well built, and well paved. Its streets are broad and regular; and, like the other towns of Holland, it abounds in canals, bridges, and trees. The buildings most worthy of notice are the palace, the public library, and the church. The last is a very large structure, crowded, as is common in that, country, with square wooden monuments, without any name, but having the arms of the deceased painted on a black ground, and the date of the death in gold letters. Its principal ornament is the organ, which is accounted the finest in the world, and which occupies the whole west end of the nave. It is supported by eight marble columns, between two of which in the centre is a noble emblematical alto-relievo, with figures as large as life. It was built in 1738, and has 8000 pipes, the largest of which is 32 feet in length, and 16 inches in diameter. There are 60 stops or voices, four separations, two shakes, two couplings, and twelve bellows. There is a pipe, which imitates the sound of the human voice, but it generally disappoints the expectations of strangers. The power and variety of tone possessed by this instrument, is said to be truly astonishing. Some of its notes are so delicate as scarcely to exceed the warblings of a small singing bird; and others so loud, as to shake the massy pile in which it stands. "When the whole strength of the organ is exerted," says Mr Fell, "never did I hear, or could conceive, sounds more godlike. The swelling majesty of each gigantic note seems of more than mortal birth, and the slightest sounds enchant the ear. Solemnity, grandeur, delicacy, and harmony, are the characteristics of this noble instrument." It is played on two days of the week, for an hour each time; and the church is, on these occasions, the resort of the first company of the place. Haerlem is still more justly celebrated as the birth-place of Laurence Costar, who is said to have invented the art of printing, and the site of whose house is still pointed out to strangers by an inscription. He is said to have made the discovery by cutting the initial letters of his name upon a piece of bark, and using it as a seal; and speci-

Hague. mens of the infancy of the art are preserved in the town-house. An academy of sciences was founded in 1752; and there is an elegant museum of natural history formed by Dr Van Marum, superior to any other cabinet in Holland. The articles are in an excellent state of preservation, and arranged with scientific taste. The insects of the *Papilio* tribe are said to be particularly numerous, and many of them of the rarest description. There is an institution founded by Peter Teyler Vander Hulst, a rich merchant of Haerlem, who bequeathed the whole of his fortune for the improvement of knowledge, and the relief of the poor. Its annual revenues are said to have amounted, before the revolution, to the sum of 100,000 florins; but, instead of being applied to objects of science, they were allowed to accumulate, and are suspected to have been secretly appropriated, during the ascendancy of the French republic, to the urgent necessities of the state. The Stadhouse is a magnificent building at one end of the market-place, and contains a number of valuable paintings, among which is the first piece in oil, by Eyert, in 1437, which was sold during the siege in 1572 for a few stivers, and is now valued at £2000. Haerlem is not a place of much trade; but is celebrated for its flourishing manufactures of velvets, damasks, fine linens, dimities, satins, worsted stuffs, ribbons, &c. which employ a number of workmen, and supply a profitable branch of traffic with Germany and Brabant. Its bleacheries, also, are famous for the delicate whiteness which they give to linen cloths, which has been attributed to a peculiar quality in the waters of the lake of Haerlem, incapable of imitation by any chemical process hitherto discovered. Great quantities of beer are exported to Friesland, &c.; and a gainful trade is carried on in flowers, one of which, a hyacinth, seen by M. Dutens in 1771, was valued by its owner at 10,000 florins. In the neighbourhood of the town are several handsome villas, and a wood of considerable extent full of delightful walks. About three miles distant is an extensive lake, called Haerlem Meer; sometimes, also, the Sea of Leyden, generally ten feet in depth, and containing a surface of fifteen square leagues. The population of Haerlem is 30,000. East Long. 4° 38′ 19″, North Lat. 52° 22′ 56″. See Trotter's *Memoirs of Fox;* Fell's *Tour in Holland;* Carr's *Tour in Holland;* and Owen's *Travels,* vol. i. (*q*)

HAGUE, a town in Holland, and the seat of the Dutch government, 10 miles south-south-west of Leyden, 14 south-west of Amsterdam, and about 3 from the coast. It is generally termed by geographers a village, because it has no municipal rights, and is not surrounded with walls; but it contains at least 38,000 inhabitants, and is one of the most elegant cities in Europe. It formed originally a part of the domains of the Counts of Holland, under the name of Graven Haag, Counts Hedge, which may perhaps account for its humble appellation of village. William II. Comte of Holland, removed his court from Gravesande to this place in 1250; from which time it has always been the seat of government, and in a political sense the metropolis of the United States. It stands in a drier soil, and a more elevated situation, than most other towns in Holland; and its atmosphere is therefore accounted more pure and healthful. The environs are delightful; and the approach to it extremely beautiful. The road, shaded on both sides by lofty rows of trees, is sufficiently broad to admit four or five carriages abreast, and so level, that not the smallest inequality of surface is to be perceived. On one side flows the canal covered with boats, and ornamented by numerous handsome villas on its banks; and directly in view of the traveller, appear the lofty edifices of the Hague, with the beautiful forest scenery on the right of the town. The streets are generally spacious, and the meanest of them extremely clean. They are decorated with trees, canals, and tasteful bridges. They are paved with a kind of light-coloured bricks, which have a gay appearance, and which are so closely joined together, that no interstices can be perceived to harbour any species of dirt. The Voorhout, which is accounted the principal street, is about half a mile in length, with a mall in the middle, and contains a number of elegant buildings, in the purest style of architecture. But the Vyverburg is the most beautiful part of the city, and forms an oblong square, with a line of magnificent buildings on one side, and a large bason of water on the other. The palace of the Stadholder consists chiefly of old buildings erected at different periods, without any regularity of design, and is surrounded by a canal, with draw-bridges. The French church is noted as being the burying-place of several Counts of Holland; and, in its vicinity, is a fine garden in imitation of that of Vauxhall. To the east and south of the town are many beautiful meadows and handsome country seats; and the trees are so disposed as to give the country the appearance of being better provided with wood than it is in reality. On the west side, leading to the fishing village of Scheveling, is a beautiful avenue nearly two miles in length, and 20 paces in breadth. It runs in a perfectly straight line, and is shaded on each side by oaks, beeches, and limes of an astonishing size, so closely and skilfully planted, as to have the appearance of an impervious forest. The utmost care is taken to preserve this magnificent grove from injury; and cautions are fixed up at short distances, denouncing the severest penalties against offenders. On the north side, about a mile from the town, is a noble wood, about two English miles in length, and nearly one in breadth, and full of the finest walks and most pleasing views. The palace called Maison de Bois, a house of retirement for the Stadholder, has nothing remarkable in its appearance or situation, but resembles the residence of a plain country gentleman. During the time of the Batavian republic, it was converted into a receptacle for the national cabinet of paintings; and, to the disgrace of the government, one suite of its apartments was occupied by the keeper of a tavern and brothel. The gardens belonging to this palace are kept with great care as a public promenade; but they are laid out in the worst taste. Every thing is unnatural and artificial, stagnant canals, puerile bridges, flower-beds of every conceivable form, and trees cut into the most fantastic shapes. One of the principal curiosities at the Hague was the prince's cabinet of natural history, and museum of rare productions, which contained an excellent selection of shells, insects, and birds, besides a great variety of toys from the East Indies. It had been removed to Paris; but is now probably restored along with the other pillaged property of the nation. The only species of trade of any consequence carried on at the Hague, consisted in the publication of continental productions, particularly of French books; but this literary traffic was completely extinguished by the revolution; and from the absence of the court, the city was falling rapidly into decay. By the recent restoration of the old government, its empty palaces have been re-occupied; and its former affluence and splendour may be expected to return. East Long. 4° 18′ 47″, North Lat. 52° 4′ 50″. See Trotter's *Memoirs of Fox*; Fell's *Tour in Holland*; Owen's *Travels*, vol. i.; and Sir J. Carr's *Travels in Holland*. (*q*)

HAIL. See Meteorology.

HAINAN, Island of. See China, vol. vi. p. 210.

HAINAU. See Hanau.

HAIR. See Anatomy, vol. i. p. 342, and vol. ii. p. 24; and Gordon's *System of Human Anatomy*, vol. i. See also Plica Polonica.

HALBERSTADT, is an ancient town of Prussia, and capital of the principality of the same name. It is situated in the circle of Lower Saxony, on the small river Holtzemme. The principal public edifices and curiosities are the cathedral, from the summit of which there is a fine view of the town, the court of St Peter's, the church of Notre Dame, and its organ. The palace now forms the town-house and excise-offices. There is here a literary society, which has published several journals of merit; and there are excellent libraries belonging to the cathedral, to the church of Sta Maria, the church of St Martin, and that of the Franciscans. The cathedral library contains a manuscript of Priscian upon parchment, and several annotations in the handwriting of Luther. The Temple of the Muses, belonging to M. Gleim, one of the celebrated German poets, is worthy of being visited. The principal manufactures of this town are those of woollen and linen goods, gloves and pipes, paper and wax. There is here also a work in which cobalt is prepared. The mountains of Spiegelberge, about half a league from this town, are deserving the notice of travellers. They have been laid out in the English style of landscape-gardening, by the late Baron Spiegel. The village of Stropke, about 1½ leagues from Halberstadt, is celebrated for the skill with which its peasantry play at chess. Halberstadt was burned in 1179 by Henry the Lion, and a remarkable diet was held there by Lotharius II. in 1134. In 1203, it was surrounded by walls and ditches. By the treaty of Tilsit it was annexed to the kingdom of Westphalia; but we believe that it has now reverted to the Prussian monarchy. Breyhahn, the supposed inventor of beer, was born in this town; and his house, containing an inscription in honour of him, is still shewn. The population, which now amounts to 11,700, is composed equally of Catholics and Calvinists. East Longitude 11° 3′ 33″, North Latitude 51° 53′ 55″.

HALES, Stephen. See Botany, p. 34.

HALF-Note, *Elementary*, in music, according to several writers, has the ratio $\frac{15}{16}$, $=57\Sigma+f+5m$, and is the Semitone-*major*, which see.

Half-note, *Finger-key*, or artificial, is of very different magnitudes in the different modes of tuning, and places in the scales of keyed instruments. The number of f's in our notation, of any musical interval (by Σ, f and m), shews its number of these half-notes; as is fully explained in our article Finger-key *Intervals*.

Half-note, *Greater*, of Holden, has the ratio $\frac{15}{16}$, $=57\Sigma+f+5m$. See Semitone *Major*.

Half-note, *Isotonic* or mean, is $\frac{1}{12}$th of the octave, $=1\div\sqrt{}^{2}2$, $=51\Sigma+f+4\frac{5}{12}m$, or $51.003276\Sigma+f+4m$. See Mean Semitone.

Half-note, *Lesser*, of Holden, has the ratio $\frac{24}{25}$, $=36\Sigma+f+3m$. See Semitone Minor.

Half-quarter *Tone*, of the Diacomatic genus, according to Feytou, is $\frac{1}{8}$ T, $=13\Sigma+\frac{1}{4}f+1\frac{1}{8}m$, $=13.038398\Sigma+m$, its common log. being .9936059,3469. Mr Hoyle and others call this interval a *comma*.

Half-stops *on the Organ*, are those ranges of pipes which do not go through the whole compass of the instrument, from the treble to the bass; as the *corne* and the *sesquialtera* stops, the *dulciana*, *basoon*, &c. stops.

Half-tone of the ancients, had the ratio $\frac{243}{256}$, $=46\Sigma+f+4m$; which is now called the Limma. See that article.

Half-tone *of Brougham*, has the ratio $\frac{11}{12}$, $=76.897955\Sigma+f+7m$; its common log $=$ 9616713,1976, and it is the hemitone major of Ptolemy's *chromaticum intensum*.

Half-tone, *Chromatic Tonicum*, is $\frac{1}{2}T.=2\sqrt{2}\div3$, $=52\Sigma+f+4\frac{1}{2}m$, $=52.0039312\Sigma\times f+4m$; its common log. $=$.9744237,3877, $=.084962\times VIII$, $=4.74070\times C$, $=\frac{1}{2}VIII+\Sigma+\frac{1}{12}m$. It is the hemitone of the soft diatonic, and the chromatic diesis of Hoyle.

Half-tone, *mean*, of Sauveur, is $\frac{1}{12}VIII$, $=1\div{}^{12}\sqrt{2}$, $=51.003276\Sigma+f+4m$. See *Mean* Semitone.

Half-tone, *mean*, of Dr Smith, is $\frac{1}{4}III$, $=\sqrt{2}\div{}^{4}\sqrt{5}$, $=49\frac{1}{4}\Sigma+f+4\frac{1}{4}m$, $=49.251966\Sigma+f+4m$; its common log. $=$.9757724,9675, $=.080482\times VIII$, $=4.490705\times C$: it is sometimes called the mean half note.

HALIFAX, is a populous market town of England, in the west riding of Yorkshire. It is situated on the western slope of a gentle eminence, washed by a branch of the river Calder, and is surrounded on all sides with high hills. The town is about three quarters of a mile long from west to east, but it is narrow and irregular in its breadth. The houses are in general neat and well built, and the town has a singularly variegated appearance, from the mixture of brick and stone buildings, and from the great number of small inclosures surrounded with stone walls. The church, which is a large Gothic structure, stands near the east end of the town. It is 64 yards long, and 20 broad, and is supposed to have been built in the reign of Henry I. The tower of the church, which is well proportioned, is said to be 117 feet high. Within the church are two chapels, one on the north, and the other on the south side. This church having been found two small, an elegant and spacious new church has lately been erected. The cloth hall, or piece hall, erected for the convenience of the manufacturers, is a large and elegant edifice of freestone, in the form of an oblong square. It covers an area of 10,000 square yards, and has 315 separate rooms for the reception of goods. It is generally open from 10 to 12 o'clock, and goods to the amount of £50,000 are often exposed to sale at a time.

The parish of Halifax is one of the largest in England. It covers a space of 150 square miles, and has 13 chapels. It contains no fewer than 26 villages, whose united population, according to the census of 1811, is 73,515. The chief manufactures carried on in the parish, are those of shalloons unpressed, and dyed of a scarlet colour, which are sent to Turkey and the Levant; tammies, duroys, calamancoes, everlastings, russets, figured and flowered armines, says, moreens, and shags, kerseys, half thicks, serges, houlies, baize, broad and narrow cloths, coatings, and carpets. Several cotton manufactories have also been erected here. The trade of this town is greatly facilitated by a navigation from Sowerby bridge, in the neighbourhood of the town, along the Calder, to Hull, and will receive additional advantages from the Rochdale canal, which will connect the Calder at Sowerby bridge with the Bridgewater canal at Manchester. Excellent wool cards are also manufactured here. Great quantities of the freestone found in the neighbourhood are sent to London.

Halifax
||
Halle.

Gough, in his Additions to Camden, informs us, "that the inhabitants within Hardwicke forest claimed a right or custom from time immemorial, that if a felon be taken with goods to the amount of 13½d. stolen within their liberty, after being carried before the lords bailiff, and tried by four frith-burghers, from four towns within the said precinct, he was, on condemnation, to be executed on the next market-day, after having been set in the stocks first; and after his execution, a coroner was to take the verdict of a jury, and sometimes of those who condemned him." The instrument used in these executions was one exactly the same as the modern guillotine, which was freely used against the robber of tenter grounds: (See GUILLOTINE.) The last execution under the "Halifax gibbet law," as it has been called, took place in 1650. The bailiff was afterwards threatened with prosecution, if he should repeat them. According to the census of 1811, the township of Halifax contains

Inhabited houses	2151
Number of families	2313
Do. employed in agriculture . . .	8
Do. in trade and manufactures . .	2261
Males	4151
Females	5008
Total population	9159

See *Beauties of England and Wales*, vol. xvi. p. 742.

HALIFAX is the principal town of the county of the same name in Nova Scotia, one of the British possessions in North America. It is situated on the Bay of Chebucto, which is very spacious, and is able to contain, in perfect security, 1000 of the largest vessels. The town, which is about two miles long, and one-fourth of a mile broad, is situated on the west side of the harbour, on the declivity of a commanding eminence, elevated 236 feet above the level of the sea. In consequence of the streets intersecting each other at right angles, the houses are arranged into oblong squares. The Royal Naval Yard, supplied with military stores of all kinds, stands at the north end of the town. The accessible nature of the harbour, and its proximity to the principal interior settlements of the province, render it the fittest place in British America for a seat of government. Halifax is entrenched with forts of timber The country around the town is rocky, and the soil unfit for cultivation. The imports of Great Britain alone, into the single port of Halifax, amounted, in 1810, to £600,000. In 1790 and 1791, the whale fishery from the port of Halifax employed 28 sail of ships and brigs from 60 to 200 tons burthen. The principal exports from Halifax, are the fish caught upon its coasts, great quantities of which are sent to the West India islands. The amount of tonnage employed in the trade to and from the West India islands, and entered at the custom-house of Halifax, was, in 1792, 6489½ tons outwards, and 6571¼ tons inwards. Roads are opened from Halifax to all the settlements in the province. Population, 1000 houses, and 8000 inhabitants. Some accounts state the population so high as 15,000 or 16,000. West Long. 63° 35′ 45″, North Lat. 44° 44′. See Morse's *Geography*; Raynal's *History of the East and West Indies*; Gray's *Letters from Canada*; and NOVA SCOTIA.

HALIOTIS. See CONCHOLOGY, vol. vii. p. 66.

HALLE, is a town of Prussia, in the duchy of Magdeburg. It is situated on an agreeable plain on the river Saale. This town is divided into four quarters, and contains three Lutheran churches, and also places of worship for the Calvinists and the Roman Catholics, and a synagogue for the Jews. The principal edifices and curiosities of the town are, the cathedral; the red tower, which rises 268 Rhenish feet; the church of St Ulrice, where there is a fine monument erected to the celebrated Bulle d'Or of the Emperor Frederick II.; the orphans physician Hoffman; the hotel de ville, which contains the hospital; the amphitheatre of anatomy, situated in the place d'Armes; the public library; the ruins of the chateau of Giebichenstein, from one of the windows of which the Landgrave of Thuringia threw himself, and received the title of the Leaper; and the ruins of the chateau of Moritzbourg. The orphans hospital was built in 1698 by Professor Franke, and contains a collection of artificial and natural curiosities, and a library. The university of Halle, formed out of a military academy, was established in 1699. It has a good library, and a cabinet of natural history. In the year 1802, it had 634 students. This town owes its celebrity to the fine salt springs in its neighbourhood. There are four of these which are very productive, lying on the Saale, in the lower part of the town, called the Vale of Saale. These salt springs furnish water, of which from 16 to 20 ounces yield from 3 to 3½ ounces of salt. They give work to 111 boiling houses. Each of these produces annually about 1200. The possessors of these springs are called Pfaenner, and the workmen Hallores. They are the descendants of the ancient Wends, and still retain their dress and manners.

Canstein's printing-office for the Bible is a very large establishment. In 1800, the number of copies printed amounted to 1,793,534 Bibles, exclusive of 877,999 copies of the New Testament, 1600 Psalms, and 52,500 copies of Jesus Sirach. The other articles of manufacture are worsted and silk stockings, starch, flannels, buttons, linen, tobacco pipes, china ware, ribbons, and red and yellow Turkey leather. Population 20,000, including 1195 Halleres, or manufacturers of salt. East Long. 11° 58′ 2″, North Lat. 51° 29′ 5″.

Haller.

HALLER, ALBERT DE, a physician and professor of the last century, celebrated for the excellence and voluminousness of his writings. He was born at Berne, in Switzerland, on the 18th of October 1708. His father was Emmanuel Haller, advocate, and chancellor of the county of Baden. His early education was committed to one Abraham Baillodz, a fanatical and severe preceptor, not well qualified for training with advantage a mind of Haller's sensibility. Yet he very early discovered an unparalleled assiduity in the pursuit of knowledge. At five years of age, having already learned to write, he arranged for himself, in alphabetical order, all the words that were taught him In a little after, he compiled dictionaries in the Hebrew, Chaldee, and Greek languages, to which he often had recourse in his advanced years. At the age of ten, he composed German and Latin verses, the merit of which astonished his teachers. He ridiculed, in a Latin satirical poem, the pedantry of his private tutor, from whose severity he had suffered. At the age of twelve, he extracted from the dictionaries of Moreri and Bayle, 2000 articles of biography of the most celebrated men. When he was thirteen he lost his father, whose death left him in a great measure destitute of the resources of fortune. Being intended for the church, he finished his studies at the public school. On one occasion, having got a passage to translate into Latin, he attracted the admiration of the professors, by giving a translation of it into excellent Greek. Having finished his literary studies at the age of fourteen, he was led, by his ardour for learning, to pay a visit to Dr Newhams, an able physician at Bienne, whose son was one of his school companions. This gentleman gave him some instructions in the Cartesian system of natural philosophy. That pursuit, however, did not engross his whole attention. He continued to cultivate polite literature, and to exercise his talent in composing verses. The house in which he lived at Bienne having caught fire, he had only time to save his poems before it was burnt down. These poems he revised in less than twelve months after; and, reflecting on the satirical strain in which they were written, he committed them to the flames, with the exception of a few, which were left to attest his poetical talent, without reproaching the goodness of his heart.

After indicating talents which qualified him for making a conspicuous figure in any pursuit, he embraced the medical profession. Towards the end of the year 1723, he began his professional studies at Tubingen, under Camerarius and Duvernois, at that time celebrated teachers of anatomy and medicine. While at Tubingen, he occasionally joined in the convivial parties of his fellow-students; but was on one occasion so powerfully shocked by the abandonment of reason exhibited in these indulgences, that he formed a resolution, which he kept for the remainder of his life, to leave off entirely the use of wine. As Boerhaave's *Institutions* were used as a medical text-book at Tubingen, Haller had an opportunity of appreciating the genius of this author, which induced him to repair to Leyden to profit by his lectures. These two great men having met in this manner, immediately perceived each other's merits. Boerhaave was then teacher of medicine and botany, and Albinus demonstrator of anatomy at that celebrated school. Both of these professors treated him with great distinction, and excited in his mind a powerful emulation. The superb museum of Ruysch, at Amsterdam, which he often visited, contributed at this time to animate and guide his studies. At the age of 19, he took the degree of Doctor of Medicine at Leyden. The subject of his thesis was one which he had discussed with Duvernois at Tubingen, the refutation of a position advanced by Professor Coschwitz, of Halle, that there were two salivary ducts in the posterior part of the tongue, which this author claimed as his discovery. Haller shewed that these supposed ducts were two veins. His works contain the plates by which this point was elucidated.

In 1727, he visited England, where he became intimately acquainted with Sir Hans Sloane, the President of the Royal Society, and Douglas and Cheselden, two of its distinguished members. He also spent some time at Oxford. He went next to France, where he formed an acquaintance with Geoffroy, Antoine and Bernard de Jussieu, Petit, and Ledran, and attended the lectures of the celebrated Winslow. A person who lived in an adjoining house having found him engaged in private dissection, denounced him to the minister of police, in consequence of which he was obliged to remain for some time in concealment. Dissections must have been conducted in that city with much greater difficulty than they are now. Paris has furnished for some time the amplest field in the world for this mode of pursuing professional knowledge: and, however much some may affect to connect this fact with the careless licentiousness of the French nation, it exhibits a bright contrast to the feelings so prevalent in our own country relative to the remains of the deceased. Like all the prejudices of savage ignorance, these feelings appear to the persons who cherish them sacred and refined, though they senselessly oppose an obstinate barrier to the dissemination of the most important knowledge.

Haller next went to Basle, where he applied himself to the study of geometry under the celebrated Bernoulli, and for a short time he filled, with great credit, the anatomical chair during a temporary illness of Professor Mieg. He returned to Berne in 1729, to practise as a physician. Those who were previously established there, detracted from his professional character, by representing him as blindly attached to delusive theories, and had even the address to prevent him from obtaining the appointment of physician to an hospital, for which, in 1734, he was a candidate. Two years after, however, he succeeded in that object, and discharged the duties of the office with great credit.

The celebrity of his talents for anatomy induced the republic of Berne to form an anatomical theatre, and appoint him their professor. About this time he cultivated various elegant studies. He pronounced an oration before a public literary assembly, in which he asserted the general superiority of the ancients to the moderns. He published a collection of German odes and poetical epistles, which evinced the refined taste and delicate sensibility of the author, were admired in every part of Europe, and soon translated into various languages. The piece which gave greatest satisfaction was one devoted to a descriptive account of the Alps, and the manners of their inhabitants. Possessing, among his other accomplishments, an extensive acquaintance with biography and civil history, he received the charge of the public library at Berne. He drew up a *catalogue raisonnée* of the books, and arranged, in luminous order, a collection of more than 5000 medals belonging to it.

In 1736, he was invited, by the regency of Hanover, to fill the chair of anatomy, surgery, and botany, in the University of Gottingen, now for the first time instituted. He embraced this opportunity of devoting himself with more decided advantages to the improvement of science. He celebrated, in an ode, the inauguration of that university, and gave a competent share of praise to George II. King of Britain, for the zeal with which he promoted science in every part of his dominions. These included the American colonies, which were then illuminated by the genius of Franklin. At his entrance on his official duties at Gottingen, Haller was subjected to domestic discouragements of a trying nature. The carriage in which his wife and three children travelled from their native country to this new situation, was overset on the road, and his wife received an injury, of which she died soon after arriving at the end of her journey. He applied himself, however, with great zeal, to his academical duties, encouraged by the increasing esteem of his colleagues, and by the assistance of his countryman Huber. He published, in 1739, his *Lectures on Boerhaave's Institutions*, on which he had annually commented to his pupils. In this work, we find some germs of those more extended undertakings in physiology, which laid the foundation for so great a share of his future fame.

Having, among his other pursuits, cultivated that of botany, he published, in 1742, his *Enumeratio Stirpium Helveticarum*, in two folio volumes, which were embellished with numerous elegant engravings. The arrangement of this work rather presents us with a

Haller.

view of the gradations which take place in the external characters of plants, than a distribution fitted for permanent reference. Differences of opinion have even been entertained on the number of classes which Haller admitted, some reckoning them 13, others 15. In the following year, he published a systematic account of the plants in the botanic garden of Gottingen, which was republished nine years after in a more complete state, and contained a description of some new species. In 1749, he published, in one work, a collection of insulated remarks in botany, which he entitled *Opuscula Botanica*. Haller's great merit consisted in the versatility of his genius, which enabled him to pass rapidly from one subject to another, excelling equally in all. From the year 1743 to 1753, he published annually a fasciculus of anatomical plates of the most remarkable dissections which occurred in the course of his labours. These were admired for the minute explanations and learned notes which accompanied them.

In 1745, he published an ingenious argumentative discourse, *De Fœtibus Monstruosis*, in which he maintained that the original germs were in such instances defective, in opposition to the opinion that monstrosity was the effect of a derangement in the evolution of a germ originally perfect.

In 1746, he announced his experiments on respiration, in which he established the identity of office of the two layers of intercostal muscles, and the whole of the doctrines regarding the mechanical part of that function which have ever since been maintained, in opposition to the vague and erroneous notions which previously prevailed.

Haller, like most other eminent men of the medical profession, was engaged in some warm disputes. Dr Hamberger, Van Swieten, De Haen, Albinus, and Lamettrie, were his antagonists. In these however, he generally displayed moderation. In the second edition of his *Essay on Respiration*, instead of accumulating rejoinders, and exposing afresh the weakness of the arguments of Hamberger, he suppressed every harsh expression which the first edition contained. He had some physiological discussions with Dr Whytt of Edinburgh, Lamore, Lecat, and Lorry, in the course of which candour and mutual respect were on all sides observed.

The subject on which he displayed greatest originality was irritability, which he considered as a property of animated bodies distinct from sensibility, and residing in different organs. On this subject, Dr Whytt of Edinburgh maintained with him a learned and instructive controversy. The latter undoubtedly had the superiority in argument, without prejudice to the genius which Haller displayed in the developement of his theory, and the command of temper with which he conducted the controversy.

In 1749, he published his *Primæ lineæ Physiologiæ*. This work maintained the pre-eminence as a text book in this department, long after a multitude of improvements had been made in the science. In the composition of it he did not indulge in theory, but exhibited facts with a rigorous exactness. He published new editions of various works in medicine, as well as in natural science. It is in the prefaces to these works and to his own that he communicates knowledge in the most striking and engaging manner. They are collected in one volume, entitled *German Opuscula*.

Betwixt the years 1747 and 1756, he was employed in publishing a collection of dissertations, composed by various authors, on anatomy in eight volumes, on surgery in five, and on the practice of medicine in seven.

Besides the works now mentioned, Haller published various physiological dissertations betwixt the years 1736 and 1753, which were of themselves sufficient to confer on him a high degree of celebrity. Among these, was one on the circulation by which the substance of the heart is supplied with blood for its own nutrition; one on the form of the Eustachian valve at different periods of life; and one on the *membrana decidua* of the fœtus.

At Gottingen, he exerted himself in the formation of various useful institutions; such as the College of Surgeons, the Gottingen Society, a lying-in hospital subservient to the obstetrical branch of education, an anatomical museum, and a seminary for instructing artists in painting objects of anatomy, botany, and natural history.

These exertions procured for M. de Haller a high degree of honourable fame. He was elected member of almost all the academies of Europe. It deserves to be mentioned, that the Academy of Upsal had the honour of taking the lead. A learned society, which shews no tendency to precipitate admiration, deserves great credit when it early distinguishes the buds of a just celebrity, and by its notice cherishes exertions which might otherwise in some measure languish. When on a visit to Berne, he was elected a member of the sovereign council of that republic.

George II. took a lively interest in the splendid success of Haller. In 1739, he appointed him his first physician as elector of Hanover; he gave him the title of aulic counsellor; and in 1749, procured for him letters of nobility from the Emperor of Germany, creating him baron. Haller always, however, declined the title.

More than one seminary of learning aspired to the honour of numbering him among their teachers. Dillenius, professor of botany at Oxford, having before his death, which happened in 1747, expressed a desire that he should be chosen his successor, an invitation was given him to fill that vacancy. The following year he was invited to succeed Albinus at Utrecht as chancellor to the university; and soon after, the King of Prussia offered him an eligible establishment at Berlin, with the presidentship of the Academy. But Haller did not so far indulge a roving ambition, as to accept of any of these honourable appointments. He thus testified a grateful attachment to that university, the founder of which was the earliest to give him the honours best suited to gratify his wishes, and to afford scope for the full exercise of his great talents. He determined not to leave Gottingen for any place except his native country.

In 1753, finding his strength unequal to the labours of his situation, conjoined with the execution of the plans of writing which he meditated, he resolved to return to Berne, to pass the remainder of his life. The seventeen years which he had spent at Gottingen, though brilliant in the eyes of Europe, and attended with much gratification to his own mind, were also marked with traces of affecting domestic vicissitudes. Two years after he had lost his wife in the manner already related, he married a second, who died a few months after marriage. He then married a third, who was his companion for the rest of his days. For thus consoling himself twice, after the death of the individual bound to him by the closest ties, he was subjected, as usually happens, to the censure of weak and vain persons, who affect a character for sensibility, because their taste leads them to admire consistency in unhappiness in an object to which, with the eyes of critical amateurs, they occasionally turn their attention, and who demand for the gratification of that preposterous selfishness, that the most worthy characters should be involved in permanent bitterness, bereft at once of self-command and consolation. Haller was not chargeable with that harsh apathy of which the ancient Stoics are sometimes accused. He allowed the tides of sensibility on proper occasions to overflow; but, with the most rational of that sect, he set bounds to this indulgence; considering protracted tears as equally unbecoming with inordinate laughter. In an elegant poem entitled *Doris*, he expressed the tenderest attachment to his first wife, and his sincere grief after her decease. In another monody within three years, he celebrated his second; and with the third, he spent many years in the enjoyment of the most respectable state of domestic happiness.

On his return to Berne, he was received by his countrymen with genuine affection and delight. He had the fortune to obtain the honourable situation of governor of the town-house, which was awarded by lot.

In a year after his return, he published his *Opuscula Pathologica*, a work containing some curious facts in morbid anatomy. It contained also a description of a singular epidemic which had appeared in Switzerland, a sort of bilious pleurisy, in which venesection was unfavourable. He made experiments on the medical power of electricity in deafness, a subject which then excited much attention in Europe, and he pronounced it wholly ineffectual. He sometimes made botanical excursions, sometimes dissected animals, and published ingenious accounts of such physiological results as he obtained; for example, the growth of the bones, the structure of the brain and eyes of fishes, the anatomy of the chick *in ovo*, and the general subject of generation. One of his conclusions on this last subject was, that the female has by far the greatest share in the production of the fœtus.

The most complete work of Haller, and that which will always be most perused, was his great System of Physiology in eight quarto volumes, which he began in 1757 and finished in 1766. This work contains a complete account of all the facts then known on this extensive subject, minute anatomical descriptions of the structure of the organs, and a detail of the systematic opinions of former authors. By this work he for ever rescued physiology from the degradation of being the sport of vain hypothesis: he divested it of the spurious riches with which fancy had decorated it, and in their stead exhibited a collection of facts, which was at once solid and extensive, and led the way for the accumulation of further results of observation and experiment, from which just theories might gradually arise.

In 1772, 1773, and 1774, he amused himself by publishing in the form of three romances, his thoughts on the degrees of happiness to be enjoyed under different forms of political government. In the first, entitled *Usong*, he delineated the happiness arising from the administration of a virtuous and judicious despotic monarch, who encourages justice and morality. In the second, *Alfred*, he represented that of a limited monarchy, in which the nobles and people preserve their right to a share in the management of the public interests; and the king, while he regulates the state, pays respect to established forms, consults systematically the public voice, and exerts himself to maintain that constitution by which his own power is at once prevented from becoming lawless, and assisted in the dispensation of national benefits. In the third, entitled *Fabius and Cato*, he described a well-regulated aristocracy. Where it is dangerous to insist on the desirableness of a complete change of government, it is wise to endeavour to stimulate to virtue those in whose power the destinies of the human race are placed. At the same time it is a beneficial exercise of a philosophical talent to speculate on the most eligible forms for those communities which have as yet no established government, or for those eras of revolution in which the persons qualified to judge of what is best, and possessed of power by their union to adopt it, are perfectly disposed to embrace such institutions as would contribute most effectually to the perpetual welfare of society. On this speculation Haller did not enter farther than by shewing himself partial to an aristocracy like that of his native country: nor did he so far complete his plan, as to paint the advantages of the best state of a democracy.

Haller drew up several articles for the French Encyclopedie: and he long guarded the interests of general literature, by writing in the German review at Gottingen. The articles of which he was the author in that work amounted to 1500.

His last works were his *Bibliotheca Botanices, Anatomicæ, Chirurgiæ et Medicinæ Practicæ.* In this extensive and well digested list of authors, he points out in the amplest manner, and with a luminous arrangement, the sources from which he derived his knowledge, and from which it might be obtained by others. It is written in the order of time, in subdivisions corresponding to the different epochs and schools of systematic opinion, and to each subdivision a short descriptive sketch of the period or sect in these sciences is prefixed. It thus exhibits an interesting history of the advances of science, accompanied by a full enumeration of the literary monuments which serve for the records of knowledge and opinion. His *Bibliotheca Medicinæ* was not completed. He had it also in view to form a similar work on Natural Philosophy.

The republic sometimes conferred on him temporary offices, which his philosophical talents enabled him to fulfil with distinguished advantage; and he was always ready to employ these talents for the public good. While he was governor of the canton of L'Aigle, he essentially benefited the resources of the state, by improving the manufacture of salt. He exerted himself for the establishment of a house for the maintenance and education of orphans and the children of decayed citizens, and also a school for the education of the children of the more opulent classes, in which the acquisition of useful knowledge was preferred to the objects of a scholastic discipline. By his influence, the situation of the clergy of the Pais de Vaud, which had been wretched and degrading, was rendered comfortable and respectable.

The University of Gottingen, and its patron the King of Britain, solicited him to return to that place, offering him the chancellorship on the death of Mosheim. The King of Prussia offered to make him chancellor of the University of Halle, and the Empress of Russia made tempting proposals to induce him to go to Petersburg. But he preferred remaining in the bosom of his native country, which at this time testified its respect for his character, and its desire of retaining him, by voting to him a competent annual salary. In 1776, he received the order of the Polar Star from the King of Sweden.

The Emperor of Germany, in the course of his last travels, visited Haller, and found him labouring under an accumulation of infirmities which he evidently could not long support. On his return to Vienna, he sent him some bottles of wine of uncommon excellence, with a quantity of the best bark; but Haller, before he had it in his power to set the due value on this simple tribute of private friendship from that monarch, had paid the debt of nature. The emperor received the news of his death with unfeigned grief; and afterwards, in order to secure an honourable relict, and a useful memorial of the studies of this great man, he purchased his library, and had it conveyed to Milan.

His disease was a form of retrocedent gout, affecting the region of the bladder, and was accompanied with so much inconvenience that he was obliged to confine himself at home. He published among the memoirs of the Society of Gottingen, an account of its progress, and of his personal experience of the effects of opium and other remedies. In the midst of this distressing illness, he published a second edition of his great work on physiology.

M. Rosselet, his physician, told him at his own desire, his opinion of the exact time at which he was likely to die. In his last moments he was perfectly collected, and, with his hand on his pulse, coolly remarked to M. Rosselet that it had now ceased to beat.

He had eleven children, eight of whom he lived to see established, 20 grandchildren, and before his death two great-grandchildren. His eldest son, Gottlieb Emanuel, was afterwards an eminent citizen of Berne, and distinguished for his historical learning.

Haller was of the Protestant religion, and sincerely attached to his religious principles. La Mettrie, in dedicating to him a work in support of materialism, created in him the utmost horror and distress, by affecting to represent his discoveries as the most valuable proofs of this doctrine. His mode of life was rigidly sober. His only beverage was water, and he delighted to represent the unfitness of the climate of Berne for the culture of the grape, as a signal advantage conferred by nature on his country.

Haller was exceeded by none of his contemporaries in the extent of his general information. He was well acquainted with most of the languages of Europe, and corresponded with the utmost facility with the literati of France, England, Italy, Holland, Denmark, and Sweden, in their respective native languages.

A more industrious literary life than that of Haller cannot be imagined. Every moment of his time was occupied. The reading of new books, and the composition of the lighter species of memoirs, and articles for reviews, were his only pastimes. During a long state of delicate health his bed was in his library, where he sometimes spent months without ever going out. There he eat his meals, and with the society of his family and his books, he concentrated within this narrow space all that he held most dear on earth. He communicated to those around him a taste for scientific pursuits. His house was a sort of sanctuary of the sciences. He was assisted by his pupils, who had the range of his library and his theatre. His wife acquired the art of drawing and painting for the purpose of rendering herself useful to him. His children, friends, and fellow citizens, all regarded it as their duty to contribute to his labours. His uncommon sensibility subjected him to quick alternations of pain and pleasure: He rarely joined in general social parties. When he did, he often rendered himself extremely agreeable; his conversation, however, was always that of a man of learning; even on trifling subjects, he displayed profound sense, and a spirit of application. He was above the ordinary size,—his eyes were lively, —and his countenance noble and expressive.

He was probably the most voluminous writer after Galen. His Latin style is sometimes dry, complicated, and not readily understood by persons unaccustomed to it: but the profundity of views, the well connected strain of reflection, and the great erudition with which his works are replete, never fail to reward the reader. Various as the subjects were which occupied his pen, he shews a consistency of doctrine, and a unity of views and of method, which characterise solidity of judgment, and announce a commanding genius. His works on medical science will long continue to be read with profit, when the labours of many others, which have attracted the notice of the day, are reduced, by the cool decision of posterity, to their just rank,—that of being regarded as the errors of exuberant fancy, imposing on the age in which they appeared, by laying premature and peremptory claim to the credit of regular scientific systems. See Vicq d'Azyr's *Eloges;* Henry's *Life of Haller;* and Haller's *Bibliotheca Anatomiæ.* (H. D.)

HALLEY, Edmund, a celebrated astronomer and natural philosopher, was born at Haggerston, in the parish of St Leonards, Shoreditch, London, on the 8th November 1656. His father, who was an opulent citizen and soapboiler, sent him to St Paul's school, where, under the care of the learned Dr Gale, he made rapid advances in his classical studies, and acquired such a taste for elementary astronomy, that he amused himself in making dials, and observed the change in the variation of the needle at London in the year 1672, the year before he left school. From this seminary, which he left in 1673, he went to Queen's College, Oxford, where he was entered s gentleman commoner, and where, with the aid of a good collection of instruments which his father had purchased for him, he devoted himself almost exclusively to the study of mathematics and astronomy. In the year 1676, he published his first paper in the Philosophical Transactions, entitled, "*A Direct and Geometrical Method of investigating the Aphelia, the Eccentricities, and the Proportions of the Orbits of the Primary Planets, without supposing the equality of the Angle of Motion at the other focus of the Planet's Ellipsis;*" and he continued to employ himself in astronomical observations. Although he had long entertained a plan of forming a complete catalogue of the fixed stars, yet he abandoned this scheme upon hearing that Flamstead and Hevelius were occupied in the same pursuit. He resolved, however, to form a catalogue of the stars of the southern hemisphere; and, by the influence of Joseph Williamson, Secretary of State, and Sir Jonas Moore, Surveyor of the Ordnance, Charles II. was prevailed upon to send Halley to St Helena, in order to accomplish this desirable object. He arrived on the island in February 1677, after a voyage of three months; and though he was much interrupted by the frequent fogs which hover over it, yet, by the most unremitting industry, he at last executed his plan, which he published in 1679, under the title of *Catalogus Stellarum Australium.* This work was presented, on his return from St Helena, in November 1678, to Charles II. who gave him a mandamus to the University of Oxford for the degree of A.M. Halley had rewarded the kindness of his patron by forming a new constellation under the name of *Robur Carolinum.* During his stay at St Helena, he had the good fortune to observe the transit of Mercury over the sun's disc.

In the year 1678, Halley was elected a Fellow of the Royal Society of London; and, in consequence of the dispute between Hevelius and Hooke respecting the use of telescopic sights, he went to Dantzic in 1679 for the purpose of settling the controversy, by examining the method of observation employed by the Polish astronomer. He remained at Dantzic from the 26th of May till the 18th July, and returned to England deeply impressed with a conviction of the wonderful perfection of Hevelius's instruments, and of the great accuracy of his observations.

In the year 1680, Halley set out for Paris, accompanied by his friend Mr Nelson, with the view of performing the grand tour of Europe. In crossing the English channel, he obtained a view of the great comet upon its return from the sun; and having been fortunate enough to observe its descent towards that luminary, he was able to complete his observations at the Royal Observatory of Paris, which was then under the direction of Dominique Cassini. From Paris he went to Italy, where he spent the greater part of the year 1681; but his private affairs obliged him to return to England about the end of the year.

Soon after his arrival in London, Halley married the daughter of Mr Tooke, auditor of the Exchequer, and took up his residence at Islington, where he put up his astronomical apparatus, and pursued with ardour his favourite study. With this amiable woman Halley lived 55 years, but was not blessed with any family.

In the Philosophical Transactions for 1683, he published his *Theory of the Variation of the Magnetical Compass*—a paper of singular merit, in which he endeavours to shew, that the " whole globe of the earth is one great magnet, having four magnetical poles or points of attraction, near each pole of the equator two; and that, in those parts of the world which lie near adjacent to any of these magnetic poles, the needle is governed thereby, the nearest pole being always predominant over the more remote."

Our author's studies were now somewhat interrupted by domestic misfortunes. His father had suffered greatly from the fire in London; and having imprudently entered into a second marriage, he was reduced comparatively to a state of poverty. His son, however, speedily resumed his usual occupations; and, in the year 1684, his attention was directed to the subject of Kepler's sesquialterate proportion, from which he concluded that the centripetal force must be inversely as the square of the distance. He found himself unable, however, to establish this by geometrical principles; and having applied in vain for assistance to Dr Hooke and Sir Christopher Wren, he at last made a visit to Cambridge, in order to consult Mr Newton. This illustrious mathematician communicated to Halley 12 theorems which he had written upon the subject, containing his theory of gravitation. Halley was so delighted with the developement of this great discovery, that he prevailed upon Newton to complete his *Principia*, which was actually published in 1686, under the immediate care of Dr Halley, who prefixed to it a discourse of his own, and complimented Newton in an elegant copy of Latin verses.

In the year 1685 Halley had been appointed clerk to the Royal Society, and was the principal person employed in the publication of its Transactions.

In 1686, he published a paper, entitled, *An Historical Account of the Trade Winds and Monsoons observable in the Seas between and near the Tropics*, with an attempt to assign their physical cause; and in 1687, appeared his *Estimate of the Quantity of Vapour raised out of the Sea by the warmth of the Sun*, which gave so much satisfaction to the Royal Society, that they requested him to pursue the subject. He accordingly published in 1691, his paper *On the Circulation of the Watery Vapours of the Sea, and the Origin of Springs*; in which he first pointed out that fine provision of nature, by which a constant circulation of water is kept up between the atmosphere and the ocean. Halley published in 1687, his paper *On the Numbers and Limits of the Roots of Cubic and Biquadratic Equations*. In 1688, he published a correct ephemeris for that year; and in 1691, appeared his paper *On the Time and Place of Julius Cæsar's Descent upon Great Britain*, in which he considers it as demonstrated, that Cæsar landed in the Downs a little to the northward of Dover cliffs, on the 26th of August, 55 before Christ. In consequence of having had the good fortune to observe the transit of Mercury when he was at St Helena, Halley directed his attention particularly to this class of phenomena; and in 1691, he published a paper *On the visible Conjunctions of the Inferior Planets with the Sun*, in which he has calculated all the transits of Mercury from A. D. 1605 to 1799, and all those of Venus from 918 to 2004. He was fully aware at this time of the great advantages which astronomy would derive from the observation of these phenomena; and he remarks, that " the principal use of these conjunctions is accurately to determine the distance of the sun from the earth, or his parallax, which astronomers have, by several methods, attempted in vain, while the smallness of the angles sought do easily elude the nicest instruments; but in observing the ingress of Venus into, and egress from, the sun, the space of time between the moments of the internal contacts may be obtained to a second of time, that is, to $\frac{1}{15}$ of a second, or 4‴ of the observed arch, by means of an ordinary telescope and clock that goes accurately for 6 or 8 hours." Halley had, however, been anticipated in this ingenious remark by our countryman James Gregory. See our life of James Gregory.

In consequence of Dr Bernard's resignation, a vacancy took place in the Savilian professorship of Astronomy at Oxford. Dr Halley was naturally considered as well qualified for the chair, and became one of the candidates. Dr David Gregory, however, was the successful competitor; and Halley is known to have lost the office solely from his adherence to the principles of infidelity. Mr Whiston inform us, " that Bishop Stillingfleet was desired to recommend him at court; but hearing that he was a sceptic and a banterer of religion, the Bishop scrupled to be concerned, till his chaplain, Bentley, should talk with him about it, which he did. But Halley was so sincere in his infidelity, that he would not so much as pretend to believe the Christian religion, though he thereby was likely to lose a professorship, which he did accordingly, and it was then given to Dr Gregory."

In 1692, Mr Halley resigned his situation as assistant-secretary to the Royal Society; and in 1696, when five different mints were established for the recoinage of the silver specie, he was made comptroller of the office at Chester. In 1692, Mr Halley published a singular paper *On the Cause of the Change of the Variation of the Magnetic Needle; with an Hypothesis of the Structure of the Internal Parts of the Earth.* In order to account for the change in the variation of the needle, he supposes that there is an interior globe within the earth, separated from the external sphere by a fluid medium; that they revolve about the same diurnal axis nearly in 24 hours, the outer sphere moving either a little slower or faster than the internal ball; that the magnetic poles both of the external shell and the included globe, are distant from the poles of rotation; and that the variation arises from the change in the relative distances of the external and internal poles, in consequence of the difference of their daily revolutions. The whole of this paper, though marked by the ingenuity of its author, is characterised by an extravagance of speculation, in which he was not accustomed to indulge. He even goes so far as to say, that there may be several internal spheres separated by atmospheres, the concave side of each shell being made up of magnetical matter; and he considers it as by no means improbable, that these different spheres may be occupied by living beings. The concave arches," says he, " may, in several places, shine with such a substance as invests the surface of the sun; nor can we, without a boldness unbecoming a philosopher, adventure to assert the impossibility of peculiar luminaries below, of which we have no sort of idea."

Till the year 1698, Dr Halley continued to enrich the Philosophical Transactions with various memoirs on the price of annuities on lives; on the foci of lenses; on the roots of equations, and on different subjects in mathematics, meteorology, antiquities, astronomy, and optics. He now, however, conceived the design of making an extensive voyage to determine the variation of the needle in different parts of the world. For this purpose, King William appointed him captain of the Paramour Pink, in which he set sail on the 20th of October 1698. Having sailed along the African coast, he crossed to the coast of America, going some degrees south of the line. His crew having begun to lose their health, and his officers to become mutinous, he proceeded to the West Indies to get them exchanged; and when he found this impracticable, he returned to England, where he arrived early in July 1699. When his lieutenant had been tried and cashiered, he again set sail on the 16th of September 1699, and after having made observations at St Helena, the Brazils, Cape Verd, Barbadoes, Madeira, Canaries, the coast of Barbary, he proceeded in a southerly direction till he was stopped by the ice in the south latitude of 53°. Having thus accomplished the object of his voyage, he returned to Britain, and anchored in Long Reach on the 7th of September 1700. From this voyage he received the title of Captain in the Navy, and through the influence of Queen Caroline, he enjoyed half pay during the remainder of his life. The results which Dr Halley obtained during this voyage were published in 1701 in his general chart, which exhibits the variation of the needle in all the seas frequented by navigators.*

In 1701, Mr Halley was sent by the King to observe the course of the tides in every part of the English Channel, and to ascertain the geographical positions of the principal headlands. This task was accomplished in 1702, and the results were published in a large chart of the English Channel.

The Emperor of Germany having resolved to form a commodious harbour in the Adriatic, Halley was sent by Queen Anne to inspect the two ports on the coast of Dalmatia. He set out on the 22d of November 1702, and went to Istria by the way of Holland and Germany; but, in consequence of the opposition which the Dutch made to the scheme, it was laid aside. The Emperor, however, when he saw him at Vienna, made him a present of a rich diamond ring from his own finger, and gave him a letter of recommendation written in his own hand to Queen Anne. No sooner had he returned to England, than he was a second time dispatched to Germany on the same errand. In passing through Hanover, he supped with the Electoral Prince, afterwards King George I. and his sister the Queen of Prussia; and after having been presented to the Emperor on the evening of the day on which he arrived at Vienna, he set out with the chief engineer for Istria, when the fortifications of Trieste were, by his advice, repaired and enlarged.

Upon his return to England in November 1703, he succeeded to the Savilian professorship of geometry at Oxford, which was vacant by the death of Dr Wallis; and the university at the same time conferred upon him the honorary title of doctor of laws. As soon as he settled in this new situation, he began, in conjunction with his colleague Dr Gregory, to publish the works of the ancient geometers, in pursuance of the plan recommended by Sir Henry Saville. He translated from the Arabic into Latin, *Apollonius de Sectione Rationis*: (See Analysis, vol. i. p. 722.) and he restored the two books of the same author, *De Sectione Spatii*, from the account given by Pappus. This work appeared in 1706. Dr Halley assisted also in preparing for the press, the Conics of Apollonius; and he supplied the whole of the 8th book which had been lost. This work appeared in 1710; and contained also Serenus *On the Section of the Cylinder and Cone*, which was printed from the original Greek, with a Latin translation. In 1708, Dr Halley published the *Miscellanea Curiosa*, in 3 vols. 8vo, which contained several original articles by himself.

On the death of Sir Hans Sloane in 1713, Dr Halley was appointed secretary to the Royal Society. In 1716, he published his paper *On the art of living under water*, which contains an account of his diving bell, and of the experiments which he made with it at great depths in the sea: (See Diving Bell, vol. viii. p. 11, 12.) At the death of Mr Flamstead in 1719, Dr Halley was appointed astronomer royal; and though he had now reached the 64th year of his age, he entered upon the duties of his new office with a degree of juvenile ardour; and without the help of an assistant, he continued for 20 years to make celestial observations with the most surprising and unremitting assiduity. In the space of 9 years, a period of the moon's apogee, he made no fewer than 1500 observations on the moon's right ascension, the object of which was to determine the inequalities of her motion, and to furnish navigators with the most correct means of finding the longitude at sea. He gave an account of this plan in the *Phil. Trans.* for 1731, in his *Proposal for finding the Longitude at Sea within a Degree, or 20 Leagues*. In an appendix to the second edition of Street's Caroline Tables, Halley had suggested this method of finding the longitude so early as 1683 and 1684; and he now shews, from a comparison of the lunar tables with accurate observations, that the longitude may always be determined to within 20 leagues under the equator, and 15 leagues in the British Channel.

Dr Halley was constantly employed in perfecting his tables of the planets. They were drawn up in 1725; but he was unwilling to publish them till they were made as perfect as he could. In 1729, he was elected a foreign member of the Academy of Sci-

* The original journals of Dr Halley's two voyages, were published by the late Alex. Dalrymple, Esq. in 1775, in a thin quarto volume.

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ences at Paris. In 1737, he was seized with a paralytic affection in his right hand; but this did not prevent him from attending the Royal Society Club every Thursday. His disorder, however, gradually increased; and he died on the 14th January 1742, in the 86th year of his age. He was buried in the church-yard of Lee, near Blackheath. Dr Halley's *Tabulæ Astronomicæ* were published in 1749. They were for a long time the most complete and accurate; but they have long since been superseded by others more correct and valuable.

There are few individuals who have been so distinguished as Dr Halley, both for their industry and their genius. He was the author of no fewer than 78 papers in the *Philosophical Transactions*, upon almost every branch of natural philosophy; and a great number of these are remarkable for their originality, and for the new and ingenious views which they unfold. The name of Halley, however, is not associated in the history of science with any brilliant effort, or any striking discovery. His reputation was widely extended, both as a profound philosopher and as a man of taste; and almost every department of physical science received some improvement from his labours. The upright character of Halley was strikingly displayed in his refusal to assume the mask of religion, when it would have conducted him to a professorship in Oxford. But while we admire this example of sincerity and disinterestedness in his unbelief, we cannot but feel that a stain is left upon his reputation, when history records that he was a " banterer of religion." In an age when a philosopher like Newton was an open defender of Christianity, it was indelicate in a philosopher like Halley to assume in public the character of an infidel.

HALO, or CORONA, is a luminous circle, sometimes containing all the prismatic colours, which occasionally appears about the sun and moon, and other luminous bodies.

In the northern regions of the globe, the sun and moon frequently appear surrounded with halos, or coloured circles, having their diameter about 44° or 92°. When a horizontal white circle intersects these halos, *parhelia* or brighter spots appear near their intersections, and also portions of inverted arches of various curvatures. In the horizontal circle, there are often *anthelia* or bright spots nearly opposite to the sun.

In order to lay before our readers a pretty full account of this curious class of phenomena, we shall begin with describing the most interesting halos that have hitherto been observed, and then give an account of the theories which have been employed to explain them. As the most minute accuracy is necessary in the description of the phenomena, we shall generally give it in the words of the observers themselves.

Roman phenomenon observed by Scheiner.

On the 20th March 1629, Scheiner observed at Rome a singular halo which Huygens describes in the following manner from the writings of Descartes and Gassendi.

PLATE CCLXXXVII Fig. 1.

" A is the place of the observer at Rome, B the vertex or point over his head, C the true sun, AB a vertical plane passing through the observer's eye, the true sun and the vertex B, which are all projected in the straight line ACB. About the sun C, there appeared two concentric rings not complete, but diversified with colours. The lesser and inner of them DEF, was fuller and more perfect; and though it was open from D to F, yet these ends D and F were perpetually endeavouring to unite. Sometimes they did unite and complete the ring, and then opened again. The other exterior and fainter and scarce discernible circle, was GKI; it had a variety of colours, but was very inconstant. The third circle KLMN was very large, and all over of a white colour, such as are often seen with paraselenæ about the moon. This was an eccentric circle passing through the middle of the sun, at first entire, but towards the end of the appearance it was weak and ragged, and scarce discernible from M towards N. In the common intersection of this circle, and of the outward iris GKI, there broke out two parhelia N and K, not entirely perfect; K was somewhat weak, but N shone brighter and stronger. The brightness in the middle of them both resembled that of the sun; but towards their edges, they were tinged with colours like those of the rainbow. They were not perfectly round and even at their edges, but uneven and ragged. The parhelion N was a little wavering, and sent out a spiked tail NP, of a colour somewhat fiery, which had a continual reciprocation. The parhelia at L and M, beyond the zenith B, were not so bright as the former, but rounder and white like the circle which they were placed in. They resembled milk or clean silver. The parhelion M was almost quite extinct at half an hour past two o'clock, excepting that some faint remains would revive now and then, and the circle itself vanished in that place. The parhelion N disappeared before K did, and while M became fainter K grew brighter, and vanished last of all." This has been generally called the Roman Phenomenon.

Halo observed by Hevelius at Dantzic in 1661.

PLATE CCLXXXV Fig. 2.

On Sunday February 20th 1661, new style, Hevelius observed at Dantzic a very curious halo, which he thus describes in the appendix to his *Mercurius in Sole Visus*, page 174. " A little before 11 o'clock, the sun being towards the south, and the sky very clear, there appeared seven suns together in several circles, some white and some coloured, and these with very long tails, waving and pointing from the true sun, together with certain white arches crossing one another. 1st, The true sun at A being about 25° high, was surrounded almost entirely by a circle whose diameter was 45°, and which was coloured like the rainbow with purple, red, and yellow, its under limb being scarce 2½° above the horizon. 2d, On each side of the sun at B and C, towards the west and east, there appeared two mock suns, coloured especially towards the sun, with very long splendid tails of a whitish colour, and terminating in a point. 3d, A far greater circle YXHVZ, almost 90° degrees in diameter, encompassed the sun and the former lesser circle GBIC, and extended itself down to the horizon. It was very strongly coloured in its upper part, but was somewhat duller and fainter on each side. 4th, At the tops of these two circles at G and H were two inverted arches, whose common centre lay in the zenith, and these were very bright and beautifully coloured. The diameter of the lower arch QGR was 90°, and that of the upper one THS was 45°. In the middle of the lower arch at G, where it coincided with the circle BGC, there appeared another mock sun; but its light and colours were dull and faintish. 5th, There appeared a circle BEFDC much bigger than the former, of an uniform whitish colour, parallel to the horizon at the distance of 25°, and 130° in diameter, which arose as it were from the collateral mock suns B and C, and passed through three other parhelia of an uniform whitish colour like silver: one at D, almost 90° from the true sun towards the east; another at E, towards the west; and a third at F in the north, diametrically opposite to the true sun, all of the same colour and brightness. There passed also two other white arches EN, DP, of the greatest circle of the sphere through the eastern and western mock suns E, D, and

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also through K, the pole of the ecliptic. They went down to the horizon at N and P, crossing the great white circle obliquely, so as to make a white cross at each parhelion; so that seven suns appeared very plain at the same time; and if I could have seen the phenomenon sooner from an eminence, I do not question but I should have found two more at H and I, which would have made nine in all; for there remained in those places such marks, as made this suspicion not improbable.

Plate CCLXXXVII F. 2.

This most delightful and extraordinary sight lasted from 30 minutes past 10 to 51 minutes past 11; though it had not the same appearance all that while, but sometimes one and sometimes another. It appeared in the perfection of this description at about 11 o'clock, and then degenerated by degrees. The northern mock sun at F vanished first of all, together with a part of its circle; the other parhelia with their arches lasted till 10 minutes past 11, then the eastern mock-sun, and after that the western vanished with both the crosses. Soon after this the collateral parhelia C, D suffered several changes; sometimes one was brighter than the other in light and colours, and sometimes fainter and darker. For at 18 minutes past 10 the eastern parhelion at C vanished, while the western parhelion at B remained very conspicuous; and 24 minutes past 11, the eastern one was very bright again, and remained so, while the western one disappeared at 40 minutes past 11; although this western one had almost always the longer tail. For the tip of it was frequently extended for 30 degrees and sometimes 90 as far as the parhelion E; but the tail of the eastern one C was scarce above 20 degrees. At 30 minutes past 11, the great vertical circle YXHVZ was destroyed; but the inverted arches H and G, together with the collateral parhelia B and C, continued to the last.

The scheme of this phenomenon is drawn in the same manner as the constellations are drawn upon an artificial globe, to be received by the eye on the outside of it. For by this means every thing is represented much clearer and distincter. Nevertheless, the place of the observer was nearly under the zenith within the circle parallel to the horizon; so that the true sun appeared to him in the meridian, the mock sun F in the north, and the other two at D and E on each hand. But if you desire to have this extraordinary phenomenon represented a little plainer; upon an artificial globe, whose pole is elevated to our altitude at Dantzic, with the centre A in the 2d degree of Pisces, where the sun then was, and with a semi-diameter of 22½ degrees, describe the circle GBIC; 2d, and then the circle YXHVZ with a radius of 45 degrees; 3d, and with the same centre and semi-diameter of 90 degrees, draw the circle NEKDP through the two white mock suns, E, D; 4th, and with a semi-diameter of 22½, the zenith being the centre, draw the arch THS; 5th, and also the arch QGR, with a radius of 90 degrees, upon the same centre; 6th, and lastly, the circle BEFDC, parallel to the horizon, with a radius of 90 degrees. And the draught being finished in this manner, will appear very beautiful and harmonious."

Halo observed by Rothman at Cassel in 1586.

On the 2d January 1586, Christopher Rothman observed at Cassel another halo, which he describes in the following manner, in his description of a comet seen in that year.

"The sky being very clear in the east just before sunrise, there appeared an upright column, exactly situated in a vertical circle. Its breadth was every where equal to the sun's diameter; and it looked as if some village was on fire beyond the mountains. For it appeared like a column of flame, excepting that its thickness was every where the same.

Soon after, in the same column, there arose an image of the sun, exactly resembling the true sun. There was scarce one digit of this image under the horizon, when the true sun began to rise in the same column, which was followed in like manner by another image. The column, with its three suns touching one another, continued always upright, or in a vertical circle, as appeared by the plummet of a quadrant.

These suns had all the same appearance, except that the true sun in the middle was brighter than the rest. This appearance of the column passing through three suns, lasted almost a quarter of an hour, till they were covered by a black cloud descending from above.

Halo observed by Scheiner in 1630.

Plate CCLXXXVII Fig. 3.

Scheiner observed in 1630, the halo represented in Fig. 3. which is thus described by Gassendi: "The diameter of the corona MQNE next to the sun, was about 45 degrees; and that of the remoter corona ORP, was about 95° 20′; they were coloured like the primary rain-bow, but the red was next the sun, and the other colours in the usual order. The breadths of all the arches were equal to one another, and about a third part less than the diameter of the sun, as represented in the scheme. Though I cannot say but the whitish circle OGP parallel to the horizon, was rather broader than the rest. The two parhelia, M, N were lively enough; but the other two at O and P were not so brisk; M and N had a purple redness next the sun, and were white in the opposite parts; O and P were all over white. They all differed in their durations. For P, which shone but seldom and but faintly, vanished first of all, being covered by a collection of pretty thick clouds. The parhelion O continued constant for a great while, though it was but faint. The two lateral parhelia M and N were seen constantly for three hours together: M was in a languishing state, and died first, after several struggles; but N continued an hour after at least. Though I did not see the last end of it, yet I was sure it was the only one that accompanied the true sun for a long time, having escaped those clouds and vapours which extinguished the rest. However it vanished at last, upon the fall of some small showers. This phenomenon was observed to last four hours and a half at least; and since it appeared in perfection when I first saw it, I am persuaded its whole duration might be above five hours.

The parhelia Q, R were situated in a vertical plane, passing through the eye at F, and the sun at G, in which vertical the arches CRH, ORP either crossed or touched one another. These parhelia were sometimes brighter, sometimes fainter than the rest; but were not so perfect in their shape and whitish colour. They varied their magnitudes and colours according to the different temperature of the sun's light at G, and the matter that received it at Q and R; and therefore their light and colours were almost always fluctuating, and continued as it were in a perpetual conflict. I took particular notice that they appeared almost the first and the last of all the parhelia excepting that at N.

The altitude of Q above the horizon in the morning at the beginning of the observation, was 49° 40′; that of R was 76° 10′; that of the true sun was 28° 30′; hence the height of Q above the sun was 21° 10′, and the height of R above the sun was 47° 40′.

"There was a north wind at the beginning of these observations, but by degrees it changed to the east, and at last to the south; yet it brought no very great nor lasting rains. For near a fortnight after, the sky looked always vapourish; and every day before dinner the sun endeavoured to create new suns, but in vain, either

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Plate CCLXXXVII Fig. 3.

for want of matter, or of a due disposition. For in the vertical circle I saw plainly some sketches of parhelia for a long time. I saw also very manifest reciprocations of the lateral parhelia. The iris ORP seems to have been a portion of a single circle concentric to the sun, but towards $\varkappa$ and θ it did not quite touch the horizon AB; and the lengths of the arches O $\varkappa$, P θ were variable. The arches Z Q α, β Q γ, $\delta \varepsilon \zeta$, that immediately surrounded the sun, seemed to the eye to compose a single circumference, but it was confused, and had unequal breadths; nor did it constantly continue like itself, but was perpetually fluctuating. But in reality it consisted of the arches expressed in the scheme, as I accurately observed for that very purpose. The horns HRC seemed to be a portion of a smaller circle touching the greater ORP in a contrary position in a common knot at R. The arches cut each other in a knot at Q, and there they formed a parhelion. The parhelia N, M sprung out from the common intersections M, N of the iris $\delta \varepsilon \zeta$, and of the whitish circle ONMP. The north part of the sky was clearer than the south, which, being overcast with slender vapours, afforded more matter for this appearance." See Gassendi's *Opera*, tom. vi. p. 401.

Paraselenæ seen by Hevelius in 1660.

Plate CCLXXXVII Fig. 4.

Hevelius observed the following paraselenæ at Dantzic on the 30th March 1660. "In the beginning, at one o'clock in the morning, the moon A was surrounded by an entire whitish circle BCDE, in which there were two mock moons at B and D, one at each side of the moon, consisting of various colours, and shooting out very long and whitish beams by fits. That on the left hand extended its tail towards the thigh of Serpentarius, the other on the right extended its tail toward Jupiter, as represented in the Figure. Afterwards, at two o'clock, a larger circle surrounded the lesser, and reached down to the horizon. The tops of both these circles were touched by coloured arches like inverted rainbows. The inferior arch at C was a portion of a larger circle, and the superior a portion of a lesser. This extraordinary sight lasted near three hours; the outward great circle vanished first of all, then the larger inverted arch at C, and presently the lesser, and, last of all, the inner circle BCDE disappeared. The diameter of this inner circle, and also of the superior arch, was 45 degrees; that of the exterior circle, and inferior arch, was 90 degrees."

Parhelia seen by Hevelius in 1660. Fig. 5.

On the 6th April 1660 Hevelius observed the parhelia shewn in Fig. 5. "At half an hour past five in the evening, while the sun was descending towards the horizon, he was crowned with arches of circles of various colours like the rainbow. In the corona, on opposite sides of the sun, there were two parhelia variously coloured with pretty long and whitish tails pointing from the sun. Near the zenith, where the corona was a little faint and imperfect, there shone out another inverted arch, having a third parhelion in the middle of it, which appeared somewhat obscure. This phenomenon lasted half an hour till sun-set, the sun being very clear. The inverted arch, and the upper parhelion, disappeared first; and then the parhelion on the left hand; but the third parhelion set with the true sun. The diameter of the corona round about the sun was about 45 degrees, as I guessed by my eye."

Paraselenæ seen by Hevelius in 1660. Fig. 6.

On the 17th December 1660, Hevelius observed at Dantzic the following paraselenæ, which are shewn in Fig. 6. "On the first day after the full moon," says he, "at thirty minutes past six in the morning, the moon being 12° high, I saw the moon in the west, with three mock moons about her in this manner. The air being very clear at first, I observed the moon surrounded with a double corona (near her body, as the figure seems to represent) tinged with very bright and beautiful colours. On each side of the moon there were two arches of a large circle, about 45 degrees in diameter, which were also coloured like the rainbow, and extended down to the horizon, in which were two mock moons with very long white tails. That on the left hand was near Procyon with a short tail; the other on the right hand had a longer tail. In the upper part, where these collateral arches concurred, there was another arch inverted, and variously coloured with a third mock moon in the middle of it, and somewhat duller than the other two. Moreover, what was very extraordinary, there passed a large white rectangular cross through the middle of the moon, whose lower part reached down to the horizon; but on each side it did not quite touch the corona, as appears by the Figure. It was so very bright and strong, that it shone distinctly and clearly till sun-rise; but the mock moons disappeared a little before."

Halo seen in 1233.

Plate CCLXXXV Fig. 7.

In Mathew Paris's History, the phenomenon seen in Fig. 7. is thus described: "A wonderful sight was seen in England A. D. 1233, April 8. in the 17th year of the reign of Henry III. and lasted from sun-rise till noon. At the same time, on the 8th of April, about one o'clock, on the borders of *Herefordshire* and *Worcestershire*, besides the true sun, there appeared in the sky four mock suns of a red colour; also a certain large circle of the colour of crystal, about two feet broad, which encompassed all England as it were. There next went semicircles from the side of it, in whose intersections the four mock suns were situated; the true sun being in the east, and the air very clear. And because this monstrous prodigy cannot be described by words, I have represented it by a scheme that shews immediately how the heavens were circled. The appearance was painted in this manner by many people for the wonderful novelty of it."

Halo seen at Leyden in 1653. Fig. 8.

Figure 8. represents a parhelion observed at Leyden A. D. 1653, Jan. 14, between one and two o'clock in the afternoon, in the academical observatory, by Samuel Char. Kechelius a Hollenstein. "The circle BDC was white, and almost 35′ broad; the altitude of its highest point D was 38° 23′. Its centre was in the sun, whose height was 15° 48′; that is, at 36′ past one, his azimuth being 23° 40′ towards the west, and the angle made by his vertical circle and the ecliptic 60° 54′. The mock suns B, C were oblong and unequal, at the distance of 22° 35′ on each side of the sun, and had the same altitudes as the sun. The western parhelion at C was the fainter of the two, and changed from yellow to white, and disappeared first; the eastern one at B was brighter, with a lucid arch shooting from the sun, and was coloured with purple, red, and yellow; the shape of its tail BF was conical, 27° long, the parhelion being the base of the cone; the part BE, 13° 10′ long, consisted of bright yellow, and red light; the other part EF being whitish, which vanished before the parhelion did. It appeared for half an hour, and lasted one quarter longer than C; and the corona disappeared a little after."

Halo seen by Huygens in 1652.

On the 13th May, 1652, Huygens observed a halo, which he thus describes:—"I observed a circle about the sun in its centre; its diameter was about 46°, and its breadth the same as that of a common rain-bow. It had also the same colours, though very weak, and scarce discernible but in a contrary order, the red being next the sun, and the blue being very dilute and whitish. All the space within the circle was possessed by a duller vapour than the rest of the air; of such a texture as to obscure the sky with a sort of a continued cloud;

Halo.

but so thin, that the blue sky colour appeared through it. The wind blew very gently from the north."

Halos observed by Halley 1702.

Plate CLXXXVII Fig. 9.

On the 8th of April, 1702, Dr Halley observed a halo with parhelia, and tangent arches, as shewn in Fig. 9. where S is the sun, Z the zenith, STPP a large white circle passing through the sun, and nearly parallel to the horizon. It was about 2° broad in the northern part about T, and continued of the same breadth in the east and west; but grew narrower towards the sun. Its edges were not very well defined, and the whole circle, seen on the pure azure sky, was considered by Dr Halley as a very extraordinary sight. The halo VXNY was 22° in diameter, the red rays being nearest to the sun. The arch PVP had its centre nearly at N; and at its intersections P, P with the large white circle, there were two bright parhelia tinged with colours. The distance PS was 31½°. Another arch appeared at N, having its centre about V. The height of the sun during the observation was from 40° to 45°. The weather was cooler than ordinary, and the vapour which produced the phenomena was higher than the clouds; for they were seen to drive under the circles. See *Phil. Trans.* 1702, vol. xxiii. No. 278, p. 1127.

Halos seen North America by Barker 1771.

A very curious halo, with its accompanying phenomena, was seen by Mr Barker on the 22d of January 1771, a little before two o'clock, at Fort Gloucester, on the river of Lake Superior. The weather was extremely cold. "There was a very large circle, or halo, round the sun, within which the sky was thick and dusky, the rest of the hemisphere being clear, and a little more than half way from the horizon to the zenith, was a beautifully enlightened circle parallel to the horizon, which went quite round, till the two ends of it terminated in the circle that surrounded the sun, where, at the points of intersection, they each formed a luminous appearance about the size of the sun, and so like him when seen through a thick hazy sky, that they might very easily have been taken for him. Directly opposite to the sun was a luminous cross, in the shape of a St Andrew's cross, cutting at the point of intersection the horizontal circle, where was formed another mock sun like the other two. The two lower limbs of the cross appeared but faintly, a little way below the circle. The two higher reached a good way above the circle towards the zenith, very clear and bright. In this horizontal circle, directly half way between the sun and the cross, and those at the ends of the same circle, were other two mock suns of the same kind and size, one on each side; so that in this horizontal circle were five mock suns at equal distances from each other, and in the same line the real sun, all at equal heights from the horizon. Besides these meteors, there was very near the zenith, but a little more towards the circle of the real sun, a rainbow of very bright and beautiful colours, not an entire semicircle, with the middle of the convex side turned towards the sun, which lowered as the sun descended. This phenomena continued in all its beauty and lustre till about half after two. The cross went gradually off first, then the horizontal circle began to disappear in parts, while in others it was visible; then the three mock suns farthest from the sun, the two in the sun's circle continuing longest; the rainbow began to decrease after these, and last of all the sun's circle; but it was observable at three o'clock or after it. See *Phil. Trans.* 1787, vol. lxxvii. p. 44.

Halos, &c. observed by Lowitz 1790. Fig. 10.

On the 18th June 1790, a complicated system of halos and parhelia was observed at St Petersburg by M. Lowitz. They are represented in Fig. 10. The arches A, B, and C were coloured, and, like all the other coloured parts, had the red towards the sun. Two anthelia appeared at D and E.

Halo observed by Mr Hall in 1796. Plate CCLXXXVII Fig. 11.

A curious halo, observed by Mr Hall in Berwickshire, on the 18th of February 1796, about 10 o'clock, is shewn in Fig. 11. The moon was about south-west, and the altitude of her limb nearly 54°. The diameter of the great halo was about 112°; and that of the small halo, having the moon in its centre, was between 8° and 12°. The weather was remarkably mild, and there was little or no wind.

Halos observed by Sir H. Englefield in 1802. Fig. 12.

On the 20th of November 1802, at 2 o'clock, Sir Henry Englefield observed at Richmond in Surry, two uncommon halos and parhelia. The altitude of the sun was 14°. The circle nearest the sun (Fig. 12.) was about 24° distant from him, and about a degree broad. Its light was a pale yellow, without any of the prismatic colours. The exterior circle was 48° from the sun, and about 1½° broad. It was tinged with the prismatic colours, the red being nearest the sun. In the left branch of the inner circle, in a line parallel to the horizon, and passing through the sun, was a very faint parhelion; but in the upper point of the same circle was a very remarkable one. Its light was so vivid that it could scarcely be viewed, and it was rather brighter than the real sun. "It was of a whiter light than the rest of the circle in which it was, and had a pearly appearance, as partaking a little of prismatic tints. It was large, perhaps in its brightest part near 2° broad, very ill defined everywhere, but most diffused in the part farthest from the sun. From each side of the bright light proceeded a bright ray, which had a double curvature very distinct, being first convex towards the sun, and then concave. The lower edge of these rays (or that nearest the sun) was tolerably well defined; the upper edge melted away into the sky with a sort of streakiness. They grew both narrower and fainter towards their termination, and they reached pretty near to the other circle. The whole form of this parhelion and its rays bore so striking a similitude to the body and extended wings of a long winged bird; such as an eagle, hovering directly over the sun, that superstition would really have had little to add to the image." See the *Journals of the Royal Institution*, vol. ii. or Nicholson's *Journal*, vol. vi. p. 54. A coloured drawing of this phenomenon, will be found in Dr Thomas Young's *Natural Philosophy*, vol i. plate xxix. Fig. 431.

Theory of halos.

Having thus given a description of some of the most interesting halos and parhelia that have been accurately observed, we shall now proceed to give some account of the theories by which these phenomena have been explained.

Opinion of Descartes.

Descartes supposes that halos are generated by the rays of the sun refracted through flat stars of pellucid ice; but it follows from this supposition, that the space within the halo should appear brighter than that without, which is contrary to observation. See Descartes, *Meteorolog.* cap. x.

Opinion of Huygens.

The subject of halos was next investigated by Huygens, who published a large dissertation concerning their cause, which has been translated and reprinted by Dr Smith, in his *Treatise on Optics*. Huygens assumes the existence of particles of hail, some of which are globular, and others cylindrical, with an opaque portion in the middle of each, bearing a certain proportion to the whole; and he supposes these cylinders to be kept in a vertical position by a current of ascending air or vapours, and sometimes to have a position inclined to the horizon in all directions when they are dispersed by the wind or otherwise. The cylinders are supposed to have been at first globules, formed of the softest and finest particles of snow. As soon as a globule is formed by a collection of these particles, many more particles will adhere to the bottom of it, but not to its sides, on account of the current of ascending vapours. The globules will thus have an oblong cylindrical figure; and when the warmth of the sun or of the air shall have melted the outsides of these cylinders, a smaller cylinder of snow will remain in the middle of each of them, surrounded with water; and after a certain part is melted, the cylinders within will become round and perfect, and will remain in this state for some time. If this coat of water should be frozen, Huygens supposes that it may possibly remain sufficiently transparent and polished to transmit, refract, and reflect the rays of the sun in a regular manner. By the aid of these assumptions, Huygens has ingeniously explained, in a very minute manner, almost all the principal phenomena of halos which had been seen at the time when he wrote. It is extremely improbable, however, that such hailstones do exist, and still more improbable that they should have such properties as to produce constantly the diameter of 47°.

Sir Isaac Newton's explanation of halos.

Sir Isaac Newton ascribes the halo of $22\frac{1}{2}$ degrees by refraction from floating hail or snow, and he accounts for the small coloured coronæ by his doctrine of fits of easy reflexion and transmission. "As light reflected by a lens," says he, "quicksilvered on the backside, makes the rings of colours above described, so it ought to make the like rings of colours in passing through a drop of water. At the first reflection of the rays within the drop, some colours ought to be transmitted, as in the case of a lens, and others to be reflected back to the eye. For instance, if the diameter of a small drop or globule of water be about the 500th part of an inch, so that a red-making ray, in passing through the middle of this globule, has 250 fits of easy transmission within the globule, and that all the red-making rays which are at a certain distance from this middle ray round about it have 249 fits within the globule, and all the like rays at a certain further distance round about it have 248 fits, and all those at a certain farther distance 247 fits, and so on; these concentric circles of rays, after their transmission, falling on a white paper, will make concentric rings of red upon the paper, supposing the light, which passes through one single globule, strong enough to be sensible; and, in like manner, the rays of other colours. Suppose now that, in a fair day, the sun shines through a thin cloud of such globules of water or hail, and that the globules are all of the same bigness, and the sun seen through this cloud shall appear encompassed with the like concentric rings of colours, and the diameter of the first ring of red shall be $7\frac{1}{4}$°, that of the second $10\frac{1}{4}$°, that of the third 12° 33′. And according as the globules of water are bigger or less, the rings shall be less or bigger. This is the theory, and experience answers it. For, in June 1692, I saw, by reflection in a vessel of stagnating water, three halos, crowns, or rings of colours about the sun, like three little rain-bows concentric to his body; the colours of the first or innermost crown were blue next the sun, red without, and white in the middle between the blue and red. Those at the second crown were purple and blue within, and pale red without, and green in the middle; and those of the third were pale blue within, and pale red without. These crowns inclosed one another immediately, so that their colours proceeded in this continual order from the sun outward; blue, white, red; purple, blue, green; pale yellow, and red; pale blue, pale red. The diameter of the second crown measured from the middle of the yellow and red on one side of the sun, to the middle of the same colour on the other side, was $9\frac{1}{3}$°, or thereabouts. The diameters of the first and third I had not time to measure; but that of the first seemed to be about five or six degrees, and that of the third about 12°. The like crowns appear sometimes about the moon; for, in the beginning of the year 1664, February 19th, at night, I saw two such crowns about her. The diameter of the first or innermost was about 3°, and that of the second about $5\frac{1}{2}$°. Next about the moon was a circle of white, and next about that the inner crown, which was of a bluish green within next the white, and of a yellow and red without, and next about these colours were blue and green on the inside of the outward crown, and red on the outside of it. At the same time, there appeared a halo about 22° 35′ distant from the centre of the moon. It was elliptical, and its long diameter was perpendicular to the horizon verging below farthest from the moon. I am told, that the moon has sometimes three or more concentric crowns of colours encompassing one another next about her body. The more equal the globules of water or ice are to one another, the more crowns of colours will appear, and the colours will be the more lively. The halo at the distance of $22\frac{1}{2}$° from the moon is of another sort. By its being oval and remoter from the moon below than above, I conclude, that it was made by refraction in some sort of hail or snow floating in the air in an horizontal posture, the refracting angle being about 58° or 60°." See Newton's *Optics*, Book ii. Part iv. *Obs.* 13.

Theory of Mariotte.

M. Mariotte supposes halos to be produced by small filaments of snow moderately transparent, and having the form of an equilateral triangular prism. He conjectures, that the hard flakes of snow which fall during a hard frost, and which have the figure of stars, are composed of little filaments like equilateral prisms, particularly those which are like fern leaves, as may be easily seen by the microscope. Upon examining the filaments which compose the hoar frost, he found them cut into three equal facets, and they exhibited rainbows when placed in the sun. Mariotte then supposes, that before the hoar frost is formed, some of these separate prisms float among the thin vapours in the air, before they unite into the compound figures. "These little stars," says he, "are very thin and very light, and the little filaments which compose them are still more so, and may often be supported a long time in the air by the winds. Hence, when the air is moderately filled with them, so as not to be much darkened, many of them, whether separate or united, will turn in every direction as the air impels them, and will be disposed to transmit to the eye for some time a coloured light, nearly like to that which would be produced by equilateral prisms of glass." M. Mariotte then calculates the angles; and by deducting 16′ for the sun's semidiameter, and 30′ for the deviation of the red rays, he finds 22° 50′ to be the semidiameter of the halo produced by equiangular prisms.

In attempting to account for parhelia, Mariotte observes, "that they are usually at the same altitude as the sun. Among the prisms of snow, there are often many heavier at one end than at the other, and consequently situated in a vertical direction. These cause a bright parhelion with a tail, which cannot be above 70° long. I have read an account of a halo seen in May, soon after sun-rise, with parhelia in its circumference, which, after two or three hours, were more than a degree distant from it. This appearance arises from the coincidence of the sun's rays with the transverse section of the prism, when they are nearly horizontal, and from their obliquity, when the sun is elevated, causing a greater deviation, and throwing the parhelia outwards, Halo. as may be shewn by an experiment on two prisms." See Mariotte *Traité des Couleurs*, Paris 1686, or *Œuvres de Mariotte*, vol. i. p. 272.

Wood's theory. A theory of halos has recently been given by Mr Wood in the Manchester Transactions. He assumes, with Dr Halley, that vapour consists of hollow sphericles of water, filled with an elastic fluid, and having a thickness equal to $\frac{1}{11}$ of their diameter; and he supposes the halos to be produced by refraction, and reflection from these, in the same manner as the rainbow is produced by solid drops. See *Manchester Memoirs*, vol. iii. p. 336. A similar opinion seems to be entertained by M. Brande. See Gilbert's *Journal*, vol. xi. p. 414.

Dr Young's theory. The subject of halos has recently been examined with much attention by our learned countryman Dr Thomas Young, who, before he was acquainted with the explanation of Mariotte, had adopted the very same theory. Our readers will no doubt be gratified with an account of Dr Young's theory and calculations in his own words.

"It is well known, that the crystals of ice and snow tend always to form angles of 60°; now a prism of water or ice of 60°, produces a deviation of about 23½°, for rays forming equal angles with its surfaces, and the angle of deviation varies at first very slowly as the inclination changes, the variation amounting to less than 3°, while the inclination changes 30°.

Now if such prisms were placed at all possible angles of inclination, differing equally from each other, one half of them would be so situated, as to be incapable of transmitting any light regularly by two successive refractions directed the same way; and of the remaining two-fourths, the one would refract all the light within these 3°, and the other would disperse the light in a space of between 20° and 30° beyond them.

In the same manner, we may imagine an immense number of prismatic particles of snow to be disposed in all possible directions, and a considerable proportion of them to be so situated, that the plane of their transverse section may pass within certain limits of the sun and the spectator. Then half of these only will appear illuminated, and the greater part of the light will be transmitted by such as are situated at an angular distance of 23½°, or within 3° of it, the limit being strongly marked internally, but the light being externally more gradually lost. And this is precisely the appearance of the most common halo. When there is a sufficient quantity of the prismatic particles, a considerable part of the light must fall, after one refraction, on a second particle; so that the effect will be doubled: and, in this case, the angle of refraction will become sufficient to present a faint appearance of colour, the red being internal, as the least refrangible light, and the external part having a tinge of blue.

These concentric halos of 23½° and 47°, are therefore sufficiently explicable, by particles of snow, situated promiscuously in all possible directions. If the prisms be so short as to form triangular plates, these plates, in falling through the air, will tend to assume a vertical direction, and a much greater number of them will be in this situation than in any other. The reflection from their flat surfaces will consequently produce a horizontal circle of equal height with the sun; and their refraction will exhibit a bright parhelion immediately over the sun, with an appearance of wings or horns, diverging upwards from the parhelion.

For all such particles as are directed nearly towards the spectator, will conspire in transmitting the light much more copiously than it can arrive from any other part of the circle; but such as are turned more obliquely, will produce a greater deviation in the light, and at the same time a deflection from the original vertical plane. This may be easily understood, by looking at a long line through a prism held parallel to it: the line appears, instead of a right line, to become a curve, the deviation being greater in those rays that pass obliquely with respect to the axis of the prism; which are also deflected from the plane in which they were passing.

The line viewed through the prism has no point of contrary flexure, but if its ordinates were referred to a centre, it would usually assume a form similar to that which has often been observed in halos.

The form of the flakes of snow as they usually fall, is indeed more complicated than we have been supposing; but their elements in the upper regions of the air are probably more simple. It happens however not uncommonly, that the forms of the luminous arches are so complicated, as almost to defy all calculation. The coincidence in the magnitude of the observed and computed angles is so striking, as to be nearly decisive with respect to the cause of halos, and it is not difficult to imagine that many circumstances may exist, which may cause the axes of the greater number of the prisms to assume a position nearly horizontal, which is all that is required for the explanation of the parhelia with their curved appendages. Perhaps also, the effect may sometimes be facilitated by the partial melting of the snow into conoidal drops; for it may be shown, by the light of a candle transmitted through a wine glass full of water, that such a form is accommodated to the production of an inverted arch of light, like that which is frequently observed to accompany a parhelion.

The situation of the lateral parhelia without the halo, is very satisfactorily explained by Mariotte; and the diversified forms of the tangent arches, may probably all be deduced from the suppositions laid down in the Journals of the Royal Institution. As an instance, we may take the case there described by Sir Henry Englefield, (see p. 615, *supra*,) where the sun's altitude was about 15°. The horizontal prisms will then cause an appearance of an arch with a contrary curvature, exactly as Sir Henry has described it.

The calculation is somewhat intricate. Its principal steps are these, taking the refractive power $\frac{4}{3}$.

Deviation of transverse rays 23° 37′.

For rays inclined 20°, the inclination of the planes of the rays is 29° 32′, the deviation 26° 12′; the altitude being 15°, the angle with the horizon is 25° 8′ more than the altitude.

For rays inclined 25°, the inclination of the planes is 34°, the deviation 27° 47′, the angle with the horizon 25° 47′ more than the altitude 15°.

For rays inclined 30°, the inclination of the planes is 120°; that is, the rays are in the planes of the surfaces, the deviation 38° 56′, the angle with the horizon 6° 4′ less than the altitude 15°.

When the altitude increases, the tangent arch descends so as to approach considerably to the halo, as in the halos observed by Halley and by Barker. For, calculating upon the true refractive power of ice, the angles become these.

For rays inclined 25°, the inclination of the planes 30° 55′, the deviation 25° 40′ = 21° 50′ + 3° 50′, the angle with the horizon 56° 24′ = 45° + 11° 24′. For altitude 15°, 38° 57′ = 15° + 23° 57′.

It may also become double, the inferior arch being visible. Thus the angle with the horizon becomes 21° 18′ or 45°—23° 42′, as well as 56° 24′.

The mode of calculation is this: A being the inclination within the prism, and r the index. Sec. B $= \frac{\text{Sec. A}}{\sqrt{\frac{3}{4}}}$ for the incidence; S.C $= r$.S.B, D $=$ C $-$ B. As S.C : Sec. A :: S : D : x, $\sqrt{\frac{3}{4}}x = y$, $1 - y : \frac{1}{2}x$ :: Rad : T.E, 2 E is the mutual inclination of the planes passing through the rays and the axis of the prism, $\frac{T.A}{r} : \frac{1}{2}x$ :: Rad : S.F; 2 F is the whole deviation; $1 - \overline{y^2 + \frac{1}{4}xx} = zz$; $z : \frac{T.A}{r}$ :: S. Altitude : S. G, the elevation of the plane of the incident ray; G $\pm$ 2 E $=$ H the elevation of the plane of the emergent ray; $\frac{T.A}{r} . z$ :: S.H : S.I, the depression of the emergent ray.

Mr Cavendish has suggested, with great apparent probability, that the external halo may be produced by the refraction of the rectangular termination of the crystals, rather than by two successive refractions through the angles of different crystals, which, with the index 1.31, would produce a deviation of 45° 44′. If this supposition is true, the index cannot be greater than 1.31; * for 1.32 would give 47° 56′, which is more than appears to have ever been assigned.

The mean of 4 accurate observations is about 45° 50′, that of 4 of the best estimations 46°.

The lateral anthelia may be produced by the rays refracted after two internal reflections, which will have a constant deviation 60° greater than those which form the halo. These anthelia ought therefore to be about 82° from the sun. They are, however, usually represented as much more distant."

In addition to the works referred to in the course of the preceding article, see Zahn *Mundi Œconomia*. Lycosthenis *Chronicon Prodigiorum*. Fritsch *On Meteors*. *Philosophical Transactions*, 1665—6, i. 219. *Id.* 1669, iv. 953. *Id.* 1670, v. 1065. *Id.* 1699, xxi. 107 and 126. *Id.* 1700, xxii. 535. *Id.* 1721, xxxi. 201, 212. *Id.* 1722, xxxii. 89. *Id.* 1727, xxxv. 257. *Id.* 1732, xxxvii. 357. *Id.* 1737, xl. 50, 54, 59. *Id.* 1740, xli. 459. *Id.* 1742, xlii. 47, 60, 157. *Id.* 1748, xlv. 524. *Id.* 1749, xlvi. 203. *Id.* 1761, 3, 94. *Id.* 1763, 351. *Id.* 1770, 129. *Id.* 1784, 59. *Id.* 1787, 44. *Mem. Acad. Par.* ii. 208. *Id.* x. 47, 152, 168, 275, 411, 454. *Id.* 1699, Hist. 82. *Id.* 1713, Hist. 67. *Id.* 1721, 231. *Id.* 1729, Hist. 2. *Id.* 1735, 87, 585. *Id.* 1743, Hist. 33. *Id.* 1745, Hist. 19. *Id.* 1753, Hist. 75. *Id.* 1754, Hist. 32. *Id.* 1755, Hist. 37. *Id.* 1758, Hist. 23. *Id.* 1786, 44. *Memoires de Berlin*, 1734, iv. 64. *Nov. Comment. Petrop.* vi. 425. *Id.* viii. 392. *Id.* x. 375. Weidler, *De Parheliis Anni* 1736. *Irish Transactions*, 1787, i. 23. *Id.* 1789, iv. 143. *Edinburgh Transactions*, iv. 174. *Edinburgh Essays*, i. 297. Rozier's *Journal*, xi. 377; xxxvii. 308. Dr Thomas Young's *Natural Philosophy*, i. 443; ii. 303—309; and our article GREENLAND.

HALSTEAD, a town of England in the county of Essex, is agreeably situated on the acclivity of a gravelly eminence, at the foot of which passes the river Colne. The streets of the town are broad and airy, but many of the houses are old and inelegant. The church dedicated to St Andrew, is an old building. It consists of a nave, chancel, and side aisles, and has a tower and spire at the west end. The spire is of wood, and is the third that has been erected, the other two having been destroyed by lightning. The grammar school was founded in the year 1594, by Dame Mary Ramsay for 40 poor children of Halstead and Colne-Engaine. The direction of it is vested in the governors, &c. of Christ's Hospital, London. The Bridewell is an ancient building. There is a Greek inscription on a house in the parish, which was brought from a village near Smyrna, where it had been erected in honour of Crato a musician, about 150 years before Christ. Halstead formerly carried on a considerable trade in baize and serges, but it has of late much declined. In 1802, 1654 were returned as employed in manufactures, whereas in 1811 only 1170 were returned. In 1811, there were in the town and parish of Halstead,

Inhabited houses	722
Number of families	803
Do. employed in agriculture	288
Total population	3279

See Morant's *History of Essex*, and the *Beauties of England and Wales*, vol. v. p. 254.

HAM, or HAMM, in Latin *Hammona*, a town of Westphalia, and capital of the county of the same name, is situated near the place where the Asse throws itself into the Lippe. Its principal public buildings are its parish church and Calvinistic academy with three professors, and it has excellent establishments for the support of the poor. Ham was formerly one of the Hanseatic towns. It has long been celebrated for its excellent hams, which are called *hammen* in Holland, and for its fishery. Great quantities of linen are bleached here; and it is famous for a kind of beer called *reut*, which is sold to a considerable extent in the neighbourhood. Distance from Munster 6 leagues S. E. and from Cologne 18 leagues N. E.

HAMAH, *Epiphania*, and the *Apamea* of Strabo, is a town of Syria, situated in a narrow valley on the banks of the Orontes. It lies between Aleppo and Tripoli, and is about 30 leagues east of Tripoli, and 40 north of Damascus. It was founded by Seleucus Nicanor, who supported no fewer than 500 elephants in its fertile territory; and is famous for having been the place where the Romans, under Aurelius, defeated Zenobia, Queen of Palmyra. Hamah was destroyed in 1157 by a dreadful earthquake, but was afterwards rebuilt. This town is now celebrated for its water works, in which the water is raised from the river by wheels 32 feet in diameter. The water falling into the buckets, is elevated to the height of 30 feet, and discharged into a reservoir, from which it is conveyed to the public and private baths. The gardens around are very agreeable and fertile, and the surrounding country is well adapted for wheat and cotton. The Maronites built a chapel and a tomb here, from which arose a convent which is celebrated in that part of Syria. There is here a strong castle. Hamah is the seat of a Jacobite bishop, and a pacha has the government of all the canton. Population, 4000. See M. De La Roque's *Voyage de Syrie*.

HAMBURGH is a free imperial city of the duchy of Holstein in Lower Saxony, and one of the largest, richest, and most populous cities in Germany. It is situated on the right or northern bank of the river Elbe, at the distance of about seventy miles from its discharge into the German Ocean. East Long. 9° 56′, North

* The index of refraction for ice, according to Dr Brewster's experiments, is 1.307. See *Treatise on New Philosophical Instruments*, p. 288. This measure renders Mr Cavendish's suggestion more probable.

Hamburgh. Lat. 53° 36′. The number of inhabitants fluctuates from 110,000 to 120,000.

Town. This city is divided by a canal into the old and new town. It is built partly on islands, and partly on the continent of the north side of the Elbe. Towards the east it is washed by the small river Bil, and towards the north by another small river called the Alster, which forms a very large basin just without the town, and another about 1000 feet square within the walls, after which it passes through different parts of the city, and then discharges itself into the Elbe. The several islands formed by the rivers Elbe and Alster, on which the town is built, have a communication with each other by eighty-four bridges. The whole city is surrounded by a lofty rampart, and a broad ditch. The town, although large and flourishing, is by no means elegant. The principal streets have long and broad canals, which are filled by the tide; the others, especially in the old town, are mean, narrow, and ill paved. The houses are mostly built after the Dutch fashion, and very lofty, several of them being six or seven stories high. The warehouses of the merchants are generally in the upper part of the building, to prevent damage from the frequent inundations occasioned by high floods in the river, the back part of the houses being commonly so near the water, that their vessels come to unload at the very doors. The most beautiful parts of the town are the *Jungfernstoig*, which is the fashionable promenade, especially on Sundays, and the streets and alleys along the Alster.

Public buildings. The principal public buildings in this city are the churches of St Peter, St Nicholas, St Catharine, St James, St Michael, St John, and the cathedral. These are mostly Gothic structures, having lofty spires, beautiful altars, and large organs. From the spire of the church of St Michael, there is an extensive and charming view of the town and its environs. The exchange, the orphan-house, the several hospitals, the room-house, the house of Eimbeck, and the obelisk in honour of Professor Busch, are also worthy of notice.

Hamburgh was founded in the beginning of the 9th century, by Charles, the eldest son of the Emperor Charlemagne, who was commanded by his father to erect two forts on the Elbe, with the view of repelling the incursions of the Venedi, a Sclavonic nation inhabiting the southern coasts of the Baltic. The fort on the north side of the river, was called Hammenburg, (whence, by abbreviation, Hamburgh,) or the castle near the wood, according to the etymology of the name given by Christopher Silvius, an ancient poet of Hamburgh:

Hamburgum silva cui notum nomen ab Hama,
Inter Billa tuos, et olorifer Alstria ductus.

History. This city has undergone a variety of revolutions. It was made an archbishop's see by Lewis the Debonnaire in 833; but the see was afterwards transferred to Bremen. Upon the extinction of the Carlovingian line, it became subject to the dukes of Saxony, of whom it was afterwards held by the counts of Holstein. Adolphus III. in consideration of a sum of money, with which the Hamburghers furnished him upon his expedition to the Holy Land, favoured them with a great many privileges, which were subsequently confirmed by the emperor Barbarossa. The citizens afterwards purchased their entire liberty from Albert of Orlamund, count of Holstein, for the sum of fifteen hundred marks of silver; and it was confirmed to them by succeeding counts, as well as by Christian I. king of Denmark, after the county of Holstein had devolved to that crown. The Danish kings, however, have, on several occasions, revived their claims to the sovereignty of this city, which has frequently obliged the inhabitants to pay very large sums for the confirmation of their liberties. But Hamburgh was declared a free imperial city in the year 1618, and was summoned to the diet of the empire in 1641.

Government. The government of this city is vested in the senate and the three colleges of burghers. The former exercises the executive power, and has the right of assembling and dissolving the body of the burghers; the latter grant taxes, and administer the revenue. The senate consists of thirty-six persons, viz. four burgomasters, four syndycs, twenty-four counsellors, and four secretaries or clerks, the chief of whom is called a prothonotary. The burgomasters and counsellors only have votes. When a vacancy occurs, a new member is chosen by lot. The members of the legislative body are chosen from the five parishes or wards of the city. The first college consists of the aldermen, three of whom are chosen by the inhabitants of each parish. Every parish also sends nine persons to the second, and twenty-four to the third college. The ordinary business is regularly brought by the senate before this assembly; but when there is a new law to be made, or a new tax to be raised, after having passed this court, the measure must farther be laid before a general assembly of the burghers, in which every inhabitant householder may appear and give his vote.

Trade and commerce. Hamburgh is most advantageously situated for trade and commerce, both foreign and domestic. The Elbe forms a good harbour, being navigable for ships of large burthen until within four miles of the town, when they must unload into smaller vessels, which, by means of the canals which traverse the city, can be brought to the very doors of the warehouses. At the period when the Hanseatic league was formed, Hamburgh became a principal member of that celebrated confederacy, which brought the trade of the world to the ports of the Baltic and the north of Germany. In subsequent times, when the other nations of Europe, particularly the Dutch and the English, cultivated a more extensive commerce, the trade of Hamburgh, along with that of the other Hanseatic towns, declined. But its situation is so favourable, that it has always been able to command a considerable commerce, especially when the great maritime powers are at war, as Hamburgh then becomes the great mart for colonial produce destined for the supply of the continent of Europe. During the war of the French revolution, the trade of this city rapidly increased; and it still continued to enjoy the advantages of its situation, capital, and credit, under the continental system adopted by Bonaparte, in consequence of which, most of the ports of Europe were shut against the commerce with England. While the blockade of the Elbe continued, the merchants of Hamburgh still carried on a profitable, though circuitous trade, by the Danish ports of Tonningen and Husum. But the prosperity of this commercial city received a severe blow by its forcible seizure and unnatural incorporation with the French empire, and the subsequent plunder of the bank. Since the overthrow of Bonaparte's system, and the consequent return of Hamburgh under its old laws and government, that city may be expected to recover, in some measure, its former prosperity and importance.

The commerce of Hamburgh consists, 1*st*, In the ex-

Hamburgh. port of its manufactured produce; *2dly,* In the importation of foreign merchandise; and, *3dly,* In the re-exportation of these last articles to different parts of the continent. The principal manufactures of this city, are the refining of sugar, the printing of cotton cloths, the manufacture of velvets and silk stuffs, of laces, metal buttons, knit stockings, sail cloth, &c. The establishments for the refining of sugar, which are very numerous, have been long flourishing, and are esteemed among the best in Europe. It has been calculated that they produced daily 700 small loaves of sugar, of about $3\frac{1}{2}$ pounds weight, and 400 large loaves, from 6 to 7 pounds. The raw sugar is procured chiefly from England, the earth used in purifying it from Rouen, and a great part of the manufactured article is exported to Russia. The printing of cotton formerly employed twelve establishments, which gave occupation to 600 workmen each; but their number has been since greatly reduced, in consequence of similar manufactories having been established in other countries. There are about twenty establishments for the manufacture of velvets and laces, which are exported to Russia and different parts of Germany. The manufacture of silk stuffs and woollens is inconsiderable, and only for home consumption. That of knit stockings is of more importance. They are sent into the interior of Germany, and some occasionally to Italy. Dyeing forms another branch of the manufactures of Hamburgh, whose dyers are esteemed the best in Germany. Besides its own manufactures, Hamburgh imports from England, France, Holland, Italy, &c. all sorts of rich silk stuffs, and the finest velvet brocades, besides fine cloths of all kinds, for the purpose of re-exportation. This city also exports timber to a considerable amount annually, particularly to France and Spain.

Manufactures.

The number of vessels which entered the port of Hamburgh in 1791 was 1484; and the value of the imports, for the same year, amounted to 112,554,026 livres, or about £4,689,751 sterling. After the raising of the blockade of the Elbe, the number of shipping which annually entered the port was calculated at from 1900 to 2000. The number of vessels belonging to the merchants of Hamburgh, and employed by them, amounted to about 400.

Bank of Hamburgh.

The bank of Hamburgh was established in the year 1619 upon the same principles with that of Amsterdam. It was intended as a general fund for the convenience of the merchants, who, by means of this institution, make and receive payment, without the intervention of specie, by a mere transfer in the books of the bank. The specie deposited consists of bank dollars and ingots of silver. This specie has no ordinary circulation; consequently the fund always remains entire; and the money of the bank thus serves as a standard for measuring the value of all other specie. The bank closes every year, from the last day of December to the 14th of January, for the purpose of balancing the books. It is under the direction of four of the principal persons of the city; and no person is entitled to have an account with it who is not either a citizen or an inhabitant. There are two kinds of money at Hamburgh; real money, and money of account; the latter being partly real and partly imaginary. The mark *lub.* which is equal to about 1s. 6d. of our money, is divided into sixteen shillings, and each shilling into twelve fennings, or pence. The rix-dollar contains three marks *lub.* It is called the rix-dollar current, which must not be confounded with the rix-dollar of the bank; the latter being more valuable, and equal to about 4s. 10d. of our money. In general the money of the bank is worth from 15 to 20 per cent. more than the current money, and the difference in exchange is called *agio*. Besides these, they have gold ducats, current at seven marks, more or less, and double ducats at fourteen marks. Foreign gold is also received at its intrinsic value, according to the rate of exchange, which is regularly advertised twice a week. The bank receives payment in its own money only. In the year 1725, the magistrates of Hamburgh resolved to coin some new specie, which is called the new current money of Hamburgh, and consists of pieces of 1 and 2 marks, of eight shillings, or half a mark, four shillings, or a quarter mark, and several of smaller denomination, conformable to the standard of the old dollar. The *agio* for this specie, in exchange with the bank, was fixed at 16 per cent. A new bank was also established, at the same time, for the convenience of the town, which could not receive any money but that coined by the city, the *agio* being regulated by a combination between the two banks. By these means, business is conducted with more ease and regularity, and the merchants are not liable to loss from the difference of value in the several denominations. The usance, or course of exchange, is at fifteen days sight, for bills drawn on any part of Germany; a month's date, for those drawn on France or on London; and two months for those drawn on Venice, or on Spain or Portugal. There are twelve days of grace allowed, including the day of the bill's falling due, the Sundays, and holidays.

Chamber of insurance.

The chamber of marine insurance was instituted in 1705. Six of the most wealthy merchants provided a fund, which was divided into 500 actions, or shares, of £100 each; and the business has been conducted with the greatest success. There are also establishments for the other species of insurance. In the Lombard, or town pledge house, money is advanced, at an interest of six per cent. on every kind of goods and merchandise, without the intervention of a broker. When the time during which the sum was lent has expired, the goods must be redeemed; otherwise they are sold for their value, and the excess is faithfully transmitted to the person to whom they belonged. By this institution the town is said to gain about 150,000 crowns annually.

Police.

The police of this city is admirable. There are few or no beggars in the streets, as the magistrates take care to employ the indigent, who are able and willing to work, in the manufacture of knit stockings, and to send all vagabonds and sturdy beggars, who refuse to work, to the house of correction. The few who are incapable of labour are maintained by their respective parishes. The establishments for the poor, indeed, are nowhere more liberal or better administered, than at Hamburgh. They have a very large hospital for ophans, which possesses a revenue amounting to between six and seven thousand pounds. There is also a large hospital for the reception of poor infirm labourers, and another for aged and disabled seamen; besides many smaller institutions for poor widowers and widows, &c.; with two houses of correction, the *Zucht-Haus*, and the *Spinn-Haus*, in which malefactors are kept close at work with a spare diet.

Citizenship.

Citizenship, at Hamburgh, is personal. The son of a citizen, therefore, is not a citizen of right, but must purchase his franchise. A Hamburgher, or a stranger, who does not chuse to purchase the citizenship, must pay a stipulated sum annually to the town, to entitle him to engage in trade as a merchant, besides all the other duties and imposts to which the other citizens are

Hamburgh, Hamel. liable. The income of the state is very large. It is composed partly of standing sources of revenue, and partly of occasional taxes granted by the community. Revenue. The aggregate revenue is estimated at 3,800,000 marks, or about £285,000 sterling. The established religion of the city is the Lutheran, and no other public exercise of religion is tolerated. Religion. But persons of a different persuasion may have an opportunity of attending worship at the chapels of the foreign envoys who reside in the city. The number of the clergy, including those of the dependent territories, amounts to fifty-three. The chief dependencies of this city are the river Alster, the bailiage of Ham, some islands, and low lands on the Elbe; and besides some districts acquired from Holstein, the bailiage of Ritzebuttel, to the north of the duchy of Bremen, including the port of Cuxhaven, and the isle called Neuwerk, situated opposite to that port.

The town cellar. The *Raths-Keller*, or town-cellar, may be reckoned one of the curiosities of Hamburgh. It is an immense subterraneous cavern, which is filled principally with Rhenish wine. Several halls and chambers have been formed, for the entertainments frequently given there by the inhabitants and strangers. It is under the direction of a burgomaster, three senators, and three burghers; but the immediate management is committed to a steward, who makes a profitable business of it. There is also an apothecaries' hall belonging to the town, which contains a great quantity of every possible species of drugs. These being superior to those sold by the other apothecaries, have a considerable sale, and produce much profit to the city.

Schools and literary establishments. In Hamburgh there are numerous schools, libraries, and literary institutions, which reflect honour on the enlightened taste of its inhabitants; besides several valuable collections of paintings and prints, and cabinets of natural history, &c. which sufficiently prove that the arts and sciences have not been neglected amidst the pursuits of commerce. This city has been, at different periods, the residence of many literary characters of the first eminence, among whom the names of Lessing and Klopstock are conspicuous. The principal amusements of the inhabitants are music and dancing, card-playing and billiards; in winter, riding upon sledges, and, in summer, walking or riding to public gardens in the environs of the town. Amusements. There is a French and a German theatre; and the musical drama, or opera, has long been cultivated with activity and success at Hamburgh. The compositions of Keiser, Matheson, Handel, and Telemann, who all commenced their career in this city, are the most celebrated. C. P. E. Bach, the greatest musician of his time, succeeded Telemann as music director in 1767, and retained the situation until his death in 1788.

The merchants of Hamburgh are very luxurious in their style of living; the tone of society is easy and animated; and there is no place where strangers are entertained with more hospitality. See Nugent's *Travels through Germany*; Riesbeck's *Travels*; Peuchet *Dict. de la Geog. Com.* vol. iv.; Reichard, *Guide des Voyageurs*; *Account of the Management of the Poor in Hamburgh*; *Hamburgische Künstler-Nachrichten*. Hamburgh, 1794. (*z*)

HAMEL, DU, du Monceau, Henry Lewis, an eminent vegetable physiologist, was born at Paris in the year 1700. In the Memoirs of the Academy for 1728, he published an Essay on a Parasitical Fungus, (*Sclerotium Crocorum* of Persoon), which infests the roots of the cultivated saffron; and, in the same year, appeared his Treatise on the Propagation of Trees by Grafting. His principal works on Botany and Vegetable Physiology were the following: Hamel, Hameln.

1. *Traité de la Culture des Terres.* Published in 6 vols. from 1750 to 1761.

2. *Elemens d'Agriculture.* 2 vols. 12mo. 1764. This work was translated into English, German, and Spanish.

3. *Traité des Arbres et Arbustes qui se Cultivent en France en pleine terre.* 2 vols. 4to. 1755.

4. *Physique des Arbres.* 2 vols. 4to. 1758. This is the principal work of Du Hamel.

5. *Des Semis et Plantations des Arbres et de leur Culture.* 4to. 1760.

6. *De L'Exploitation des Bois, ou moyen de tirer parti des taillis demi futayes et haut futayes.* 2 vols 4to. 1769.

7. *Du Transport, de la conservation, et de la force du Bois.* 4to. 1767. See our article Carpentry, vol. v. p. 496. See also the *Mem. Acad. Par.* 1742, 1768, 1744, 1764, 1767.

8. *Traité des Arbres Fruitiers.* 2 vols. 4to. 1768.

Du Hamel was also the author of a treatise on the cultivation and preparation of madder. His works on the mechanical arts are numerous. The following, which were published separately, are the most important:

1. *Art de faire les cartes à jouer.*

2. *Art du Couvreur.* See *Mem. Acad. Par.* 1766. Hist. 156.

3. *Traité de la Corderie perfectionné.*

4. *Art du Drapier.* See *Mem. Acad.* 1765. Hist. 132.

5. *Art de faire des Tapis.* See *Mem. Acad.* 1766, Hist. 157.

6. *Art de friser et de ratiner les etoffes de Laine.* See *Mem. Acad.* 1766, Hist. 156.

7. *Art de L'Epinglier.* See *Mem. Acad.* 1761, Hist. 152.

8. *Art de forger les enclumes.* See *Mem. Acad.* 1762, Hist. 188.

9. *Art de Peche.*

10. *Architecture Navale.* 4to. Par. 1758. See *Mem. Acad.* 1752, Hist. 141.

11. *Art de la Fabrique des Ancres.* See *Mem. Acad.* 1761, Hist. 152.

12. *Art de Fabriquer les Pipes.*

13. *Art du Potier de terre.*

14. *Art du Serrurier.*

15. *Art de reduire le fer en fil d'orchal.* See *Mem. Acad.* 1768, Hist. 128, 1778, Hist. 110.

M. Du Hamel died at Paris in 1782. See Botany, p. 34.

HAMELN, formerly called *Quern* or *Muehlen-Hameln*, is a town of Germany, in the kingdom of Hanover. It is situated in a pleasant territory, at the confluence of the Hamel and the Weser. It is very strongly fortified, and contains some good buildings, particularly the Hotel de Ville. Its barracks can accommodate a whole battalion. A fine sluice was erected here in 1734, by George II. for the purpose of facilitating the navigation of the Weser, by which the town carries on a considerable trade. Hameln has been celebrated for its tanneries, its breweries of beer, and for the manufactures which were established by the French refugees. There is here a refinery of sugar. At the mouth of a cave not far from the town, is a monument erected to commemorate the loss of 130 children, who were swallowed up in 1284. From the fort there is a very fine view of the surrounding country. Population 4000. Distance 30 miles south-west from Hanover.

Hamilcar, Hamilton.

HAMILCAR. See CARTHAGE, vol. v. p. 573, 574.

HAMILTON, the chief town of the middle ward of Lanarkshire, is about 12 miles to the south-east of Glasgow, and situated in the parish of the same name. In ancient times, the district in the neighbourhood of Hamilton appears to have borne the designation of *Cadzow*, while the town seems to have been called "the Orchard," probably from the fruit-grounds with which the houses were surrounded. There is little doubt that the town derives its present appellation from the noble family of Hamilton, who appear to have settled in Clydesdale soon after the year 1215.

The first residence of the family was Cadzow Castle, situated on the precipitous banks of the Avon, about a mile from the town. In the statistical account of Hamilton, it is mentioned, that this building was deserted after the injuries it sustained from the army of the regent Murray, but a considerable portion of it is still to be seen, denoting the massy strength of the original structure. The palace of Hamilton, now occupied, (A.D. 1816,) by the most noble the Marquis of Douglas, as representative of his father the Duke of Hamilton, is situated in the higher part of the beautiful and fertile valley through which the Clyde pursues its course, and lies to the west of the confluence of that noble river with the Avon. It was built about the end of the 17th century, and forms three sides of a quadrangle. The apartments are large and lofty, and have lately been very splendidly fitted up. The gallery of paintings is perhaps the finest in Scotland, many additions having been made to it by the present Marquis of Douglas. The portrait of the Earl of Denbigh by Vandyke, and "Daniel in the Den of Lions," by Rubens, have been noticed by every traveller. To these may be added, a St Sebastian by Guido Reni, a St Francis, an infant St John, by Corregio, and in particular an "Ecce Homo" by the same master. Two landscapes of rocks, and a head of Diogenes by Salvator Rosa, a dying Madona by Ludovico Caracci, and an admirable painting of the Virgin embracing the head of Christ, by Mabeuge. In the great gallery there is likewise a bust of Cleopatra, in which the depth and aggravation of grief are most wonderfully expressed; and in one of the lower apartments there is a statue of "the Venus de Medici." Among the valuable curiosities, we have observed a large table of the most beautiful *malachite*, unequalled, as far as we have been able to learn, in any part of the British empire.

Nearly opposite to Cadzow upon the Avon, and in full view of the palace, stands the castle of Chatelherault, built by the Duke of Hamilton in the year 1730, and meant to represent the castle of the same name in France, of which his ancestors were dukes. It was executed from a design of the elder Adams. In the surrounding park are some of the largest oaks in Scotland, the remains of those extensive forests with which the country was formerly covered. Among these trees grazed the ancient Caledonian cows, mentioned by Hector Boece, as a peculiar breed, and distinguished by their manes resembling those of lions, by their snowy whiteness, and their untameable ferocity. It is believed that the original race are now extinct; for the present breed are not remarkably different in their appearance from the common cow, excepting only that they are all over white, or rather cream-coloured, and have black or brown ears and muzzles. They may be approached without fear or difficulty.

By the exertions of the Marquis of Douglas, the palace is now wholly separated from the town. The latter consists of a main street, running in a south-eastern direction, and forming part of the road from Glasgow to Lanark. There are many cross streets, and individual houses with gardens attached to them. The prison and town-hall are in the centre of the town, and on the former there is a tolerable spire. The parish church was built in 1732, from a design of Adams. It stands upon a rising ground in the upper part of the town, and is a very handsome structure, uniting stability with lightness. Though by no means well seated, it is understood to accommodate about 1300 people. The charge is collegiate, but the stipends of the ministers have lately been equalized. Besides the parish church, there is one belonging to the Relief Seceders, another to the Burghers, and a third to the Antiburghers. The schools are numerous. There is a large hall for a grammar school. It was in this school that the celebrated Dr William Cullen, the father of physic in Scotland, received a part of his education; and the traditionary report of the townsmen bears, that he appeared at one of the annual examinations in girls clothes, acting the part of a shepherdess, in a Latin pastoral. Nor ought we to omit, that Dr Baillie of London, and the late Mr John Millar, professor of law in the university of Glasgow, are indebted for a portion of their fame, to the instructions they received in the schools of Hamilton.

The town is what is called a burgh of regality; but the appointment of the magistrates rests entirely with the family of Hamilton. It is governed by a first and second magistrate, with the assistance of a town-council, treasurer, and clerk. The population of the town was, in 1753, 3815; in 1792, 5017; and it is now above 7000 souls. Some years ago a subscription library was established in Hamilton, owing principally to the zealous exertions of Dr John Hume. The library is under the direction of a committee of management, who are chosen annually; and the collection of books is multifarious and valuable. (*h*)

HAMMERSMITH. See MIDDLESEX.

HAMPDEN. See BRITAIN, vol. iv. p. 576.

Hamilton || Hampshire.

Boundaries and extent.

HAMPSHIRE, HANTS, or the *County of Southampton*, is a maritime county, situated on the southern coast of England. It is bounded on the north by Berkshire; on the east by Sussex and Surrey; on the south by the English Channel, and the sound, which separates it from that part of the county, called the Isle of Wight; and on the west by Dorsetshire. Its limits on the south side are the numerous creeks and inlets formed by the sea; on the west and east they are mostly artificial; on the north they are chiefly composed by the rivers Enborsa and Blackwater. The figure of Hampshire is nearly that of a square, with a triangular projection at the south-west angle, resembling the bastion of a fortification. Besides the Isle of Wight, the islands of Jersey and Guernsey are included as parts of the county: its length, exclusive of the projection of the south-west and the isle of Wight, is about 42 miles, and its breadth about 38.

Division.

Hampshire is divided into 52 hundreds and liberties; these are subdivided into 356 parishes, precincts, hamlets, and tythings, the parishes alone being 253. In it there is one city, Winchester, which is also the county town, though Southampton is sometimes regarded in that light. Besides Winchester and Southampton, there are 18 other market towns, of which the principal are Portsmouth, Andover, Lymington, Christchurch, Basingstoke, Alton, Fareham, and Romsey. Winchester, Southampton, Portsmouth, Andover, Lymington, Christchurch, Stockbridge, Whitchurch, and Petersfield, send each two members to Parliament, so that the county sends in all twenty members to Parliament, exclusive of those sent by the Isle of Wight: it pays 14 parts of the land-tax. Hampshire lies in the province of Canterbury, and diocese of Winchester, and, with the county of the town of Southampton, is included in the western circuit.

...ace and ...iate. This county is justly regarded as one of the most agreeable in England, being equally distinguished for the goodness of its soil, the healthiness and mildness of its climate, and the beauty of its prospects. The surface is finely varied with hills of gentle elevation and fruitful vallies, adorned with numerous gentlemen's seats and villages, and interspersed with numerous woodlands. Its southern parts were the first peopled, and there the population is still the greatest; the mildness of the seasons, and the convenience of the ports, operating as strong inducements to continued residence. The ridge of chalk hills may be traced across the county, passing in the parallel of Winchester. The climate in the higher parts is bracing and healthy, from the clearness and pureness of the air; towards the sea, it is mild, and rather moist.

The soil of Hampshire is extremely various, though, for the most part, of a calcareous nature. On the borders of Berkshire, it is deep, of a good quality, and very productive of corn and timber, particularly oak and elm. On the acclivities of the hills towards Basingstoke, it is also very deep and strong, with a calcareous subsoil. Round Whitchurch it is less deep and chalky. From Overton towards Stockbridge, and thence to Redbridge, there is a beautiful vale, which is divided into well-watered meadows. Round Andover the land is high, and approaches to the nature of downs. Towards Romsey it is more fertile. The country here is very beautiful, being interspersed with woods, and fine hedge-row timber. The centre of the county in general, may be described as consisting of land higher and more chalky than the rest of the county, but by no means of an unfertile soil. On the borders of Dorsetshire, are vast tracts of waste land covered with heath. The vicinity of Redbridge is distinguished for its valuable salt marshes. Down land is met with between Petersfield and Portsmouth. On the banks of the Itchin, are some valuable water meadows. Perhaps the richest and most valuable soil in this county is near Alton.

...ers. The principal rivers in Hampshire, are the Itchin, the Avon, the Boldre Water, the Exe, the Anton, and the Tesse, or Test. Several smaller streams rise in the north-west parts of the county, but these soon quit it in their course to the Thames. The Itchin rises near Alresford, near the centre of the county; and after passing Winchester, it unites its streams with the water of Southampton, about half a mile to the east of that town. The Avon enters the county from Wiltshire, near Fordingbridge, and coasts the edge of the New Forest. This part of its course is thus not only well wooded, but enlivened by the numerous villas that ornament its banks. After passing Ringwood, it flows through a less interesting sandy level towards Christchurch. Below this town, it receives the waters of the Stour from Dorsetshire, and with them falls into Christchurch bay. The Bolder Water is formed by various springs rising in the New Forest, which uniting, pass Boldre and Lymington to the sea. The Exe also rises in the same district, and opens in a broad estuary to the sea, below Exbury. The Anton rises in the north-west angle of the county, and flowing through Andover, runs into the Tesse about a mile below Whirwell. The Tesse has its origin below Whitchurch; and after its junction with the Anton assumes a southerly course, and passing Stockbridge and Romsay, receives several small streams from the New Forest, near Redbridge. Below this place it expands considerably, and forms the head of Southampton Water. This, properly speaking, is an arm of the sea, extending from above Southampton to Caldshot Castle, and rendered very picturesque by its woody and irregular banks. Its whole extent is nearly 10 miles. Near Southampton, it is about four miles broad. It is navigable almost to the head for vessels of considerable burden; and the two principal rivers which flow into it, admit small craft some way up into the county. On tracing the sea coast from the east, we come to Portsea island, a low tract of considerable extent, separated from the main by a shallow creek, over which a bridge is built. On this island Portsmouth is situated. Off the point of land terminating this peninsula, is the noted road of Spithead, where the men of war anchor when prepared for actual service. From this, on the east side, commences Trissanton Bay, or Southampton Water.

Mineral productions. There are very few mineral substances found in this county. On the southern shores, iron-stone was formerly gathered in some quantity, which seems to have been rolled up by the surf. Between Milton and Christchurch a hard reddish stone is found, apparently calcareous, tinged with the oxide of iron. Several ancient structures in the county are built with it. Chalk of various qualities and colours is worked in different parts. Potters' clay is met with in great abundance in Poolheath, at various depths, from 10 to 20 feet. From the circumstance of this heath bearing all the external marks by which the heath of Purbeck is distinguished, and their being divided only by Pool Water, it is not improbable that the Hampshire clay will be found equally valuable and useful as the Purbeck.

Landed property. Hampshire is distinguished as an agricultural county for its fine corn, especially wheat; its hops, cattle, sheep, wool, bacon, honey, timber, and the extent and excellent management of its water meadows. The largest estates and farms are in the chalky parts of the county. The largest estate, however, does not exceed £8000 per annum. Tenures are various. Those estates, which formerly composed the demesne lands of the see of Winchester, are granted by the bishop as freeholds for three lives, and generally renewed to the families who hold them for many generations. These estates consist chiefly of ancient manors and houses, to which certain feudal rights still appertain. Copyhold tenures are granted from manors vested in the church, or by the lay proprietors. There are also lands held on lives by lease, or indenture. Other leases are for 21 and 14 years; but here, as in other parts of England, the practice is extending of letting lands only at will. The average size of farms in the county is small, probably not exceeding 200 acres; and certainly, if the chalk districts are excluded, not reaching that extent. The ploughs are various; but principally with one or two wheels, and by no means constructed on good mechanical principles. There are a few thrashing machines in the county. The chief part of Hampshire is inclosed, though large tracts of open heath and uncultivated land remain in the vicinity of Christchurch, and on the borders of Dorsetshire. The aggregate extent of the waste lands, exclusive of the forests, is supposed to amount to nearly 100,000 acres.

Hampshire. Agriculture.

In Hampshire a considerable quantity of land is annually sown with wheat, which is cultivated with great skill; its quality is excellent. Barley is grown principally on the lighter soils and higher ground. The soil round Andover is very favourable to the growth of this grain. It is generally sown either after turnips, or a winter fallow. In the cultivation of oats, the Hampshire farmers do not display much agricultural skill, since, for the most part, they are sown after one or two white crops. Beans are not much cultivated, even upon soils well adapted to them. The white pea is grown to a considerable extent in various parts of the county; the cultivation is well understood; and the produce abundant and valuable. Turnips are extending; but their culture is not yet nearly so general as it might, or ought to be; nor is it well understood. Potatoes are grown in almost every part on a good plan, and with abundant produce. The utility and value of the calcareous soils in Hampshire are very much increased by the growth of sainfoin on them. This plant seems to have been long known here, and its culture is well understood. The parishes to the east of Alton, on the borders of Surrey, are chiefly appropriated to the growth of hops, the plantations of which have been greatly increased lately, chiefly in consequence of the high character of the hops grown at Farnham, in the immediate vicinity of Alton; the Hampshire hops, in a great degree, partaking of this character. The hop grounds are supposed to occupy 800 acres. The water meadows, as has already been noticed, are numerous, extensive, and extremely well managed. They are made at first at the expence of £5 or £6 per acre; and the expence of continual repairs is very considerable. But they pay the farmer well. They are usually shut up in November, or the beginning of December; and are watered every alternate week, till the beginning of March, when they are pastured for about five or six weeks with ewes and lambs. An acre is considered equal to the feeding of 400 couples for one day. They are shut up about the beginning of May, and produce at the regular season an abundant crop of hay. Perhaps the largest and finest tract of water meadows in the county lies on the banks of the Itchin, extending from the north side of Winchester, through Twyford and Otterburne, towards Bishops Stoke.

Hops. Water meadows.

Gardens and orchards.

Gardening is carried to a considerable extent in the neighbourhood of all the large towns: Portsea island is supposed to produce the finest broccoli in the kingdom. Orchards are not common or productive in the woodland or chalky districts; but on the marly and clay soils, in the south, and south-western parts of the county, they are more common: even here, however, little or no cyder is made for sale, the farmer contenting himself with making two or three hogsheads annually for the use of his family. A considerable portion of Hampshire is occupied by the forest of Alice Holt and Walmer, the forest of Bare, and the New Forest: the first is divided into two portions by intervening private property, one part containing 15,493 acres, and the other 2,744. This forest is situated on the borders of Surrey and Sussex. The forest of Bare extends northward from the Portsdown hills, including about 16,000 acres. The ancient boundaries of the New Forest included the whole of that part of Hampshire, which lies between Southampton water on the east, the British Channel on the south, and the river Avon on the West. By a perambulation on the 22d of Charles II. it was ascertained that it extended from Godshill on the north-west to the sea, on the south-east about 20 miles, and from Hardley on the east to Ringwood on the west, about 15 miles, containing within those limits 92,365 acres: of these 24,797 belong to individuals; 901 acres are encroachments; 1192 are inclosed land in the possession of the master, keepers, &c.; and the remainder, being about 63,845 acres, constitute the woods and waste lands of the forest. Its officers are a lord warden, a lieutenant, riding forester, bow bearer, two rangers, woodward, under woodward, four verderers, high steward, under steward, 12 regarders, 9 foresters or master keepers, and usually 15 under foresters. The quantity of timber supplied by this forest for naval purposes from 1761 to 1786 was 23,000 loads of oak, and 7003 loads of beech; and the number of deer killed annually is about 76 brace of bucks, and 17 brace of does. The timber was so very much neglected, that, in the year 1800, an act of parliament was passed for its increase and preservation. The scenery of the New Forest affords as great a variety of beautiful and picturesque landscape, as can be met with in any part of England, of the same extent. The oaks seldom rise into lofty stems, but their branches are adapted for knee timber, and are commonly twisted into the most picturesque forms. The Cadenham oak is regarded as one of the curiosities of the forest, the buds appearing every year in the depth of winter. The advantages which this forest derives from its situation, in respect to conveniency of water carriage, are superior to those of any other forest in England; in its vicinity are many places for shipping timber, amongst which are Lymington, Beaulieu, and Redbridge, with the additional advantage of the remotest of those places being little more than 30 miles from the dockyard of Portsmouth.—Hampshire is remarkable for the great quantity and excellent quality of its oak bark, supplied chiefly by the timber in the New Forest.

Woods.

New Forest.

Hampshire.

Cadenham oak.

Cattle, sheep, and hogs.

Hampshire does not possess any peculiar or specific breed of cattle; the Sussex, Suffolk, Hereford, Glamorgan, and North and South Devon, are chiefly employed for draught, and the Norman for the dairy. Cows kept for the latter purpose are rented out to dairymen at from £7 to £9 per cow, per annum. In the woodland district of the county, the heath sheep are sometimes met with; but the most common in other parts are the Old Hampshire, something resembling the Dorsetshire in their size, shape, and qualities, and the New Leicester. The Wiltshire and Dorsetshire are also kept for the purpose of house lamb. On the Downs, the South Down sheep are spreading fast. Hampshire has long been justly celebrated for the excellency of its bacon. The native hog of the county is a coarse, ill-fattening animal, from which neither much nor good bacon would be expected; but the mart, and other food which the forests produce, and the excellent mode of curing in practice, have contributed, in a far greater degree, to establish the superiority of Hampshire bacon, than any inherent excellence in its native breed of hogs. These, however, have been greatly improved in form and quality, by crosses with the Berkshire, Suffolk, and Chinese breed.

Canals.

In this county, there are three distinct series of canals, two of which terminate in the water of Southampton. The north-western part of the county has also been much benefited by the Kennet navigation, leading from Newberry to Reading. The Basingstoke canal commences at that town, and falls into the river Wey near the village of Westley; it is something more than 37 miles in length, with a fall of 195 feet. The Ando-

Hampshire.

ver and Redbridge canal begins near the former place, and falls into the Southampton water near the latter. Its length is 22½ miles; its fall, 176 feet 9 inches. A collateral branch is navigable to within 2 miles of Salisbury. The Winchester and Southampton canal is one of the most ancient in the kingdom. The act for making it was obtained in the reign of Charles I.

Fish ponds.

There are several fish-ponds in Hampshire, particularly on the wet soils on the borders of Surry. These ponds are usually stocked with carp and tench; and, in favourable circumstances, five acres of water will support 1250 brace of these fish, until the stock are fit for market, and have obtained an average size of 2 lb. per brace, and consequently weigh 2500 lb.; which, at 9d. per lb. the price at which they are usually sold to the London fishmongers, will amount to £93, 15s. the value of five acres of land so employed for three years.

Manufactures.

The manufactures of Hampshire are not very considerable or numerous. At Alton, there are manufactures of serges, and a variety of worsted articles, bombazines, &c. Worsted yarn is spun in this town and neighbourhood. Nearly the same kind of manufactures exist at Alresford. Basingstoke is distinguished for its manufactures of malt and leather. At Overton there is a silk mill of considerable magnitude; and in this part of the county the young female peasantry are much employed in making straw hats. The paper mills near Overton are famous for being employed in making paper for the notes of the Bank of England. There are also paper mills in other parts of Hampshire. Andover is remarkable for the large quantities, as well as for the excellent quality, of the malt made in it and the vicinity. Its former manufacture of shalloons is on the decay. A considerable quantity of yarn and worsted is spun in this part for the manufactures at Salisbury. Stockbridge is noted for wheelwrights and carpenters. In Winchester, many people are employed in the manufacture of light silk goods, and in preparing and winding the silk. The manufactured goods are principally used for umbrellas. Romsey is famous for its beer; the manufacture of shalloons is greatly decayed; considerable quantities of sacking are made. At Fordingbridge, there is an extensive and flourishing manufacture of striped bed ticking; nearly two-thirds of the inhabitants being employed in spinning, bleaching, weaving, &c. for this manufacture. Knit silk stockings, and a watch chain manufactory, particularly distinguish Christchurch. At Lymington there are very extensive and valuable manufactures of culinary and medicinal salts from sea-water. Southampton was formerly famous for its trade in French and port wines; but this is in a great measure gone to decay. At Farnham, there are manufactures of bricks, tiles, chimney pots, and sacking and cordage. There is one fair in Hampshire which deserves particular notice.

Wey-hill fair.

This is held at Wey-hill, in the hundred of Andover. It commences the day before Michaelmas-day, and is one of the largest in the kingdom for hops, sheep, and cheese. Upwards of 140,000 sheep have been sold in one day. The Farnham hops are almost entirely sold here. The fair generally lasts 6 or 7 days.

Isle of Wight.

The isle of Wight must be particularly noticed. It is separated from the main land of the county by a channel varying from 2 to 7 miles in breadth. Its form is that of an irregular lozenge. It is nearly divided into two equal parts by the river of Corves. Through the middle of it, in the longest direction, extends a range of downs. The eastern and western parts of the island are almost cut off from the body by arms of the sea. Its length from east to west is about 22 miles; its breadth 13 miles; its circumference about 6. It contains 105,000 acres, of which 75,000 are in a course of tillage, 20,000 in pasturage, and the remainder downs and waste. It is divided into two hundreds, one market town, Newport, and 3 boroughs, returning each two members, Newton, Newport, and Yarmouth. The other towns of consequence are Corves and Ryde. It contains 30 parishes. The face of the country is very diversified. The land round the coast being in some places very high, particularly on the south or back of the island, where there are steep cliffs of chalk and freestone, hollowed out into caverns. On the north side the ground slopes to the water in easy declivities. The western side is fenced with ridges of rocks, of which the most remarkable are those called, from their sharp extremities, the Needles. The height of the cliffs in the north-west is, in some places, 600 feet above the level of the sea. They are frequented by immense numbers of marine birds. Between the island and the mainland are various sand banks, especially off the eastern part, where is the safe road of St Helens.

The land to the north of the ridge already mentioned, is chiefly pasture. To the south of it is a rich arable country, producing great crops of corn. It is said that the grain annually grown here is sometimes greater than the consumption of the island. The farms are small. The crops usually obtained are wheat, barley, oats, beans, turnips, clover, &c.; the prevalent soil, a strong loam on a dry subsoil, being well calculated for all these crops. The butter made here is excellent: the cheese, the worst in England except the Suffolk. The cattle are the Devonshire and Alderney; the sheep mostly Southdown and Dorset. On the downs a great number of fine-fleeced sheep are fed, about 40,000 being annually shorn, and about 5000 lambs sold. Rabbits are very plentiful. The climate is almost proverbially mild; and as the scenery is scarcely equalled in any part of Europe, this isle is a favourite residence. There are not many woods. The most extensive are those of Swainston, Wooten, and Quarr. The chief rivers are the Medina, the Yar, and the Wooten. The Medina, passing Newport, falls into the sea at Corves: the Yar falls into the Channel at Yarmouth: the Wooten falls into Braden's harbour. There are also various creeks and bays Great variety of fish is found on the coast, particularly lobsters and crabs. The cockles are much celebrated, and the sandeel is very plentiful.

Among the products of this island are to be reckoned a pure white pipe-clay, and a fine white crystalline sand. Great quantities of the latter are exported for the use of the glass-works. Alum formerly was manufactured in some of the western coves of the island.

Poor rates in 1803 and 1815.

By the returns respecting the poor-rates in the year 1803, it appears, that in the whole county, including the isle of Wight, £153,427 was annually raised for poor and other rates. The average rate in the pound on the rack-rental was 4s. 5¼d. £130,983 was actually expended on account of the poor. The number of friendly societies was 62, containing 4733 members. The number of children in schools of industry amounted to 614. In the year ending 25th March 1815, the sum raised in this county for poor and other parochial rates amounted to £211,557, making an increase since 1803, or in the space of 12 years, of £58,130, or nearly 30 per cent.

Hampshire, Hampshire, New.

History.

At the invasion of the Romans, great part of Hampshire was possessed by the Regni and Belgæ. The latter kept possession of it for 60 years after the first landing of the Saxons; afterwards it formed part of Wessex. The most remarkable antiquities in the county are Netley Abbey, near Southampton, founded in the

Antiquities.

year 1239. The ruins of this abbey, situated as they are on the declivity of a hill, rising gently from the water, and environed by most beautiful wood scenery, form a very interesting object. The cathedral of Winchester, curious as an instructive example of architecture; the chapel of our Lady, the choir, and a magnificently carved screen in stone work, are particularly celebrated. The college of William of Wykeham, at Winchester, is also a remarkable building, independently of their character and utility as a seminary. Hurst and Carisbrooke castles, the latter in the isle of Wight, are remarkable for having been the prisons of Charles I.

Population.

The following results, respecting the population of this county, appear from the returns made in the year 1811:

Houses inhabited, ...	43,210
Families occupying them, ...	50,916
Houses building, ...	441
——— uninhabited, ...	1030
Families employed in agriculture, . . .	21,401
——————— manufactures, &c.	18,024
——— not comprised in these classes,	11,481
Males, ...	118,855
Females, ...	126,225
Total, ...	245,080
Population in 1801, ...	226,900
Increase, ...	38,180

See Vancouver's *Agriculture of Hampshire*; *Beauties of England and Wales*, vol. v.: Worsley's *Isle of Wight*; and Gilpin's *Forest Scenery*. (W. S.)

HAMPSHIRE, NEW, one of the northern states of America, is bounded on the north by Lower Canada, on the east by Maine and the Atlantic Ocean, on the south by Massachussets, and on the west by the west bank of the Connecticut. It extends from north to south about 168 miles; its greatest breadth is 90 miles, and its breadth at its northern extremity 19 miles. It has 18 miles of sea coast, and a superficial extent of 9491 square miles, or 6,074,240 acres.

This state is divided into six counties, viz.

Counties.	No. of Towns.	Population in 1810.	Principal Towns.	Population.
Coos . . .	24	3,991	Lancaster	717
Grafton . .	35	28,462	Haverhill	1,105
			Hanover	937
Cheshire . .	35	40,988	Charleston	1,501
			Keene	1,646
Hillsborough	42	49,249	Amherst	1,554
Rockingham	46	50,175	Exeter	1,759
			Portsmouth	6,934
			Concord	2,393
Strafford . .	31	41,595	Dover	2,228
			Durham	1,449
Total . . .	213	214,460		

Islands.

The Isles of Shoals, which are about eight in number, belong partly to New Hampshire and partly to Massachussets. They were discovered by Captain Smith in 1614, and are situated 9 miles S. E. of Portsmouth light-house. They consist chiefly of barren rocks, and are inhabited only by about 100 souls, who subsist by fishing. The *dumb fish*, which is caught here, is in the highest estimation. Before the American war, the fishing was carried on by about 600 inhabitants.

General aspect.

The shore of this state is principally a sandy beach, within which are many salt marshes intersected by creeks. The county is mountainous, or consists of hill and dale for about 20 or 30 miles from the coast. At the distance of 30 miles from the coast, commences the first range of mountains called the Blue Hills. Several detached mountains of considerable elevation rise

Mountains.

beyond these. Another range succeeds, and the principal range, called the White Mountain range, lies between the Merrimac and the Connecticut. The mountains are almost all covered with wood. Moosehillock, the loftiest in the main range, is 4500 feet high. Sunapee is farther south in the same chain, and still farther to the south rises Monadnoc, which is 3254 feet in height. Its base is 5 miles long from north to south, and its breadth 3 miles. Volcanic appearances are distinctly presented in different parts of the mountain. In 1730, the garrison of Fort Dummer heard frequent explosions, and saw columns of fire and smoke issuing from the mountains. Similar phenomena were seen in 1732.

Soil and agriculture.

The soil of this state is extremely rich and fertile. The lands on the large rivers afford immense crops of hay, and a single acre will produce 40 or 50 bushels of wheat. The uplands yield only about 20 bushels, but they afford very rich pasture.

Rivers.

The principal rivers in this state are the Connecticut, the Ameriscoggin, the Saco, the Merrimac, the Contoocock, the Piscataqua, and the Upper and Lower Ammonoosuc. The three first have their origin in New Hampshire. The Merrimac rises in the Moosehillock, at Sanborntown, where it receives the Winnipeseogee, and takes the name of Merrimac, and falls into the sea at Newbury Port after a course of 100 miles. Canals have been formed at the Hookset falls, 8 miles below Concord, where the river falls 15 feet in 30 roods, and also at the Amoskeag fall, 8 miles lower down, where the river makes three large pitches, amounting in all to 80 feet in half a mile. The Contoocock, which is the principal tributary stream of the Merrimac, rises in Massachussets, and joins the Merrimac a little above Concord, after a course of 60 or 70 miles. The Piscataqua rises in the north east corner of Wakefield, and falls into the sea after a course of 50 miles. In 1794, a bridge was built over the river about 6 miles above Portsmouth. It is 2600 feet long, and is built chiefly on piles. The rest is a magnificent arch of 244 feet span over water about 46 feet deep. The expence of it was 68,000 dollars. The Upper Ammonoosuc rises on the north side of the White Mountains, and after running 35 miles, it throws itself into the Connecticut at Northumberland. The Lower Ammonoosuc rises on the west side of the White Mountains, and after a course of 40 miles, it empties itself into the Connecticut between Bath and Haverhill, where its width is 300 feet.

Lakes.

The principal lakes in this state are the Winnipiseogee, which is about 24 miles long, and from 3 to 12 broad; the Umbagog, the next largest, which throws its waters into the Ameriscoggin; the Squam Lake, which is 5 miles long, and 4 broad; the Ossapee, which runs into the Saco; and the Sunapee, which is 8 miles long, and 3 broad, and runs into the Connecticut.

The principal towns of New Hampshire are Ports-

[New Hampshire. Principal towns.] mouth, Exeter, Concord, Charleston, Dartmouth, Haverhill, and Keene. *Portsmouth*, the principal town, is situated on the south bank of the Piscataqua, about two miles from its mouth. Its harbour can hold vessels of any size. It has a state-house, a work-house, two banks, three congregational churches, one episcopalian, and one universalist church. *Exeter* is situated at the head of the navigation, on the Swamscot, a branch of the Piscataqua, which will admit vessels of 500 tons. It has a court-house, a gaol, two congregational churches, and an academy, which was incorporated in 1781. It is in great reputation, and has about 70 students, and funds amounting to 80,000 dollars. *Concord* is a thriving and agreeable town on the west bank of the Merrimac, which is here crossed by two bridges. It is rising rapidly into importance, and will probably become the permanent seat of government. *Charleston*, which consists of one street, is pleasantly situated on the Connecticut. It has a church, court-house, and gaol. The village of *Dartmouth* in Hanover stands in an elevated plain about 36 miles above Charleston. It is well built, and is laid out in squares. It has an academy, a church, a college and chapel, with 2135 inhabitants. *Haverhill* is situated at the lower Coos, a singular bend in the Connecticut. It has two churches and a court-house. *Keene* is a beautiful little town, pleasantly situated a few miles to the east of the same river. It has a church, court-house, and gaol.

Dartmouth College. The college of New Hampshire is situated in Hanover, on a plain about half a mile east of Connecticut-river. Its charter is dated 1769, and it received the name of Dartmouth college from the Earl of Dartmouth, one of its principal benefactors. Its annual revenue is about 1333 dollars, arising from about 80,000 acres of land. There are here professorships of divinity, civil and ecclesiastical history, mathematics, natural philosophy, chemistry, and medicine. A large brick edifice has lately been erected for the medical establishment. The number of under graduates is upwards of 170, besides 50 who attend the medical lectures. The college has a good chemical and medical apparatus, and the library contains about 4000 volumes.

Manufactures and trade. The principal manufactures in this state are linen and woollen goods, iron articles, pot and pearl ashes, maple sugar, bricks, and pottery. The iron works are established in the township of Franconia, but they do not supply the home consumption.

The chief articles of export are timber of various kinds, dried and pickled fish, whale oil, tar, flax seed, beef, corn, oxen, cows, horses, sheep, bricks, and pearl ashes. The amount of exports in 1798, was 723,242 dollars, and in 1810, 234,650. The articles imported into New Hampshire are West India rum, gin, molasses, wine, porter, sugars, tea, coffee, cotton, cheese, nails, cordage, salt, sea-coal, steel, lead, and grindstones. About 27 schooners, and 20 boats, with 250 men, are annually employed in the fisheries, exclusive of those in the islands already mentioned.

The inland trade of this state is greatly facilitated by many canals and turnpike roads. There are two canals in Connecticut river within the limits of the state, which open up a communication for nearly 250 miles from its mouth. Another canal has been cut for eight miles through the marshes of Hampton and Salisbury, which meets the Merrimac opposite Newbury port.

Government. The executive power of this state is vested in a governor and council. The governor, who is elected annually by the people, must be worth £500. The council consists of five persons, two chosen by the senate, and three by the representatives. The senate consists of twelve members, each of whom must be worth a freehold of £200. Every town that contains 150 rateable polls, sends one representative, who must be worth £100.

The judiciary court consists of five judges, who make two circuits annually. There is an inferior court in each county that sits four times a year, and has four judges. All judges hold their office during their good behaviour.

Religion. The principal religious sects in this state are the Congregationalists, Presbyterians, Episcopalians, Baptists, Universalists, and Quakers.

History. New Hampshire was discovered in 1614, by Captain John Smith. It was granted to Captains Mason and Gorges in 1622, under the name of Laconia, and the first settlement in it was made in 1623, at the mouth of the Piscataqua, and also at what is now called Dover. In September 1679, it was separated from Massachussets and made a royal government. In 1784, its present constitution took effect.

Population. The following is the population of this state from 1749 to 1810:

	Inhabitants.		Inhabitants.		Inhabitants.
1749	30,000	1775	82,000	1800	183,858
1767	52,000	1790	141,885	1810	214,460

New Hampshire is now the 14th of the United States in point of population. In 1810, the number of inhabitants below 16 and 45 years of age, was 39,396. See Morse's *Universal Geography*, 8vo. p. 124.

HANAU is a town of Germany, and formerly capital of the county and principality of Hanau Munzenburg. This beautiful town is divided into the old and new town, the former of which was built in 1303, and the latter in 1597, by the Walloons. The town contains several churches, and the palace in which the reigning Landgrave of Hesse Cassel has apartments; but he generally occupies a small house at Wilhelmsbad when he comes to this part of the country. The garden of the palace, the pleasure house of Philippsruhe, and the baths of Wilhelmsbad in the neighbourhood of the town, are deserving of notice. Hanau contains manufactures of earthen ware, tobacco, woollen stockings, playing cards, arms, and articles in steel. Population 11,000.

HANDEL, George Frederic, a celebrated composer, was born at Halle in Saxony, in the year 1684. His father, an eminent physician, designed him for the study of the law; but the decided propensities which he displayed for music at an age when youthful genius rarely begins to expand, speedily demonstrated that his intentions would be disappointed. Handel is said to have privately resorted to a clavichord, an instrument strung with catgut, resembling a piano-forte, in a remote apartment, and continued playing upon it when the rest of the family had retired to sleep. His father, therefore, was induced to place him under the tuition of the organist of the cathedral; and at only nine years of age, he is said to have composed some motets which were adopted in the service of the churches. Distinguished musicians have sometimes exhibited similar precocious talents, but they seldom attain proportional excellence in maturer age: and if we admire the productions of children, it is generally in forgetting how much they would be undervalued were they the compositions of men.

The improvement of Handel, however, was great and rapid, and was strikingly displayed in the composition of an opera at the early period of fourteen, while he filled the ostensible situation of manager of the Hamburgh theatre. He was promoted to this situation in consequence of the flight of Keisser, the regular manager, who had attempted to assassinate him. Having composed the operas of Almeria, Florinda, and Nero, Handel proceeded to Florence, where he prudently resisted the consequences of an attachment, which an actress, who was mistress to the Grand Duke, had conceived for him; and repairing to other parts of Italy, he formed an acquaintance with Corelli and Scarlatti, famous musicians of that era. Then travelling to Hanover, he obtained a considerable pension from the Elector, afterwards Geo. I. of Britain, and arrived in London in 1710.

His fame had already preceded him, and he enjoyed high favour at court. Some of his compositions were intended for the practice of queen Anne; and when he returned to Hanover, after urgent solicitations by the admirers of music to remain in England, she dismissed him with a pension and valuable presents.

After a short interval, Handel revisited Britain, where he was more caressed than ever, and where his musical reputation began to extend. He first resided with the most distinguished persons, composing for performances, and managing some concerts for the nobility; and afterwards a society, called the Royal Academy, was instituted, by a subscription of £ 50,000, to which the King contributed £1000, for the execution of his works.

Handel now went to Dresden, in quest of performers for this great establishment, where he engaged a native of Siena, Francesco Bernardino Senesino, and Margarita Durastanti, two singers of celebrity, with whom he opened the Academy. But he had to contend with two formidable rivals in composition, Bononcini and Attilio, whose works were performed with applause in the Haymarket theatre. The friends of these three musicians, therefore, in order to decide their respective merits, agreed that each should compose the music for an act of an opera, called Muzio Scævola, of which the third fell to Handel's share. Public opinion unanimously declared in favour of the last; and it has been observed, that the performance of one of Handel's operas after those of the other two, "is going from Arabia Petræa to Arabia Felix; from barren rocks to spontaneous fertility." Handel, therefore, held unrivalled possession of the stage. Some years afterwards, having profited by the talents of Francesca Cuzzoni, a female singer, of whom it was said, "that her intonations were so just and fixed, that it appeared as if she could not sing out of tune," he engaged Faustina, a young, beautiful, and interesting Venetian. But a rivalship commenced between them, and the audience participated in it so keenly, that, amidst the violence of partisans, the merits of the institution were altogether obscured. Each was supported with indiscreet and indecent zeal; and one of them having become refractory, Handel, from a previous example of the same in Senesino, refused to compose for this singer, and obtained his dismissal, probably in order to intimidate the others. By this, and some arrangements of a different kind, he offended the directors of the Academy, which led to its dissolution in nine years from its commencement.

Handel, however, endeavoured to carry on an opera at his own expence, while a rival amusement, patronised by many of the leading persons of the metropolis, was established in Lincoln's Inn Fields. But his success did not correspond with his expectations; and although he continued to compose with great facility and expedition, his productions were at length performed to empty houses. Neither did his opponents experience better fortune; from which we may infer, that the English taste for operas was beginning to decline. Handel produced no less than thirty operas between 1721 and 1740; but in the latter part of this period, both his health and his fortune were so deeply impaired, that he left Britain to visit the baths of Aix-la-Chapelle.

Having returned to London in a state of convalescence, Handel began to direct his attention more particularly to another species of composition, oratorios, or sacred dramas, in which he expected, by the simplicity of songs, and the grandeur of chorus, to command that public notice which was denied to lighter compositions. The Messiah was performed at Covent Garden in 1741, and it will scarcely be believed, after an interval of 70 or 80 years, that it was but indifferently received. The inhabitants of Dublin, however, to whom the author had it performed for the benefit of the prisoners of that city, viewed it differently; and it was afterwards repeated in England to the most crowded audiences with unbounded applause. Many other oratorios followed in rapid succession, of which the majority were favourably received. The tide of public favour was restored to its original current, and Handel's merits gained their due appreciation. But some of his productions were nevertheless so little adapted to general taste, that the late King George II. attended them almost alone, when abandoned by the rest of his court. Handel annually superintended the performance of the Messiah, with laudable liberality, for the benefit of the Foundling Hospital, which produced above £500 yearly.

In the year 1751, he was attacked by gutta serena; and from the moment that apprehensions for his sight were entertained, his spirits and vigorous imagination deserted him. An operation proving unsuccessful, his melancholy increased; and he was obliged to resort to extraneous assistance for the management of his oratorios. Years were now crowding upon him without bringing any alleviation of his disease; and when he, whose works had so often charmed an admiring audience, was led forward to make his obeisance; or when his own composition—"Total eclipse—no sun, no moon—all dark amid the blaze of noon,"—was performed, it is difficult to determine whether he himself or the spectators were most affected.

Handel was attacked by a general debility in 1758, and from that time he considered his own recovery as hopeless. Nor were his anticipations wrong, for he expired in April 1759, in the 76th year of his age. He was entombed in Westminster Abbey, and a statue was erected to his memory, as one, erected in Vauxhall Gardens in 1738, had already celebrated his genius. In person he was large, and rather corpulent and ungraceful; and in manners he was rough and impetuous. Over his performers he exercised a magisterial sway, exacting implicit obedience in the fulfilment of their respective duties; but it is probable, that posterity has heard his music to even greater advantage than was done by himself. He had no prominent vices however, and he practised many virtues. Handel died possessed of considerable wealth for the period, and what must be esteemed great for a musician, whose fortune was once ruined; he left about £20,000, of which £1000 was bequeathed to the Society for supporting decayed musicians, instituted in London in the year 1738. This

Society derived £6000 more, from the profits of a grand commemoration in honour of Handel, performed by 525 voices and instruments in Westminster Abbey, in 1784.

Handel's merit as a composer ranks very high; and few if any have excelled him in that particular path which he latterly chalked out for himself. The style of music indeed, has undergone inconceivable alterations since his death; but many of his compositions are even at this day heard with delight, though a century has elapsed since their production. His music is alike sublime in one character, and pathetic in another; and so long as simplicity and grandeur are valued by mankind, they will never lose their impression. The quantity that Handel wrote is surprising. It certainly exceeds what has flowed from the pen of any other composer, however voluminous his works; and it is so great, that we must be content with observing, that he produced between 40 and 50 operas, between 20 and 30 oratorios, besides organ concertos, and other music. A complete edition of the whole, we believe, was published a few years ago, in 80 folio volumes. Although a large proportion of Handel's compositions are excellent, it is undeniable that many seem dull and heavy to modern taste; and the reiteration of favourite, or what he might conceive appropriate passages, certainly impairs their effect. The Grand Chorusses of the Messiah, the Coronation Anthem, Farewell ye limpid streams, Angels ever bright and fair, and numerous others, can never be listened to without emotion. Yet Handel, with all his excellence, committed that egregious error to which musicians are so prone,—he wrote too much. It is vain to expect perpetual novelty in thoughts or actions; the inexhaustible renewal of human genius does not exist, or it appears only in arrangement. Nature has bestowed but a trifling portion of originality on any individual, however comprehensive his intellect; and so soon is that of composers betowed on their works, that extravagance and caprice are offered for what is already exhausted. They enjoy a latitude, it is true, which is denied to literature or painting. These must be guided by certain principles which are special and defined, and of which the violation will ever be rejected by genuine taste. But music is not restricted within definite boundaries; while we acknowledge a few imperfections that should be avoided, we cannot describe that particular course which shall guide us to excellence. Hence public opinion will long be divided on musical merit; that which pleases the ear will gratify the majority; and the rest will seek for some less prominent property, which may be the subject of reflection. Perhaps a piece of music should be compared to a narrative, while it is agreeable in one part, nothing ought to be outdone in another. A general character should be preserved throughout. Were this attended to, fewer useless compositions, particularly instrumental compositions, would be obtruded on the public. Handel's works unquestionably evince the mind of a great master. He who can move an audience, both by pathos and grandeur, must be admitted to have no ordinary genius. Nevertheless he has perhaps fallen into another error, in endeavouring to make the imagination feel what it is necessary to behold, before being alive to the impression, or what it would probably require a kind of complex machinery to represent. For example, the sun standing still, a phenomenon of nature, from which we should at this day expect the annihilation of the terrestrial globe, is feebly imitated by a note of uncommon duration. The hopping of frogs, the buzzing of flies, the falling of hail, are sufficient in words; they are scarcely appropriate in music. Another inimitable master, Haydn, has followed the footsteps of his countryman in these questionable points. But how can any one discover flashes of lightning, the flowing of streams, the roaring of lions, or the crawling of worms, from any association of musical notes? Such allegories are beyond the reach of the most vigorous imagination, which would be perplexed in searching for the analogy. One of Handel's operas opens with an imitation of a storm and a shipwreck; and a symphony is introduced in another to express the shrieks and cries of tortured souls in the infernal regions.

We must conclude, on the whole, that Handel is one of the greatest masters who has ever flourished; and that his style and performance materially contributed to produce that revolution in music, which has taken place in the course of the eighteenth century. (*c*)

HANG-TCHEOU-FOO. See China, p. 211.

HANNIBAL, the celebrated Carthaginian commander, was born about 220 years B. C.; and, when only nine years of age, accompanied his father Hamilcar to the army in Spain. Before his departure, he vowed at the altar, that he would never be in friendship with the Romans; and in the camp of Hamilcar, the most distinguished general of those times, he acquired that military skill, which afterwards rendered his enmity so formidable. At the death of his father, nine years after, he continued to serve in the field under his brother-in-law, Asdrubal, who had succeeded to the command; and, when this general fell by assassination, about eight years afterwards, he was unanimously chosen by the army as their leader, while the senate at Carthage with one voice ratified the election. Soon after his confirmation in the command of the troops, he accomplished the reduction of the Olcades, and, loaded with booty, took up his winter quarters in New Carthage, (the modern Carthagena), where he completely secured the affections of the soldiery by his liberal distribution of the plunder, and the hopes of farther conquests, with which he inspired them. In the following year he reduced all the Spanish nations on the south of the Iberus, except the Saguntines, the allies of Rome; and, upon returning to his former winter quarters, received an admonition from the Romans to beware of molesting a people who had been taken under their protection. Conceiving the armies of his country to have now attained sufficient strength to contend with the legions of Rome, and eager to vent his long cherished hatred against that rival republic, he returned such an answer as clearly intimated his hostile intentions, and immediately transmitted to Carthage direct charges against the Saguntimes of having committed outrages upon the allies of the state. Having received permission to make reprisals, he pushed his measures with a celerity and decision which the Romans were not prepared to anticipate; and, after an obstinate siege of eight months, gained possession of Saguntum before any succours could be received from Rome. While the Romans were supposing the designs of the Carthaginians to have been limited to the reduction of Saguntum, and were preparing to send an army by sea to Spain, as the seat of the approaching contest, Hannibal having secured the friendship of the Gauls on both sides of the Alps, began his march for Italy with an army of 50,000 infantry, and 9000 horse; evaded the Consul P. Scipio, who attempted, by landing at the mouth of the Rhone, to intercept his progress, carried his army across the

Alps in the beginning of winter in the space of 15 days, and appeared in the vicinity of Turin after a march of 1000 miles from New Carthage, accomplished in five months and a half. His army was now reduced to 20,000 foot, (of which 12,000 were Africans, and the rest Spaniards), and about 6000 cavalry. Having taken in three days the city of the Taurini, and put all who opposed him to the sword, he hastened forward to meet the Consul Publius Scipio, who had returned with the utmost expedition from the banks of the Rhone, and had already passed the river Po with his army. The two armies joined battle on the banks of the Ticinus, a small river in Lombardy; and Hannibal, chiefly by the superiority of his cavalry, gained an easy victory over a general who was neither deficient in courage or experience, but who seems to have been little aware of the talents of his adversary. The other Consul Sempronius, having arrived with a fresh army, acted with still greater rashness, and, engaging the Carthaginians near the river Trebia, sustained a much more decisive defeat. In the following campaign Hannibal was again fortunate in having to contend with a self-confident commander, Caius Flaminius; and, having carefully studied his temper, drew him into a defile by pretending a retreat, and cut to pieces, near the Lake Thrasymenus, the greater part of his army. But all his talents and expedients were brought into requisition by the dictator Fabius Maximus, who justly concluded, that to stop the progress of an invader is to gain a victory, and who cautiously directed his operations to preserve a commanding position, and to intercept the foragers of the enemy. The Carthaginian leader, baffled in all his artful movements to surprise his opponent, or to force an engagement, resolved at least to attach the neighbouring nations to his interests, by proving himself master of all the open country, boldly directed his march to the fruitful plains of Campania, which he quietly ravaged within sight of the Roman army. Upon attempting to return with his booty through the same pass by which he entered the country, he found himself, when encamped at the foot of Mount Callicula, hemmed in by the masterly movements of the Dictator; but by dispersing, during the night, 2000 oxen with burning faggots on their horns, he contrived to draw off the detachment which occupied the heights in the line of his march, and to bring off his army in complete safety. By taking care, in the general devastation, to spare the lands of Fabius, he encouraged the accusations and suspicions, which were ungenerously cast upon that general, of holding a secret correspondence with the enemy. In a short time he found means to draw into a snare the one half of the Roman army, commanded by Minucius, who had been raised to equal authority with the Dictator; but, when in full pursuit of the routed legions, he was checked by the advance of Fabius, and obliged to sound a retreat. While reluctantly retiring to his camp, he is reported to have said to his attendants, "Have I not often told you, that that cloud which hovered upon the mountains, would one day burst upon us in a storm?" The Roman generals, enjoined by the senate to follow the plans of Fabius, continuing merely to watch the motions of the Carthaginians without risking a decisive engagement, he found his difficulties fearfully accumulating. Without any hope of succours from Carthage, and left to the resources of his own genius for the means of subsisting his troops, in perpetual distrust of his allies in Italy, and daily assailed by the murmurs of his exhausted soldiers, he was on the point of sacrificing one part of his army to save the other, when the rashness of his adversaries again afforded him not only a season of respite, but an occasion of triumph. Having understood the fiery temper of Terentius Varro, one of the new consuls, (who held the command of the Roman army, and who bore with the utmost impatience, the cautious counsels of Paulus Emilius, his colleague), he attacked him in all his detachments, insulted him even in his camp, and succeeded at length in drawing him into the field, near the fatal village of Cannæ. The Roman army consisted of 80,000 foot, and 6000 horse, and that of Hannibal amounted only to 50,000 in all, of which 10,000 were cavalry. Varro, on the day of his turn to command, impatient to punish, as he expressed it, the insolence of the Carthaginian, and confiding in the number of his troops, descended into level ground, as if he had studied to favour the enemy's superiority in cavalry; and in a battle, which has already been described in the work, (see CANNÆ), lost nearly the whole of the largest army which had ever been equipped by Rome, while the loss of Hannibal did not exceed 6000 men. "Follow me," said one of the Carthaginian officers, elated with the annihilation of the Roman army; "I will be at Rome with the cavalry before they have notice of my approach. In five days we shall sup in the Capitol." To the refusal of Hannibal to adopt this advice, the preservation of Rome and its empire has been ascribed by Livy, and several other ancient historians; but many later writers have questioned the justice of the censure. Rome had been carefully fortified after the battle of Thrasymenus, and was provided with every thing necessary to sustain a siege. It was full of soldiers well trained to war, and supplied the dictator Junius Pera with four new legions and 100 horse, immediately after the battle of Cannæ. Hannibal's advantages had been principally gained by his superiority in cavalry, which could be of little use in attacking a city; and the rest of his army did not exceed 35,000 men. "His own judgment," says Dr Adam Fergusson, "is of more weight than that of the persons who censure him. He knew the character of the Romans, and his own strength. Though victorious, he was greatly weakened by his victories, and at a distance from the means of a reinforcement or supply. He was unprovided with engines of attack; and so far from being in a condition to venture on the siege of Rome, that he could not attack even Naples, which, after the battle of Cannæ, refused to open its gates."

Hannibal, soon after his victory at Cannæ, withdrew his army to Capua, the principal city of Campania, where he finally took up his winter quarters, after several unsuccessful attempts to gain possession of Nola, Casilinum, and particularly Naples, as affording an easy communication with Africa. Notwithstanding the assertion of the Roman historians, that Capua, by its enervating pleasures, proved as fatal to the Carthaginians as Cannæ had been to the Romans, it does not appear that Hannibal or his troops had lost much of their martial activity and ardour. As soon as the rigour of the season began to relax, he renewed the siege of Casilinum in sight of an army from Rome, amounting, exclusive of allies, to 25,000 men; and the want of supplies from Carthage, which had indeed been promised, but were slow in their arrival, was the principal cause of his power declining in Italy. He had not troops to oppose the Roman armies, which were so rapidly collected against him, and, at the same time, to garrison the towns and protect the countries which had

Hannibal. submitted to his authority or accepted his alliance. During the space of four years after the battle of Cannæ, no decisive advantage was gained by either party in the war; and though several victories are stated, by Livy and Plutarch, to have been gained over Hannibal by Marcellus, it is affirmed by Nepos, that the latter was always victorious in Italy, and by Polybius, that he was never vanquished before the battle of Zama. In the eighth year of the war, while Capua was hard pressed by the Romans, Hannibal made an attempt to draw off the besiegers, by marching to the gates of Rome, but found that city too well prepared to resist an attack, which he seems after all to have rather feigned than intended. After the fall of Capua, he was frequently obliged to decline the battle which the Roman generals were now ready to offer; and at length, in the thirteenth year of the war, after the death and defeat of his brother Asdrubal, being unable to preserve his conquests in Italy, he retired with all his forces to the barren rocks of Bruttium. Even in this weakened condition, in a country incapable of supplying him with subsistence, and at the head of an army composed of Africans, Spaniards, Gauls, Carthaginians, Italians, and Greeks, he continued, by his extraordinary talents as a general, to preserve the discipline of his troops, and to render himself formidable to the Roman commanders, till, in the sixteenth year of the war, he was recalled to Africa for the immediate protection of Carthage against the victorious legions of Scipio. Leaving Italy with the utmost reluctance, and landing at Little Leptis, a city between Susa and Adrumetum, he received instant orders from the Carthaginian senate to advance and give battle to the Romans. In obedience to these instructions, he proceeded by forced marches to Zama, about five days journey south west from Carthage; and being struck with the undaunted generosity of Scipio in sending back the spies who had been taken in his camp, requested an interview with the Roman general. The armies had encamped within four miles of each other, and there was a large open plain between them, where no ambush could be laid. Here the two generals, escorted by an equal number of guards, arrived for the conference; and each, attended by an interpreter, met in the midway, where they remained for a while in silence, viewing one another with mutual admiration. Hannibal first spoke, and proposed a treaty of peace, upon terms which had been recently agreed upon between the two countries; but Scipio insisting upon the perfidy of the Carthaginians in breaking the truce during the negociations, required them to surrender at discretion. Hannibal, however, much disheartened by his misfortunes, and doubtful of victory, could not bring himself to make, at the head of an army, so humiliating a submission. The conference terminated; and both the generals returning to their camps, prepared for battle on the following day. According to the testimony of Polybius, Hannibal drew up his army in the most skilful manner, and performed every thing in the engagement which could have been expected from a great commander. The victory was long and eagerly contested; and the Romans, though superior in numbers, appear to have at one time been on the point of losing the battle. But Masinessa, who commanded the Numidian cavalry, and Lolius who headed that of the Romans, having routed the wings of the Carthaginian army, came in the rear of Hannibal's veteran soldiers, who were almost entirely cut to pieces in their ranks. Of the Carthaginians, 20,000 are said to have fallen in the field, and about the same number were taken prisoners. Hannibal escaped with a few horsemen to Adrumetum, whence he was called to Carthage to aid the falling republic with his counsels. He instantly declared, that there was no resource except in a peace; and this reply, from the constant advocate of the war, and most inveterate foe of the Roman name, decided the senate to submit to the conqueror. See CARTHAGE and ROME.

Hannibal, who had now spent thirty-six years in arms, continued to reside at Carthage; and was afterwards honoured with the chief magistracy in that republic. Having exerted himself to remedy various abuses in the management of public affairs, and having particularly brought to light many instances of the embezzlement of the revenue, he was accused by his enemies to the Romans of secretly holding intelligence with Antiochus the Great, in the designs which that prince was meditating against the power of Rome. In spite of the remonstrances of Scipio, (who generously defended his former opponent in arms, and strongly insisted that it was below the dignity of the Roman people to range themselves among the personal enemies of Hannibal, and take part in the factions of Carthage,) ambassadors were dispatched by the senate to bring the charge against Hannibal, and to require that he should be delivered into their hands. Aware of their design, and doubtful of his countrymen, he made his escape to Tyre, where he was received and entertained in a manner suited to his reputation; and afterwards joined Antiochus at Ephesus, whom he found in a state of hesitation between peace and war. Upon being consulted on the subject, he asserted, as he had always done, that the Romans were invincible every where but in Italy; proposed, if entrusted with 10,000 foot and 1000 horse, to make a descent in that country; and, at the same time, dispatched a messenger to Carthage to persuade them to join in the enterprize. Before the commencement of hostilities, a Roman ambassador, accompanied by Scipio Africanus, arrived at Ephesus; and, during their residence there, many civilities are said to have passed, and frequent conversations to have taken place between them and Hannibal. It is reported that, during this friendly intercourse, Scipio one day asked the Carthaginian, "Whom he thought the greatest general?" Hannibal immediately replied, "Alexander," because that, with a small body of men, he had defeated very numerous armies, and had overrun a great part of the world. "And, who do you think deserves the next place?" continued the Roman. "Pyrrhus," replied the other: "he first taught the method of forming a camp to the best advantage. Nobody knew better how to choose, or post guards more properly." "And, whom do you place next to those?" said Scipio. Hannibal named himself; at which Scipio asked, with a smile, "Where, then, would you have placed yourself if you had conquered me?" "Above Alexander," replied the Carthaginian, "above Pyrrhus, and above all other generals;" thus, by a most refined strain of compliment, separating Scipio from the crowd of commanders, as one of inestimable qualities. These familiar conversations are said to have been sought by the Roman deputies for the purpose of discovering the designs of Hannibal; and they had at least the effect of rendering him suspected by Antiochus. That prince, though afterwards cured of their suspicions of his guest, refused to follow his counsels as to the prosecution of the war; and, upon suing for peace after his defeat at Magnesia, was required, among other conditions, to deliver up Hannibal to the Romans. This illustrious exile, however, anticipating such a demand, had removed from the dominions of the Syrian monarch, and taken refuge with Prusias king of Bithynia, to whom he rendered eminent services in various wars. At length Flaminius arrived as an ambassador from Rome, for the ostensible purpose of requiring Prusias to desist from hostilities against the king of Pergamus; but principally with a view to induce him to betray his Carthaginian guest. The king, reluctantly, according to Plutarch, but readily, according to Livy, complied with the dishonourable proposal; but Hannibal, who resided in the castle of Libyssa, upon learning that the place was surrounded by soldiers, resolved to die, rather than fall into the power of his persecutors. Taking into his hand a poison which he had kept ready for such an exigence; "let us deliver Rome," he said, "from her perpetual fears and disgust, since she has not patience to wait for the death of an old man." Then, having invoked the gods to take vengeance upon Prusias for his violation of hospitality, he swallowed the poison and expired. He died at the age of 65 years, of which he had passed 36 in camps, and 13 in exile. He had little opportunity, therefore, to cultivate the moral and civil virtues; though, perhaps, if impartially tried even by this test, he will be found, notwithstanding the shocking portrait drawn of him by Livy, to have been by no means inferior to the great body of conquerors in ancient times, or even to his celebrated opponent Scipio Africanus. Neither Plutarch nor Polybius makes any mention of that cruelty, perfidiousness, and irreligion, with which he has been charged. In point of military talents, he may be pronounced to stand in the foremost rank; and all the qualities which make a complete general, have not been more constantly and conspicuously manifested in the conduct of any captain of antiquity, than in that of Hannibal. He appears, especially, to have surpassed them all in the talent of forming brave and disciplined soldiers; though he was opposed by troops consisting chiefly of Roman legions, warriors by choice and education, he was victorious, even over superior numbers, in every battle except his last; and that with an army, which he had in a great measure renewed in conquered countries, which he had collected from various nations differing in manners and language, and which he preserved attached to his interests in the midst of privations and reverses. See Nepos, Livy, Plutarch, Polybius; Rollin's *Ancient History*, vol. vii.; Ferguson's *History of the Roman Republic*, vol. iii.; Abbé de St Pierre's *Life of Scipio Africanus*; and Hooke's *Rom. Hist.* vol. iv. and v. (*q*)

HANOVER.

Hanover.

Boundaries.

HANOVER is a kingdom of Europe, which was formed in 1815 out of the electorate of Hanover and the principality of Osnaburg. It is situated in the circle of Lower Saxony; and is bounded on the north by the territory of Hamburgh, Holstein, and Mecklenburgh, the Elbe forming the line of demarcation as far as Inapesse; on the north-east by Prussia; on the east by the duchies of Brunswick and Prussia; on the south by Hesse and Prussia; on the west by the lands of Lippe, Hesse, Waldeck, and Prussia; on the north-west by the territory of Bremen, and the possessions of the Duke of Olders, and the territories of Aremberg and Looz.

Hanover is of a very irregular form. It comprehends the duchies of Luneburgh-Zell, Bremen, Verden, and Saxe Lauenburg, on the northern side of the Elbe; the countries of Calenburg and Grubenhagen on the south; those of Diepholtz and Hoya on the west; and that of Danneberg on the east. At the treaty of Ratisbon, Hanover lost the bailiwick of Wildehausen; but in 1802, it acquired the principality of Osnaburg.

Duchy of Luneburg.

1. The principality or duchy of Luneburg-Zell, is bounded on the north by the duchies of Lauenburg and Mecklenburg; on the east by the electorate of Brandenburg and duchy of Brunswick; on the south by those of Brunswick and Calenburg; and on the west by the circle of Westphalia. The Elbe forms the north and north-east boundary. It is from 75 to 80 miles from north to south, and from 60 to 70 from east to west. It contains 200 parishes and 27 towns. It possesses some fruitful marsh lands along the Elbe, the Aller, and the Jetze; but towards the centre and northern parts, it is sandy, heathy, and barren. The principal towns are LUNEBURG, HARBURG, ZELL, Helzen, Danneberg, and Lucho. See p. 635.

Duchy of Bremen.

2. The duchy of Bremen, is bounded by Holstein, Luneburg, Verden, and Westphalia. It is about 65 to 70 miles long from north to south, and 45 to 50 from east to west. The Marschland, or low country, on the rivers Oster, Weser, and Elbe, is fertile, but liable to inundations. The Geestland, or high country, is in some places fruitful, and has its heaths covered with sheep. In this duchy, are 2 cities, 12 market towns, 22,276 taxable hearths, 118 Lutheran churches, and 28 noble jurisdictions. The principal towns are BREMEN, STADE, Buxtehude, Closter Seven or Zeven.

Duchy of Verden.

3. The duchy of Verden, which has a peninsular form, lies on the right bank of the Weser between Bremen and Luneburg. The extent from north to south and from east to west, is from 25 to 30 miles. It is an elevated, heathy, and dry country, traversed by the rivers Aller and Wumme. Its principal towns are VERDEN, Rottenburg, and Languedal.

Duchy of Saxe-Lauenburg.

4. The duchy of Saxe-Lauenburg, is bounded by Holstein, Mecklenburg, and Luneburg, and the territories of Lubeck and Hamburgh. The country is level, and in some places fertile. It yields considerable quantities of wood and flax, and exports, rye, butter, cheese, wool, wood, and fish. The small rivers Belle, Steckenitz, &c. which fall into the Elbe, water the southern part of the duchy. The principal lakes are those of Ratzeburg and Schall; and the chief towns RATZEBURG, Lauenburg, and Mollen.

Principality of Calenburg.

5. The principality of Calenburg is situated in the south-west corner of Lower Saxony, and is cut into two parts by a part of the principality of Wolfenbuttel. The northern part is bounded by Luneburg, Hildesheim, Pyrmont, Lippe, Schauenburg, Hoya, and Minden; and the southern part by Wolfenbuttel, Grubenhagen, Eichfeld, and Lower Hesse. It is about 48 leagues long, and from 6 to 10 broad. The Weser, which forms part of the western boundary, is every where navigable. The country is in some places hilly, and in others marshy and sandy, and nowhere very fertile. The principal hills, are the Deister, Suntel, and

Solingerwald. The principality contains 36 towns, and 221 churches. It is divided into three quarters, viz. 1. The quarter of Hanover, which contains 11 towns, 2 abbies, 6 convents, 81 manors, and 212 villages. The chief towns are HANOVER, Munder, Wunstorf, Pattensen, Eldagsen, &c. 2. The quarter of Hameln and Lauenau, which contains 13 towns, and 128 villages. The principal towns are HAMELN, and Bodenwarden. 3. The Gottingen quarter, which contains 15 royal bailiwicks, 11 noble jurisdictions, 12 towns, 8 convents, and 180 villages. The chief towns are GOTTINGEN, NORDHEIM, MUNDEN, Dransfeld, Moringen, Uslar, and Hardegsen.

[P]rincipality [of] Gruben[hagen]. 6. The principality of Grubenhagen, is bounded by Calenberg, Wolfenbuttel, Wernigerode, Blankenburg, Hohenstein, and Eichfeld. The greater part of this principality is mountainous, and covered with woods. It contains, however, some fruitful plains, where considerable quantities of flax are raised. Grubenhagen contains a part of the famous chain of the Hartz. The principal minerals which it contains, are slates, alabaster, marble, rock salt, calamine, sulphur, lead, copper, iron, silver, and gold. For an account of the produce of the mines, see p. 634. Grubenhagen contains 9 small towns, 44 parochial churches, and 7000 taxable hearths. The chief towns are Einbeck and Osterde, which are described in p. 635.

[Co]unty of [Die]pholtz. 7. The county of Diepholtz is bounded on the north by Delmenhorst and Bremen, on the east by Hoya, on the south by Minden, and on the west by Osnaburg and Munster. It is 25 miles long from north to south, and 10 to 14 from east to west. This county consists of heaths, moors, and pasture lands; and the people are chiefly employed in breeding cattle, and manufacturing coarse linens. It contains ten parishes, and five towns, the principal of which are Diepholtz and Lemforde.

[Co]unty of [Ho]ya. 8. The county of Hoya is bounded on the north by Delmenhorst, Bremen, and Verden, on the east by Luneburg and Calenburg, on the south by Minden, and on the west by Minden and Diepholtz. It is 25 to 30 miles from north to south, and 30 to 33 from west to east. The soil is chiefly sandy; but there are some fruitful tracts, which produce wheat, barley, and flax. Some parts are heathy, and others fit for pasture. It contains 54 parishes, and 100 towns and villages, the chief of which are Hoya, Drakenburg, Nienburg, Liebenau, Suhlingen, Harpstedt, &c.

[Pri]ncipality [of] Osna[bur]g. 9. The principality of Osnaburg is bounded on the north and south by Munster, on the east by Hoya, Minden, and Ravensberg, on the west by Techlenburg and Lingen. It is about 43 miles long from north to south, and 32 from west to east. The river Hase traverses it from north to south. Nearly one half of the county consists of heathy and barren land. Rye and flax are its chief produce. It contains seven towns, the principal of which are Osnaburg, Iburg, Furstenau, Quackenbruck, Vorden, and Wiedenbruck. See OSNABURG.

[Riv]ers. Hanover comprehends 107 bailiwicks. The country is intersected by a great number of rivers and streamlets, and is in general extremely marshy. The principal rivers are the Elbe towards the north, the Weser and the Leine on the west, and the Aller and the Ilmenau in the centre of the kingdom. The chief lakes are those of Diepholtz and Stinhuder. The Aller rises in the duchy of Magdeburg; and, after traversing the southern parts of Lunebourg-Zell, it falls into the Weser below Verden. The Leine rises in Eichfeld, runs northward through the eastern part of Calenburg, and falls into the Aller. The lake of Diepholtz is called the Drummer-see, and though very extensive is extremely shallow.

Climate. The climate is by no means good. The temperature is very variable. The winters are rigorous, and frosty days often intervene between the greatest heats of summer. A north-west wind commonly blows during the cold season, an east wind in spring, and a south-west wind in summer. **Diseases.** The common diseases are catarrhs, intermittent and nervous fevers, phthisis, apoplexy, and palsy. When July is very warm, dysenteries are peculiarly malignant. The epidemics are of a rheumatic nature, and consumptions are very fatal.

Mountains. The Hartz mountains are the most considerable in the kingdom. See HARTZ. The mountains which separate the west and south of Hanover from the principality of Hesse are either of a calcareous or basaltic nature, and consist of large pyramidal blocks, which furnish excellent stones for mending the roads, and paving the streets.

Agriculture and soil. Very little progress has been made in improving the heaths and the marshy grounds of Hanover. A few fertile spots are occasionally seen in the midst of barren wastes, although, by a little judicious management, a great part of the soil might be brought under cultivation. Nearly one half of the land is covered with weeds; a fifth part of the arable fields is employed in pasturage; and of the parts from which grain is raised, a third is occupied by peas and beans, a fourth by wheat, rye, and buckwheat, a fifth by barley, and a sixth by oats. On the sandy lands good potatoes are produced. Notwithstanding the general sterility of the country, there are many fertile and populous vallies on the banks of the Elbe and the Weser. The duchy of Saxe Lauenberg is completely cultivated, owing to a wise agreement between the seigneurs and the peasants to relinquish some mutual privileges. The grain raised in Hanover is not sufficient for the consumption of the inhabitants; but though the pasturage is not luxuriant, they export a considerable number of horses to France, Italy, and Saxony. If the operation of draining were extensively carried on, Hanover might supply Germany, Holland, and France with a sufficient number of horses and black cattle. The wool is of a very bad quality. It is used in Belgium in the manufacture of coarse cloth, and the Hanoverians work it into a tolerably good looking stuff. Several rams of the Merino breed have, however, been imported from Upper Saxony; and the wool has thus been greatly ameliorated. The cows are neither large nor beautiful. They are generally of a black and white, or a white and fawn colour. In order to improve the breed, bulls are brought from Holland. The Hanoverian goats are very poor, and few in number. The oxen are of a middle size, and make excellent beef, the pork is good, and the mountain mutton is highly esteemed. Flax is more abundant than hemp throughout the kingdom, and it is the chief occupation of the females to spin it in the winter evenings.

Natural history. The natural history of this country is in no respects interesting. Boars and deers are much less numerous than formerly; and, during the last century, wolves have been extremely rare. The last bear was killed at Hartz about the beginning of the 18th century. Roebucks and hares are excellent, but rabbits are very scarce. Thrushes, partridges, skylarks, wild-ducks, heathcocks, and a small species of tetran, are very numerous. The rivers do not produce a great variety of

Hanover.

fish, but the markets are well supplied with turbot, perch, carp, pike, and large eels. The streams that issue from the Hartz, and other wooded mountains, abound with a small trout of exquisite flavour. The mineral waters of Limmer are much frequented. The hot baths of Limmer are built of grey stone, firmly cemented and fixed in the ground. The descent is by four steps, with a ballustrade. A bench 5 inches broad serves for a seat, and it has a fir back, in order to prevent a sudden shock from the cold stone before it has acquired the temperature of the water. The charge for each bath is a franc.

Minerals.

The minerals of this country are rich and numerous: They consist of silver, copper, lead, iron, cobalt and zinc, with marble slate, coal, turf, and limestone. Boracite has been found in the Kalkberg and Staurolite at Andreasberg in the Hartz. The annual produce of the mines of the Hartz which belong to Hanover, is reckoned at 1,172,733 rixdollars. The annual produce of the lead mine called Caroline, is 194,000 rixdollars. See the article Hartz.

Government.

The territory of Hanover is governed by a regency composed of seven ministers. Four of these reside in Hanover, the capital; and the fourth, who presides over the law department, the police, and the high court of appeal, resides at Zell. The sixth, who is at the head of the College of Nobles, likewise presides over the subordinate regency of Bremen and Verden, which is held at Stade; and the seventh has a permanent establishment in the court of the electoral king. This regency possesses regal power, and decides in all matters on which the provincial states are not entitled to interfere. It communicates with these assemblies in the same manner as the elector himself, and superintends all the departments of the government. There is a subordinate regency for the bailiwicks of Lauenburg, which sits at Ratzeburg, and another for the principality of Osnaburg, which sits at Osnaburg.

Provincial states.

The provincial states of the kingdom consist of the prelates of the equestrian order, and the magistrates of cities. The priests are of the first rank, the nobles are of the second, and the magistrates of the third rank. the duty of the states is to watch over the liberties of the people, and the different orders of the citizens,—to enforce a regular administration of the laws,—and to superintend the distribution of the public money. No tax can be levied without their consent, and every new law must have their sanction.

Laws.

The Roman and public law, the constitution of the empire, the bulls of the emperors, and the particular constitutions of the different provinces of which Hanover is composed, are precedents by which the magistrates are guided in their political, civil, and criminal judgments. The high court of appeal sits at Zell, and the minister is bound to consult the regency in certain difficult cases. The decisions of this court have always been highly respected. When M. Wrisberg was its president, George II. one day said to him, "How does it happen that I lose every process that I bring before your tribunal?" "Sire," replied the president, "It is because your Majesty is always in the wrong." "M. de Wrisberg," replied the king, "you speak to me like a magistrate." Capital punishments are very rare in Hanover. The principal punishments are fine, reprimand, detention in a house of correction, imprisonment, or compulsion to labour for a limited period. Breaking on the wheel is still practised in this country, but it is always preceded by strangulation. Every sentence, however, which inflicts this punishment, must be submitted to the deliberation of the regency. Public works, where the criminals labour, are established in five of the principal cities: the more hardened are sent to Hameln, and others to the quarries of Luneburg. The use of preparatory torture is said to remain unabolished.

Revenue.

The revenues of the kingdom are derived principally from a tax on land,—from a contribution from the peasantry in money, grain, and labour on the roads,—from a poll tax from the different classes of citizens,—from duties on cattle, on the consumption of luxuries, and on salt, coals, and turf. Taxes are also levied on mills, leases, horses, and public carriages, and considerable sums are obtained from tythes,—from tolls on the transit of goods,—from the custom-house, the forests, fisheries, game-laws, the mines of Hartz, the coinage of money, and the postage of letters. The total amount of the revenues has been estimated at £962,500 sterling. The national debt is considerable, and was principally contracted to support the seven years war.

Military state.

Hanover has 10 garrison towns, viz. Hanover, Munden, Zell, Luneburg, Nienburg, Stade, Harburg, Ratzeburg, and Osnaburg. The works of Hameln and Harburg are the most considerable. The fortifications of Stade were demolished in 1781, but those erected on the Klutberg, above the Weser, in 1760, and called Fort George, have become very strong from the addition of new works. The military commandants of these garrison towns enjoy no rank in the army. The following is the military force:—

Infantry	12,015
Cavalry	4,600
Artillery	671
Corps of engineers	95
Militia	5,500
	22,881

The soldiers are all Hanoverians. The cavalry is generally composed of the sons of farmers, and the militia consists of pensioners who have served 25 years in the army. They have the same organization, equipment, and clothing as the regular troops. The operations of the commander in chief are subordinate to the regency. Every soldier has a right to demand his discharge after 20 years service, and he is entitled to a pension according to his rank. The number of invalids amounts to 7000. No British subjects are employed in the Hanoverian army. The cannon foundry is at Hanover. It is situated on the glacis of the city, on the side next the road leading to Zell. The only manufactory of small arms is one at Hertzberg, which enjoys much reputation in Germany. The best gunpowder is made at Hersen near Hameln. The manufacture of cannon and of powder are both carried on by private individuals.

Ecclesiastical state.

Hanover contains about 750 parishes, with seven superintendants. The people are divided into Jews and Christians, and the Christians into Catholics, Calvinists, and Lutherans. Before the union of Osnaburg the Jews were the most numerous sect next to the Lutherans. The Jews are the principal bankers in the large cities, and they keep butchers' shops in the small villages.

The Lutheran is the established religion. The supreme consistory, composed of some of the most enlightened citizens, has the right of superintending all

Hanover. the other sects. The Lutheran clergy are supported by a portion of the property which once belonged to the Catholic church; but the greatest part of it is appropriated for the university of Gottingen, the lyceum of Hefeld, and other public institutions. The ministers of the other sects receive a small sum from government, and derive the rest of their income from their parishioners. The Calvinists are few in number, and there are only a very few Roman Catholics in the kingdom.

'le of ılic instruction. A regular system of instruction was adopted in Hanover after the year 1750, in consequence of the liberality of M. Botticher, who endowed a seminary for schoolmasters in the city of Hanover. The electoral regency did all in its power to promote the objects of this institution; and, in order to combine practical with moral and literary knowledge, the children of both sexes were taught to sew, spin, knit, &c. In the middle or secondary schools are taught geography, history, drawing, the French and English languages, together with the elements of geometry. In the academies, or schools of the third order, are taught antiquities, and the Latin, Greek, and other languages. Academies of this kind are established at Zell, Clausthal, Einbeck, Hameln, Hanover, Harburg, Ultzen, Hefeld, Gottingen, Bremen, Luneburg, Minden, Nordheim, Osterode, Stade, and Verden. Besides these academies, there are establishments at Hanover and Luneburg for the education of the young nobility of both sexes, from the period of eight to fifteen years of age. The Georgianum, an establishment of this kind, was founded in May 1796, for the education of 40 pupils, who must be the sons of Hanoverian nobles. Every pupil pays at his entrance about 95 Thalers, or nearly £16 sterling; and 15 of those whose parents can afford it, pay the additional sum of 120 Thalers. They are all boarded, clothed, and taught at the expence of the establishment. Their dress is a blue uniform, faced with scarlet. They are admitted at the age of 10, and as soon as they have received a suitable education, they may either enter into the military service, or pursue their studies at the university of Gottingen, in order to fit themselves for any other profession. Those who enter into any regiment receive 260 thalers for their equipment out of the funds of the institution; and the most distinguished of the pupils, who are sent to Gottingen, enjoy an annual income of 300 thalers during their three years residence at the univerity. Belonging to the institution is an excellent library, a collection of natural and artificial curiosities, and a good philosophical apparatus. Primary schools are established in every village; while schools for the classics and the elements of the sciences are founded in all the principal towns. The university of Gottingen is provided with 42 professors. See GOTTINGEN.

'ude. Hanover is very far from being a commercial country. At the four fairs which are held annually at Hanover, and the two at Osnaburg, are exposed to sale the commodities which have been purchased at the fairs of Brunswick, Leipsick, and Frankfort. They consist chiefly of earthen-ware, agricultural and handicraft implements, pins, needles, coarse linen drapery, baskets, coarse stuffs, lace, thread, ribbons, and toys. Articles of English merchandise are brought from Hamburgh, Emden, Bremen, and Brunswick; and the linens of Friesland and of Prussia, and the cloths, silks, and jewels of France, are also met with in Hanover.

-nufactures. A great deal of plain and table linen is manufactured in Hanover. At Osnaburg the most common employment is spinning flax, which is afterwards wrought up into damask, greatly inferior to that of Prussia and Friesland. The greater part of it is sold at home; but in times of peace, the surplus is exported, through the Hanse towns, to North America and the Spanish colonies. Very little hemp is raised in Hanover. Their domestic linens are principally made of flax, which is never spun sufficiently fine to be made into lawns or cambrics. There are also manufactories for coarse cloth and paper, several tanneries, and some glass-houses; and a manufactory for iron and copper utensils at Hartz. The coarse cloths are principally used by the poor, and for clothing the army. The paper is inferior to the Dutch and French papers. One half of the leather, which is not good, is consumed in the kingdom, and the other half exported to Saxony and Belgium. The best glass is made in the bailiwick of Lauinstein. The manufacture of iron articles at Hartz is said by Mangourit to be superior to any thing of the kind carried on in France. Silver plate, jewellery, gold and silver lace, embroidery, and saddlery, are made at Hanover. Diamonds are set in a very superior manner, and the artists also cut white, yellow, or red amber globes, with facets for ear-rings, necklaces, and bracelets, which are bought by the Jews, and sold at an enormous profit.

The principal articles of export, are horses, black cattle, wax, lead, linens, leather, salt, oats, barley, thread, the iron and copper of Hartz, the turf of Bremen, and planks of timber. The two last articles are bought by the merchants of the hanse and maritime cities. Articles of export.

The principal towns in the kingdom of Hanover, are Hanover, Gottingen, Bremen, Osnaburg, Stade, Ratzeburg, Munden, Zell, Hameln, Klausthal, Einbeck, Harburg, Ultzen, Lauenburg, Mollen, Hefeld, Nordheim, Osterode, Verden, and Nienburg. Principal towns.

Einbeck, or Einbike, the capital of the principality of Grubenhagen, is a walled and fortified town, situated in a fertile territory at the confluence of the Ilm, Krumewasser, and Leine, near the borders of Calenburg. Besides ramparts, bulwarks, and towers, it has moats and outworks. Considerable quantities of woollen cloth are made here, and it has several breweries. Its population is 4500. Osterode, containing 4000 inhabitants, is situated six leagues east of Einbeck, at the conflux of the Sole and Apenke. It has an ancient castle; and a manufacture of camblets, besides quarries and mills, and lime-kilns. Nordheim, erected into a town in 1252, is situated on the Ruhme, which here divides itself into two branches, a few miles above their influx into the Leine. The organ of the parish church is famous for its immense size. Tobacco is cultivated in the neighbourhood, and it has several flourishing manufactures. Near this town a sulphureous spring was discovered in 1804, and baths have been erected at the house of the woodkeeper. It contains 3000 inhabitants. Ultzen, or Uelzen, is a trading town, consisting of 330 houses, situated on the Ilmenau, at the confluence of several small streams. It had formerly a great trade in flax, linens, wool, wax, and butter; but it is now on the decline. Verden has a fine cathedral, with very interesting monuments, and a population of 4000. Danneberg is a decayed town of 160 houses, with a ruinous castle on an eminence, watered by the Tetze. The chief export is beer. Nienburg is situated on the Saale, in Upper Saxony, but near the borders of Lower Saxony, it has a fine stone bridge over the Weser. It contains a palace erected out of a convent of monks, and is celebrated for a kind of beer like English ale. For an account of the other towns, see BREMEN, GOTTINGEN, HAMELN, HANOVER, HARBOURG, KLAUSTHAL, LUNEBURG, MUNDEN, OSNABURG, RATZEBURG, STADE, ZELLE. Einbeck. Osterode. Nordheim. Ultzen. Verden. Danneberg. Nienburg.

The illustrious house of Hanover is descended from Margrave Azo, who possessed the Milanese, Genoa, and part of Lombardy, in the 11th century. He was succeeded by Welpho the Fat, who married the Marchioness of Tuscany. Welpho having died without issue, his Italian estates, and the duchy of Bavaria, came into the possession of his brother Henry the Black, who obtained the county of Luneburgh with his wife Wulphilda, daughter of Magnus Duke of Saxony. His son Henry the Proud having married the daughter of Lotharius II. obtained along with her the duchy of Saxony, and the hereditary lands of Brunswick Nordheim, and Supplingenburg; and the dominions of the family extended from the Rhine to the Vistula, when her son Henry the Lyon reduced the Slavi, on the coast of the Baltic. In 1179, he was put under the ban by the Emperor, and deprived of all his possessions in Italy and Swabia, and of the duchies of Saxony and Bavaria. He was allowed, however, to retain Luneburg, some lordships, and his Slavian conquests. His son Otho obtained the imperial dignity in 1209; and, in the course of time, his family was divided into two branches, two of which now exist, viz. those of Wolfenbuttel and Zell. The first was founded by Henry, and the second by William, the sons of the Duke Ernest, who introduced into his dominions the reformed faith. Ernest Augustus, his grand nephew, and Elector of Hanover, married Sophia, the daughter of the Elector Palatine, and of Elizabeth, the daughter of James I. of England, and established the right of primogeniture in the Wilhelmine line. In the year 1714, George Louis his son succeeded, in virtue of the act of succession, (see BRITAIN,) to the throne of England, and since that time the kings of England have been the electors of Hanover. In the year 1715, the Duchy of Verden was ceded to the Elector of Hanover by the alliance concluded at Wismar; and in 1719, by the treaty of Stockholm, Bremen was also transferred to the elector, who, in 1732, obtained the emperor's investiture for both Bremen and Verden. In October 1801, the Prussians, under the fatal influence of the government of France, had declared war against Great Britain, and had taken possession of the electorate of Hanover; but at the peace of Amiens, the electorate was restored to its lawful sovereign. The Bishopric of Osnaburg, or Osnabruck, which, by the peace of Osnaburg, was to be occupied alternately by a Roman Catholic and a Lutheran bishop, the last of whom must be selected out of the house of Brunswick Luneburg, was secularised by the treaty of Luneville, and was ceded by the treaty of Amiens, in 1802, to George III. as elector of Hanover.

When Bonaparte had determined to make war upon Great Britain, he marched his army into Osnaburg and Hanover. On the 9th of June 1803, the French under the command of General Drouet, took possession of the country and city of Osnaburg; and, after a slight engagement, the convention of Suhlingen was entered into on the 3d of June 1803, between General Mortier and Marshal Walmoden, the commander of the Hanoverian army. The first consul immediately sent this convention to England, declaring that he would ratify it as soon as it had been sanctioned by his Britannic Majesty. The English government, however, refused to give any sanction to this convention. They averred, that the character of George III. as elector of Hanover, was distinct from his character as king of Great Britain, and that in the year 1795, the French government had acknowledged his neutrality as elector of Hanover during the existence of a war with Great Britain. The king therefore resolved to abstain from every act which might be considered as contravening the stipulations of the convention concluded on the 3d of June, between the deputies appointed by the regency of Hanover, and the French government; until he should make an appeal to the empire and to the powers of Europe, who had guaranteed the Germanic constitution, and consequently his rights and possessions as a prince of the empire. On the 30th of June, General Mortier communicated the resolution of the British government to Marshal Walmoden, and summoned him to surrender his army in 24 hours, to be sent prisoners of war into France. The Hanoverian general declared that his army should perish in the field rather than consent to such humiliating terms. General Mortier was thus induced to offer milder terms, and a capitulation was signed on the 4th of July, by which the Hanoverian army laid down its arms, which, with all the artillery, was to be delivered up to the French, along with the cavalry and artillery horses, to the amount of 4000. The soldiers were to return to their respective homes, and engaged not to serve against the French till regularly exchanged.

Hanover continued in the possession of the French till the year 1806, when it was occupied by the Prussians. It was afterwards annexed to the new kingdom of Westphalia, which was formed for Jerome Bonaparte.

In consequence of the great events in 1813, (see FRANCE, vol. ix.) which have led to the liberation of Germany, Hanover was restored to its ancient rights, by the army of the Crown Prince of Sweden. It of course reverted to its legitimate sovereign at the treaty of Paris in 1814, and has since continued in a state of tranquillity and happiness. At the second treaty of Paris in 1815, the electorate of Hanover was converted into a kingdom.

Population.

The population of Hanover is about 800,000 souls, which gives about 1500 to every square German mile. The population of the principality of Osnaburg is about 133,000; so that we have, according to Mangourit,

Hanover Proper,	800,000
Principality of Osnaburg	133,000
Population of Osnaburg	933,000

The following is another estimate of the population:

Principality of Calenburg,	210,000
Principality of Luneburg-Zell,	200,000
Duchy of Bremen,	167,149
Principality of Osnaburg,	117,896
Principality of Grubenhagen,	80,000
Duchy of Saxe Lauenburg,	40,000
County of Hoya	40,000
Duchy of Verden,	30,000
County of Diepholtz,	12,000
	897,045

See particularly Mangourit's *Travels in Hanover*, during the time of its occupation by the French; Catteau de Calleville's *Voyage en Allemande*; Peuchet's *Dictionnaire de la Geogr. Commerç.*; and the article HARTZ.

HANOVER is a fortified town of Germany, and capital of the kingdom of the same name. It is situated in a sandy plain, on both sides of the river Leine, which divides it into two towns, viz. Old and New Hanover. The old town lies on the left bank of the river, which here forms two branches, and, after inclosing an island, they again reunite and become navigable. The old and

Hanover. new towns are connected by bridges. The town is built in the form of a half moon, and contains several good streets. The houses of the new street called George-strass are all built on the same plan. This street, or rather row, is built along the side of a fine rampart, from which it is separated by iron chains, resting on pillars of free-stone. There is a Gothic appearance in most of the buildings of Hanover. The houses resemble the galleries of a vessel of the sixteenth century, and the time of their erection is always marked upon them. In those dated 1565, each story projects several feet over the one below it, and exhibits medallions, pagan deities, warriors, and verses of the Psalms. Red and green bricks are intermixed in some of the edifices, and in others varnished tiles are arranged in rows. Sometimes bricks are only used for the doors and windows, while the rest of the house consists of wood, painted of various colours. In some houses, the bricks are placed in wooden frames, and secured by plaster. The town, however, contains many handsome buildings. The Elector's palace, which, after being destroyed by fire, was rebuilt in 1791, is a fine building constructed of hewn stone. This was the seat of the regency. The newly erected part of the electoral church, and the palace of the Princess of Wales, are likewise excellent buildings of stone. Hanover contains also a theatre, three parish churches, a poor-house, and three hospitals. The public library of Hanover is a respectable building. The first story is appropriated to charts, state papers, and juridical records. The upper stories contain works of imagination and belles lettres. When the French threatened to invade Hanover, the Elector ordered the four copies of the beautiful Oxford Bible, the books, and the precious monuments, to be packed up and removed. We believe that they were afterwards sent back to the capital. This library was founded by Leibnitz, who bequeathed to it his own fine collection of books. There are two portraits of this great man in the library, one at the age of 40, and the other at 60; and the arm-chair in which he expired is there carefully preserved. His remains are interred under a stone in the Lutheran church in the new city. A very fine monument is also erected to his memory by private subscription. It is an Arian temple, situated in an umbrageous thicket, at the end of a long avenue of linden trees. Twelve columns, of the Tuscan order, of hard grey stone, quarried in the Hartz mountains, support a light cupola, beneath which is placed a white marble bust of Leibnitz, taken from the picture of him at the age of 60. "To the memory of Leibnitz," is the simple inscription which reminds us of the labours of this great philosopher.

The cemetery of the Jews is situated on an oval eminence near the city; and that of the Lutherans is a vast field surrounded by a parapet, and crowded with funeral monuments. The tomb-stones of the noble families occupy a large space in the middle of the field. The graves of the lower classes are every day covered with fresh flowers. The remains of the celebrated physician Wherloff lie under a triangular pyramid. "Not far distant," says Mangourit, "is a monument representing a mother stretched upon the body of a beloved daughter; the scissars of fate cut a half blown rose, and the parent tree, stripped of its leaves, is torn up by the root. Just by is the tomb of the lover of the young lady. The sculptor has succeeded in depicting the beauty and elegant figure of this youth. On one side of the monument we behold a superb oak; on the other, the oak is reversed, its branches are broken, its leaves fallen, and its seed scattered." There are here some tombs and sarcophagi of white marble; but the greater number are formed out of stones from the Hartz mountains.

Hanover. Hanse Towns. There is at Hanover a society of natural history; the seminary for schoolmasters; the female school of industry, conducted by Madame Klockenbrigg, in which some excellent pieces of embroidery are executed and sold at a very high price.

Hanover formerly carried on manufactures of various kinds, particularly linen, damask, printed cotton, tapestry, wax-cloths, stockings, caps, gloves, flannels, serges, tobacco, lace, gold and silver lace, and ribbands; but we have not been able to learn in what state these manufactures are at present. There is a cannon foundry at Hanover, situated on the glacis of the city. The retail shops of Hanover, and the ware-houses of cloths and of French silks, are well supplied; English cloths and cottons also abound.

The environs of Hanover are very beautiful. The city looks well at a distance with its four steeples, its houses intermixed with poplars and lime-trees, and its rural suburbs. The irregular assemblage of religious monuments, plain and handsome palaces, Gothic buildings, small wooden houses, churches painted of various colours, and arbours of different shapes and sizes, have a very singular effect. The windings of the Leine are very agreeable, and the triple row of lime-trees planted along its banks, which are covered with rose bushes and sword-grass. The windings of the Leine are, however, artificial. The springs near the fortifications not being sufficient to fill the ditches, a canal was cut in a serpentine direction, to the distance of about three kilometers above the city. This canal now conveys the provisions to the capital. In order to prevent the river from flowing back to its former bed, and to relieve it when too full, a large barrier, about 2 kilometers long, has been built of gray stone, so as to allow the surplus waters to flow into its former channel by three long dams. This work is admirably and solidly executed.

The principal promenades at Hanover are the garden of Madame La Baronne de Decker, the garden of Count Field Marshal Walmoden, Montbrillant and Herrenhausen, the country seat of the Electors of Hanover. The approach to Herrenhausen is by a long avenue of lime-trees. The castle is by no means a handsome building, and the grounds are laid out with the greatest uniformity. The water-works are good, and before the central basin is a neat rural theatre. The orangerie, which formerly served as a ball-room to the court, is a very long hall decorated at every twelve feet with copies of ancient busts. It contains some fine orange plants placed in boxes surrounded with laurels, and cut into a pyramidal shape. The garden of Herrenhausen is extremely interesting to botanists, and is said to be surpassed only by that of Schoenbrunn. Population, 15,500, or 19,444 according to Tynna *Almanac du Commerce pour* 1811. East Long. 9° 42′ 55″, and North Lat. 52° 22′ 25″. See Mangourit's *Travels in Hanover*, passim; and Reichard's *Guide des Voyageurs en Europe*, tom. ii.

HANSE TOWNS, is the name given to a number of towns in Germany and the north of Europe, who entered into a league for the protection of their commerce. This association is supposed to have commenced in 1169. It was confirmed in 1226 and 1284, and a general assembly of the members was held every ten years.

Almost every trading town in Europe became ambitious of joining the league; but it seems to have been a fixed principle, that every town was excluded that was not situated on the sea, or on some navigable river.

In the year 1226, the Hanse Towns were 72 in number; and among these were Calais, Rouen, St Maloe, Bourdeaux, Bayonne, Marseilles, Barcelona, Seville, Cadiz, London, Lisbon, Antwerp, Bruges, Rotterdam, Ostend, Dunkirk, Messina, Leghorn, and Naples.

The towns were distinguished into four classes, at the head of which were Lubeck, the capital of the league, Cologne, Brunswick, and Dantzic.

This powerful association was in its most flourishing condition about the end of the 14th and the beginning of the 15th century, and interfered, to a great extent, in the affairs of Europe. The jealousy, however, of the European princes induced them to withdraw the merchants of their respective countries from the league; and in a short time it was so much reduced, as to comprehend only the four principal towns of Lubeck, Cologne, Brunswick, and Dantzic. In 1803, the only members of the league were Lubeck, Hamburgh, and Bremen. What changes it is to receive from the recent revolutions which have taken place in Europe, time only can determine. See COMMERCE, vol. vii. p. 74, and DENMARK, vol. vii. p. 623, 629.

HAN-TCHONG-FOO. See CHINA, vol. vi. p. 208, col. 2.

HAPAEE ISLANDS. See FRIENDLY ISLANDS, vol. ix. p. 755, col. 1.

HAREM. See SERAGLIO.

HARBOROUGH. See LEICESTERSHIRE.

HARBOUR. See INLAND *Navigation*.

HARBOURG, or HAARBURG, is a town of Germany, in the kingdom of Hanover. It is situated opposite to Hamburgh, on the Seeve, near its influx into the Elbe. It is pretty strongly fortified, and is advantageously situated for carrying on a considerable trade. Great quantities of wood are cut in the neighbourhood, and sent to Holland and France. There is here a manufactory for bleaching wax, a refinery of sugar, and manufactories of starch, stockings, ribbonds, and hats. Two packet boats set out every morning and evening for Hamburgh, the distance of which is only seven miles. The harbour of Harbourg, which is called Lotz, is so deep, that the largest vessels from Holland and Friesland can enter it and deliver their cargoes. A ditch or canal, furnished with two sluices, has been cut from the Elbe to the castle, which greatly facilitates the navigation and trade of the town. Population of the town 3500.

HARDICANUTE. See ENGLAND, vol. viii. p. 596.

HARE. See MAMMALIA.

HARELIP. See SURGERY.

HAREWOOD, is a small town of England, in the west riding of Yorkshire, and one of the most beautiful in the kingdom. It lies between Harrowgate and Leeds, in a fine, rich, and beautifully wooded country. The houses are almost all built uniformly, and covered with slate. Before we enter the town from the north, is Harewood castle on the westside of the road. It stands on the brow of the hill, and is a lovely ruin almost covered with ivy. It is esteemed a fine specimen of castellated architecture, and is described in the *Archæologia*, vol. vi. The gateway to Harewood house, the seat of Lord Harewood, is at the south end of the town. It is recently built, and is one of the finest pieces of architecture we have seen. The view of Harewood house, and the surrounding country from the top of the hill, at the southern gate, is unusually grand.

HARFLEUR, is an ancient town of France, in the department of the Seine. It was formerly called *Harefiotum*, *Harflevium*, and *Heriflorium*. It is situated on the small river Lezarde, at the mouth of the Seine, and was formerly the key of France on the side of England; but it has fallen into decay, in proportion as Havre has risen in importance. Its walls have been razed, its harbour choked with sand, its fortifications demolished, and its trade ruined. There are here small manufactories for lace, cotton, linen, and beer. Peuchet, in 1800, has stated the population at 4388; but Tynna, in the *Almanac du Commerce* for 1811, makes it only 1600. A work was published at Harfleur in 1720, entitled *Antiquites de Harfleur*. See ENGLAND, vol. viii. page 633, for an account of the siege of Harfleur.

HARIDI. See ACHMIM, vol. i. p. 104.

HARMATTAN. See GUINEA.

HARMONIÆ, in music, an interval so named by M. Henfling, whose ratio is $\frac{125}{128}$, $=21\Sigma+2\,m$, and is the greater ENHARMONIC *Diesis*, which see.

HARMONIC ELEMENTS, or *Concordant Elements*, are the three smallest concords, viz. 3d, III, and 4th, each one of which singly is harmonious; so is the sum of every two of them, as 3d+III=V, 3d+4th=6th, and III+4th=VI; and so is the sum of all three, as 3d+III+4th=VIII; and further, this latter concord (VIII) may be added once, or any greater number of times, to itself, or to any one of the six concords above mentioned, and still a concord will result: thus, 2 VIII=XV; 3 VIII=XXII; VIII+3=10th; VIII+III=X; 2 VIII+4 = 18th; 2 VIII+V = XIX, &c. are all concords; and, except the *Unison* (1), there are in nature no other *concords*, or combinations of two sounds, which are agreeable and pleasant to the ear, and produce *beats* when slightly altered or tempered, but those derived in the manner above described. See CONCORD. (ε)

HARMONIC SLIDERS, are the contrivance of Dr Thomas Young, for exhibiting to the eye the effects of the undulations or *beats* of tempered concords, which he has described in the *Journals of the Royal Institution*, p. 261. and illustrated the same by a drawing, intended to represent the *beating* of the imperfect *unison*, whose ratio is $\frac{17}{18}$, $=50.46033\Sigma+f+4\,m$; but which being nearly as large as the elementary *semitone* and a discord, is very improperly called a *unison*, or a beating concord.

The following is Dr Young's own account of this invention: "The combination of undulations is of acknowledged utility in illustrating the phenomena of musical consonances and dissonances, and of undeniable importance in accounting for many of the phenomena of the tides. Each tide is an undulation on a large scale; and, supposing the general form of the ocean, in consequence of the attraction of a distant body, to coincide with that of an oblong spheroid, as it is found by calculation to do, the section of the surface of each tide, if conceived to be unbent from the circular form, and extended on a plane, would form the harmonic curve: (Young's *Syllabus*, IV. 151. 155.) It is remarkable that the motions of the particles of the air in sound have been generally supposed in theory to correspond with the ordinates of this same curve, and that there is also experimental reason to believe, that the purest and most homogeneous sounds do in fact agree

Harmonic Sliders.

very nearly with the law of this curve. It is therefore by far the most natural as well as the most convenient to be assumed, as representing the state of an undulation in general; and the name of these harmonic sliders is very properly deduced from the harmonic curve.

By means of this instrument, the process of nature, in the combinations of motion which take place in various cases of the junction of undulations, is rendered visible and intelligible, with great ease, in the most complicated cases. It is unnecessary to explain here, how accurately both the situations and motions of the particles of air, in sound, may be represented by the ordinates of the curve at different points: it is sufficient to consider them as merely indicating the height of the water constituting a tide, or a wave of any kind, which exists at once in its whole extent, and of which each point passes also in succession through any given place of observation. We have then to examine what will be the effect of two tides, produced by different causes, when united. In order to represent this effect, we must add to the elevations or depressions in consequence of the first tide, the elevations or depressions in consequence of the second, and subtract them when they counteract the effect of the first: or we may add the whole height of the second above any given point or line, and then subtract, from all the sums, the distance of the point assumed below the medium.

To do this mechanically is the object of the harmonic sliders. The surface of the first tide is represented by the curvilinear termination of a single board, Plate CCLXXXVIII. Fig. 1. The second tide is also represented by the termination of another surface; but, in order that the height at each point may be added to the height of the first tide, the surface is cut transversely into a number of separate pieces or sliders, which are confined within a groove or frame, and tightened by a screw, Fig. 2. Their lower ends are situated originally in a right line; but, by loosening the screw and moving the sliders, they may be made to assume any other form: thus they may be applied to the surface representing the first tide; and if the similar parts of each correspond, Fig. 3, the combination will represent a tide of twice the magnitude of the simple tides.

(Margin: Plate CCLXXXVIII. Fig. 1. — Fig. 2. — Fig. 3.)

The more the corresponding parts are separated, the weaker will be the joint effect, Fig. 4.; and, when they are furthest removed, the whole tides, if equal, will be annihilated, Fig. 5. Thus, when the general tide of the ocean arrives by two different channels at the same port, at such intervals of time that the high water of one would happen at the same instant with the low water of the other, the whole effect is destroyed, except so far as the partial tides differ in magnitude. The principle being once understood, it may easily be applied to a multiplicity of cases: for instance, where the undulations differ in their dimensions with regard to extent. Thus, the series of sliders being extended to three or four alternations, the effect of combining undulations in the ratio of 2 to 1, of 3 to 1, of 2 to 3, of 3 to 4, may be ascertained, by making a fixed surface, terminating in a series of curves, that bear to those of the sliding surface the ratio required: and, by making them differ but slightly, the phenomenon of the beating of an imperfect unison in music may be imitated, where the joint undulation becomes alternately redoubled and evanescent. In Fig. 6. the proportion is that of 17 to 18, and the curvilinear outline represents the progress of the joint sound from the greatest degree of intensity to the least, and a little beyond it."

(Margin: Fig. 4. — Fig. 5. — Fig. 6.)

HARMONICAL MEAN, is a term used by arithmetical and algebraical writers to express certain relations of numbers and quantities: but with which *musical* calculators will find, that they need have little to do; any more than with the harmonical or *musical* proportions and progressions, of the same writers. If two quantities a and b are given, then $\frac{2ab}{a+b}$ is said to be the *harmonical mean* between them; for example, between 2 and 6, the harmonical mean is $\frac{24}{8}=3$: between 5 and 9, it is $\frac{90}{14}=6\frac{1}{7}$. Dr Smith in his *Harmonics*, 2d edit. p. 125, shews, how to find the harmonical mean, among any number of quantities: see also p. 141, *Ibid.*

HARMONICAL or MUSICAL PROPORTION, of arithmetical and algebraical writers, is said to obtain between three quantities, as a, b and c, when $a:c::a-b:b-c$; and between four quantities, as d, e, f and g, when $d:g::d-e:f-g$; and so 2, 3 and 6; and 1, 3, 2 and 6 are said to be in musical proportion: And several of these writers say, that if to the three terms above mentioned, "proportional terms are continued, there will arise an *harmonical progression*" or series: but in all these cases, the terms *harmonical* and *musical*, seem only *figuratively* applied. (¿)

HARMONICS, in music, besides being used to designate the science or philosophy of musical sounds, as Dr Robert Smith uses this term, in making it the title of his justly famous work on this subject, imply also certain derivative or dependent *new sounds*, which, under favourable circumstances, are generated and heard, along with every single musical sound, or accompanying every consonance of two such sounds, but with less intensity or loudness than the original, or *generators* of these new sounds; and in the latter case, of their production by a consonance, when they are called *grave* HARMONICS, (see that article,) such new sounds are further distinguished, by not having a *fixed direction*, towards (or from) the sounding body, but, like the sensation called "a singing in the ear," they are alike heard in any direction to which the ear is turned; a property of these derivative sounds, which Mr John Gough first explained, we believe, in Nicholson's *Journal*, 8vo. vol. iv. p. 2. The other kind of these new sounds, derived from a single sound, are called *acute* HARMONICS, which see. (¿)

HARMONICS, ACUTE, are phenomena attending a sounding string or pipe, &c. which were first noticed by Galileo, and subsequently by Peter Marsenne, M. Sauveur, M. Tartini, &c.: but Daniel Bernoulli first discovered the reason, and explained the theory of the acute harmonics, by shewing, that a sounding string, at the same time that its whole length vibrated a given note, might maintain subordinate vibrations of its *half*, its *third* part, its *fourth*, and its *fifth* parts in length; each of such vibrating parts impressing on the surrounding air, independent pulses, the times of whose single vibrations are in the ratios 1, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$; and by which the original sound or *generator*, would be accompanied by its octave or VIII, its major twelfth or XII, its double octave or XV, and by its major seventeenth or XVII; although only the XIIth and XVIIth, or octave of the fifth and double octave of the major third, had yet been described, among the acute harmonics attending a sound. And this great mathematician, although unable to contrive any experiment, by which the vibrations of the $\frac{1}{2}$ and $\frac{1}{4}$th part of the string might be evidently shewn to subsist, along with the whole vibrations, yet he shewed, from the nature of the Taylorean or harmonical curve, that these subdivisions of a sounding string, were not only alike possible, and even more probable to happen than those of $\frac{1}{3}$d, and $\frac{1}{5}$th; but that theory and probability were not against the happening, of even more minute vibrating divisions of the whole string, as $\frac{1}{6}$th; $\frac{1}{7}$th, $\frac{1}{8}$th, $\frac{1}{9}$th, &c.: and that in the use of the trumpet, horn, and other sounding tubes or pipes, all these subdivisions of the whole vibrating column of air might be made, separated by nodes or points in the axis of the tube in a comparative state of rest with regard to these inferior or harmonical vibrations, although moving to and fro with the velocity peculiar to the sound of the whole tube: and he inferred, with great seeming probability, that the parts of bells and most other bodies yielding musical sounds, were in the same manner capable of subordinate or acute-harmonic vibrations, along with those of their principal or gravest sound.

It was probably not until about the year 1765, after the very ingenious Mr James Watt of Birmingham had contrived his wheel monochord, that the acute harmonics of a vibrating string were produced in experiment, and some of them actually rendered visible to the eye; as is related by the late Dr Robison, who, several years after, made a more extended and complete set of experiments on the same instrument which Mr Watt had before used; thereby fully confirming all that D. Bernoulli had theoretically advanced.

Some years after this, Mr John Isaac Hawkins of London, the ingenious inventor of the piano-forte with spirally coiled strings, and of the *claviole*, or finger-keyed viol, contrived an experiment, which seems to leave nothing to wish with regard to this very curious and interesting subject. A spirally coiled string, many feet in length, was prepared by winding a brass piano-forte bass wire closely round a steel wire about the size of a crow-quill, and when removed therefrom, pulling it out, so that its spirals became considerably more open, comparatively, than those of a common cork-screw, or the string was nearly in the state of being "cockled," as tuners call it, at equal distances, throughout its whole length. Along the side of a large wainscoated room, this spirally coiled string was stretched, over two bridges, near its extremities, and brought to such a degree of tension, as not to yield a sound, but leave its vibrations, when strongly twitched, plainly visible to the eye. The space between the bridges had previously been carefully divided, on the wainscoat, into numerous equal parts, and marked $\frac{1}{2}$; $\frac{1}{3}$, $\frac{2}{3}$; $\frac{1}{4}$, $(\frac{2}{4})$, $\frac{3}{4}$; $\frac{1}{5}$, $\frac{2}{5}$, $\frac{3}{5}$, $\frac{4}{5}$; $\frac{1}{6}$, $(\frac{2}{6})$, $(\frac{3}{6})$, $(\frac{4}{6})$, $\frac{5}{6}$, &c.; and if, when the whole string was vibrating, a slight obstacle was opposed to the vibrations of the string, opposite to any one of these divisions, like the edge of the feathers of a quill, held to touch it very lightly, or even, if a sudden blast of air from the mouth were made on the string, opposite a division, the string instantly assumed all the subordinate vibrations proper to the aliquot division against which the obstacle or impulse was directed; and the eye and ear too, in many of the instances, could be gratified, by seeing these very compound vibrations simultaneously carried on by the whole string, and by its several aliquot parts, during several minutes, under favourable circumstances, many of the vibrations being slow enough to be counted, and their number in a given time ascertained and compared, by which every point of the theory of D. Bernoulli is in the fullest manner confirmed.

Thus an evident explanation is offered, of all the curious harmonic effects, of several unison strings on the ÆOLIAN *Harp*, (see that article) when agitated by irregular gusts of wind: acting momentarily on the whole string, and on its different nodes, with sufficient force, to excite *the determinate vibrations*, which the elasticity of the string, and its parts, *dispose them* severally to take; but all of which vibratory motions are so vastly quicker than the mere motion of the wind, that we cannot agree with Dr Matthew Young in thinking, that particular tones are excited, or kept up, by that means.

We have calculated the values of all the aliquot parts of a string or pipe (in Farey's Notation of Intervals) above the note of the whole string, viz. $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, &c. as far as $\frac{1}{32}$, and deducted octaves, so as to bring them all within the compass of one octave; and the same when arranged under their respective finger-key intervals, stand as follows, viz.

VIII	$\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{16}, \frac{1}{32}$,
	$\frac{1}{31}, = 5\,\mathrm{VIII} - 28.11748\,\Sigma - 2\,\mathrm{m}$
VII	$\frac{1}{15}, \frac{1}{30}$
7th	$\frac{1}{29} = 4\,\mathrm{VIII} + 7\mathrm{th}^{*} + 6.12449\,\Sigma + \mathrm{m}$.
	$\frac{1}{7}, \frac{1}{14}, \frac{1}{28}, \ldots\ 7\mathrm{th} - 24.9472\,\Sigma - 2\mathrm{m}$
VI	$\frac{1}{27} = \mathrm{VI}', = \mathrm{VI} + 11\,\Sigma + \mathrm{m}$
	$\frac{1}{13}, \frac{1}{26}, \ldots\ \mathrm{VI} - 22.58107\,\Sigma - 2\,\mathrm{m}$
6th	$\frac{1}{25} = 6\mathrm{th} - 21\,\Sigma - 2\,\mathrm{m}$
V	$\frac{1}{3}, \frac{1}{6}, \frac{1}{12}, \frac{1}{24}$
5th / IV	$\frac{1}{23}$ $\begin{cases} 5\mathrm{th} + 9.46026\,\Sigma + \mathrm{m} \\ \mathrm{IV} + 19.46026\,\Sigma + 2\,\mathrm{m} \end{cases}$
4th	$\frac{1}{11}, \frac{1}{22}, \ldots\ 4\mathrm{th} + 27.25171\,\Sigma + 2\,\mathrm{m}$
	$\frac{1}{21} = 4\mathrm{th} - 13.9472\,\Sigma - \mathrm{m}$
III	$\frac{1}{5}, \frac{1}{10}, \frac{1}{20}$
3d	$\frac{1}{19} \ldots\ldots = 3\mathrm{d} - 9.27098\,\Sigma - \mathrm{m}$
II	$\frac{1}{9}, \frac{1}{18}$
2d	$\frac{1}{17} \ldots\ldots = \mathrm{S} - 3.46819\,\Sigma$
I	$\frac{1}{1}$

Wherein the errors or temperaments of all these acute harmonic notes are set down; and hence we perceive clearly the reason why a sound is accompanied chiefly by its VIIIth, VIII+Vth, and 2 VIII+IIIrd, and rarely by any other of its harmonics, viz. because $\frac{1}{2}$ of the string is strengthened, or reinforced by four other octaves to it: the XIIth (or V) is re-inforced by 3 other octaves to it, and the XVIIth (or III) by two other octaves to it; and these three are the only *concords* to the whole string, that are found among its numerous harmonics. The II and the VII, each with the reinforcement of an octave thereto, should, and accordingly are, next heard in the order of acute harmonics. The harmonic 6th, being a diatonic interval, viz. 6—ε, whose ratio is $\frac{16}{25}$, $= 394\,\Sigma + 8\,\mathrm{f} + 34\,\mathrm{m}$, may perhaps, under very favourable circumstances, be heard as an acute harmonic: but when the very discordant nature of all the remaining sounds in one table, both with the generator and with all of its other harmonics, respectively, are considered, it seems very plain why these sounds, although momentarily produced by a gust of wind, or other impulse, *on the proper part of the string*, almost immediately die away, and cannot be maintained, as the VIIIth, XIIth, and XVIIth may be, and others, in less degrees. (ε)

HARMONICS, GRAVE. These are low sounds, of small intensity or loudness, which, if attentively observed by an experienced ear, will be heard to accompany every accurate or perfect consonance of two sounds, whose ratio is expressible in small numbers, whether the same may be composed of the Diatonic primes 1, 2, 3, and 5, or of somewhat larger prime numbers.

A grave harmonic of a different species from the above

* The ratio of this minor seventh being $\frac{5}{9}$, $= 519\,\Sigma + 10\,\mathrm{f} + 45\,\mathrm{m}$.

is also heard whenever the Beats of an imperfect or tempered concord (see that article) exceed 12 or 13 in a second of time.

About the beginning of the last century, M. Sauveur considered the reinforcement of sound which must periodically take place, while we hear a consonance of two musical sounds whose ratios are in small numbers, occasioned by the coincidence at short intervals of the pulses of the two sounds. These reinforcements he called *beats*; and, as Dr Robert Smith has observed, improperly confounded these, which are grave harmonic sounds, (because rarely occurring so seldom as 12 times in a second,) with the *beats* (of imperfect concords) properly so called, which can be separately heard, and distinctly counted, in every instance where the degree of temperament or imperfection is sufficiently small.

About the year 1754, M. Rameau and M. Tartini first made observations on the coincident pulses of consonances with small ratios; but each of the ten grave harmonics which the latter has mentioned, have been found by later observers to be an octave too high; that is, the new sounds really heard to result from the rapid coincidences of the pulses of the single sounds, are an octave lower with regard to these sounds than Tartini supposed; errors which few will wonder at, who have experienced the difficulty of avoiding errors of an octave, or sometimes more than one, in estimating sounds, that are either very high or very low.

In 1807, Mr John Holder published a work on music, in which he attempted to build a good deal of the theory of composition and harmonical effect on these grave harmonic sounds, accompanying consonances as their "dependants;" but most of his speculations have failed, and many of them led to very absurd conclusions, owing to his having set up and used a defective or false rule, for assigning the grave harmonic of a given consonance.

It is the more necessary, therefore, to give here a true rule for the finding the grave harmonic of any given consonance, viz. Find the vibrations made by each of the sounds of the given consonance in one second, divide these successively by the reversed terms of the given ratio of the consonance, and the quotient (in each case) will give the vibrations for 1″ of the grave harmonic; the ratio of which vibrations, to the vibrations of either of the given sounds respectively, will give the interval of the harmonic below such given sound.

If, for example, the major second CD were given in the middle of the scale, where the ratio is $\frac{8}{9}$, and the sound of the lowest note (on the tenor cliff line) makes 240 vibrations per 1″, then $\frac{9}{8}\times 240=270$ is the vibrations of D, and $\frac{270}{9}=30$, or $\frac{240}{8}=30$, the vibrations of the harmonic note; and its interval below the lower note C is $\frac{30}{240}=\frac{1}{8}$, or 3 VIII; and below the upper note D is $\frac{30}{270}=\frac{1}{9}$, = 3VIII + II. The principal intervals of the scale, and some others, calculated as above, have their grave harmonics shewn in the following Table, viz.

$\frac{1}{2}$	VIII	480	240	$\frac{1}{1}$	1	$\frac{1}{2}$	VIII
$\frac{8}{15}$	VII	450	30	$\frac{1}{8}$	XXII	$\frac{1}{15}$	XXVIII
$\frac{5}{9}$	7′	432	48	$\frac{1}{5}$	XVII	$\frac{1}{9}$	XXIII
$\frac{9}{16}$	7	$426\frac{2}{3}$	$26\frac{2}{3}$	$\frac{1}{9}$	XXIII	$\frac{1}{16}$	XXIX
$\frac{3}{5}$	VI	400	80	$\frac{1}{3}$	XII	$\frac{1}{5}$	XVII
$\frac{5}{8}$	6	384	48	$\frac{1}{5}$	XVII	$\frac{1}{8}$	XXII
$\frac{2}{3}$	V	360	120	$\frac{1}{2}$	VIII	$\frac{1}{3}$	XII
$\frac{3}{4}$	4	320	80	$\frac{1}{4}$	XII	$\frac{1}{4}$	XV
$\frac{4}{5}$	III	300	60	$\frac{1}{4}$	XV	$\frac{1}{5}$	XVII
$\frac{5}{6}$	3	288	48	$\frac{1}{5}$	XVII	$\frac{1}{6}$	XIX
$\frac{27}{32}$	3′	$284\frac{4}{9}$	$8\frac{8}{9}$	$\frac{1}{27}$	XXXIV	$\frac{1}{32}$	XXXVI
$\frac{8}{9}$	II	270	30	$\frac{1}{8}$	XXII	$\frac{1}{9}$	XXIII
$\frac{9}{10}$	II′	$266\frac{2}{3}$	$26\frac{2}{3}$	$\frac{1}{9}$	XXIII	$\frac{1}{10}$	XXIV
$\frac{15}{16}$	2	256	16	$\frac{1}{15}$	XXVIII	$\frac{1}{16}$	XXIX
$\frac{1}{1}$	1	240	0				

The *first* column of the above Table, shews the ratios of the given consonances; the *second*, the intervals expressed in numerals; the *third*, the vibrations per second supposing the lower part to be the note on the tenor-cliff line of the stave; the *fourth* column contains the calculated vibrations of the harmonic note; column *five* shews the ratio, and column *six* the interval of this harmonic, below the lowest of the given notes or C; and columns *seven* and *eight* shew the same things with regard to the highest of the given notes.

For the sake of more ready comparison with Mr Holder's defective rule for calculating grave harmonics, the errors of which it seemed of some importance to place in as clear a view as possible, we have given above a far less simple rule for obtaining the ratios of the new sounds, with relation to either of their generators, than the one which we are now about to add, viz. The ratio of any given consonance above a bass or fundamental note, being $\frac{a}{b}$, a being the least term of the ratio; then $\frac{1}{b}$ is the ratio of the grave harmonic below the bass note, and $\frac{1}{b}$ the ratio of the same harmonic below the upper note of the consonance; which is too evident, from an inspection of the above Table, to need a particular example.

With regard to the other kind of grave harmonics, the results of *tempered* concords, which beat too fast to be separately counted or perceived: If, for instance, we were to consider the grave minor third $\frac{27}{32}$ in the above Table to be a tempered concord, we should have, by our fourth method in the article Beats, $240\times 6 - 284\frac{4}{9}\times 5 = 1440 - 1422\frac{2}{9} = 17\frac{7}{9}$, the beats per second, or vibrations of this grave harmonic, being just double, or an octave higher than those in the Table above, and so of others; but our limits will not admit of our enlarging further on this subject. (ϱ)

HARMONICA. See Musical Glasses.

HARMONY, in Music, is a term which appears to have completely changed its signification since the first use of it. The ancient Greek writers, who seem to have contemplated only the *succession* of sounds which we call Melody, (see that article,) attached to such successions as were pleasing and agreeable to the ear, the name of a woman celebrated among them. But in more modern times, when the *simultaneous* as well as the progressive effects of sounds on the ear came to be practised and considered by writers on this subject, the term *melody* was applied to successions of sounds, particularly to such successions as are on the whole pleasing, and the term harmony was transferred to the newly contemplated and pleasing effects of certain intervals, when their limiting sounds are heard together, viz. 1, 3, III, 4, V, 6, VI; VIII, 10, X, 11, XII, 13, XIII; XV, 17, XVII, &c.* whose ratios are $\frac{1}{1}$, $\frac{5}{6}$, $\frac{4}{5}$, $\frac{3}{4}$, $\frac{2}{3}$, $\frac{5}{8}$, $\frac{3}{5}$;

* No limits have yet been assigned to this harmonic or concordant series; found by adding *seven*, *fourteen*, *twenty-one*, &c. to each of the first seven numeral terms; or by multiplying the terms of the first seven ratios by $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, &c. to produce the ratios of concords in the successive octaves.

$\frac{1}{2}$, $\frac{5}{12}$, $\frac{2}{5}$, $\frac{3}{8}$, $\frac{1}{3}$, $\frac{5}{16}$, $\frac{3}{10}$; $\frac{1}{4}$, $\frac{5}{24}$, $\frac{1}{5}$, &c. called CONCORDS. See that article.

The further progress of musical discoveries next shewed, that certain others of the simple intervals, as I, 2, II, IV, 5, 7, VII; 8, 9, IX, XI, 12, 14, XIV; 15, 16, XVI, &c.; or $\frac{128}{135}$, $\frac{15}{16}$, $\frac{8}{9}$, $\frac{32}{45}$, $\frac{45}{64}$, $\frac{9}{16}$, $\frac{8}{15}$; $\frac{64}{135}$, $\frac{15}{32}$, $\frac{4}{9}$, $\frac{16}{45}$, $\frac{45}{128}$, $\frac{9}{32}$, $\frac{4}{15}$; $\frac{32}{135}$, $\frac{15}{64}$, $\frac{2}{9}$, &c. called DISCORDS, (see that article,) might be occasionally introduced among, or in the place of some of the concords above mentioned, without destroying, but, on the contrary, heightening the pleasure of their effect on an ear accustomed to this mixed harmony of concords and discords.

When this mixed harmony came to be practised on instruments having fixed notes, the pitch of which the performer could not alter, as the singer, violinist, &c. can their notes, it was further discovered that each of the concords and discords above mentioned, admitted of alteration, in small and unequal degrees, without altogether losing their respective characters or effects, when heard together in chords; but the pleasing effect in composition of many of these chords, were sometimes even improved, by the alteration of a major comma, (c, or $\frac{80}{81}$); and hereby another class, of comma-deficient and of comma-redundant concords were introduced, as 3\`, 3′, III′, 4′, V\`, V′, 6\`, 6′, VI′, VIII\`; &c. and so of the discords, I\`, 2′, II\`, II′, IV\`, IV′, V′, 7′, VII\`, VII′, 8′, &c.

And in adapting music to only 12 fixed sounds, within each octave, the simple or numeral intervals above mentioned were found altered, in some instances more than the major comma, but in more numerous instances, by less and very different degrees of alteration or attemperament, in order to render music played thereon tolerably agreeable to the ear. And hence it becomes necessary for the musical student to be aware of the distinctions, which we shall now proceed briefly to enumerate, viz.

Artificial HARMONY, implies a mixture of simple or untempered concords, and of discords in the chords, or between the notes that are heard together, in any piece of music.

Equal HARMONY implies, according to one class of writers, an equality of harmoniousness between the different *keys* of music, but which is more properly called EQUAL *Temperament*: See that article, and ISOTONIC. But according to Dr Robert Smith, and others of our best writers on the subject, this term should be restricted to systems in which each of the six concords, 3, III, 4, V, 6, and VI, are so tempered, as to be equally and the most harmonious or pleasing amongst themselves, while 1 and VIII remain perfect. See EQUAL *Harmony*.

Natural HARMONY, according to Dr Busby, admits only of the harmonic triod, or common chord $\genfrac{}{}{0pt}{}{\text{V}}{\text{III}}$, in the accompaniments of a piece of music.

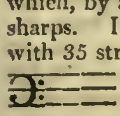
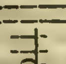
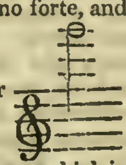
Perfect HARMONY, implies the use of perfect or untempered concords only, such as are produced by good singers, violinists, &c. when they perform full music in concert, and which, as Mr Farey has shewn, in the *Philosophical Magazine*, vol. xxvii. pp. 206 and 314, contains all its temperaments in the leaps or successive intervals of the melodies of the different parts, and none of such in their combined or simultaneous intervals of harmony, all of which are produced perfect, or without temperament. Mr Maxwell, in 1781, fully explained this system, as applicable to the violin, and made some attempts at applying the same to the organ, but without effect, (see MAXWELL'S *Scales*.) Several years afterwards, however, the Rev. Mr Liston completed his EUHARMONIC *Organ*, (see that article,) and, in 1812, published his *Essay on perfect Intonation*, wherein this curious and important system is fully explained. See LISTON'S *Scales*.

Tempered HARMONY, is such as must of unavoidable necessity be heard, in several or all of the concords, (and discords too,) in performance on the common or imperfect keyed instruments, having only twelve, or even a greater number of sounds in each octave. See TEMPERED *Systems*. (*ę*)

HAROLD I. See ENGLAND, vol. viii. p. 595—600.

HAROLD II. See ENGLAND, vol. viii. p. 597.

HARP, is a stringed musical instrument, which has gained much celebrity from the estimation in which it was held among the ancients. Though the harp be of eastern origin, it has been the subject of animated controversies, whether the instrument was actually known to the Greeks and Romans in any shape analogous to its present form. It appears most probable, however, that they were not ignorant of it, and that some of the instruments passing under different names, whose elementary parts and principles are the same, should be considered only as modifications of each other. But the researches of late travellers have brought more interesting objects to view than those exciting dry disputations. Mr Bruce, in visiting the catacombs of the Theban kings, who are supposed to have been cotemporaries with David king of the Jews, 1000 years before Christ, discovered two paintings of the harp in fresco, each played by an old man standing, clothed in a wide tunic, and having his head shaven. One has 13 strings, but wants the upright, or that piece of the frame next to the longest; and the sounding board is of a conical form, enlarging below in proportion to the length of the string. The other has 18 strings, and seems to be a harp formed of similar materials; but the distribution of the parts is different, and the lower strings are united to the base, not to the sounding board. Both are represented as being played in the same manner, and by men in the same position. After describing the ornamental parts, Mr Bruce affirms, that "it would be even now impossible either to construct or finish a harp of any form with more taste and elegance." However, while preparing to make further researches, he could not prevail on his conductors to wait any longer in the catacombs; "with great clamour and marks of discontent, they dashed their torches against the largest harp, and made the best of their way out of the cave, leaving me and my people in the dark; and all the way they went, they made dreadful denunciations of tragical events that were to follow their departure." It is to be inferred from the figures, that each harp is above six feet high. The purport of Mr Bruce's description, which is much more copious than quoted here, has been strangely misunderstood, though it must be admitted that this was partly owing to his own imperfect communications to Dr Burney. Whence it has been asked by Mr Jones, "Whether the Theban harp originated in a phantasm?" and even Mr Browne, the African traveller, says, while visiting the catacombs of Thebes, "I particularly observed the two harpers described by Bruce, but his engraved figures seem to be from memory." We cannot entirely solve these difficulties; but had those who have spoke most positively on the subject, referred to the first volume of Mr Bruce's Travels, instead of Dr Burney's History of Music, they would have obtained more distinct ideas of it. However, during the late expedition of the French, the sepulchres of the kings of Thebes were again visited; and M. Denon acquaints us, that in a "fourth chamber, there is a figure clothed in white, playing on a harp with eleven strings: the harp sculptured with ornaments of the same tint, and consisting of the same wood as ours are now made" On recurring to Plate CXXXV. of the large edition published by the French government, we observe two figures playing on harps, one represented with 27 strings, the other with 33; and also a third, apparently in miniature, touching a harp with only 9. The first of these is a person standing, clothed in a robe tucked up between the legs; the second is a naked woman on her knees. Both harps are of elegant workmanship, ornamented with sphinxes; and, instead of being triangular, the upright is bent into a curve along with the base. Neither of them bears any resemblance to the first or triangular 13-stringed harp of Mr Bruce, but his second is formed after the same fashion. From all this it is to be inferred, that the harps represented by Denon were seen in a chamber different from that visited by Bruce, and most probably the same remark will apply to what is said by Mr Browne. We can scarcely suppose it possible that there could be so irreconcileable an error as to mistake a naked woman sitting on her knees for a man standing, and clothed after a particular manner. Farther, it is likely that Denon was in more sepulchral chambers than one, or in different recesses of the same apartments: and it has never been said that these paintings were confined to a single excavation only. The harp, therefore, was an instrument evidently brought to a degree of perfection among the Egyptians, while Greece was yet in its infancy.

In order to facilitate the understanding of illustrations which may be given of the more ancient construction of the harp, we shall briefly describe its present structure and compass. This instrument is now, as it has always been, of a triangular shape; and the gradual elongation of the strings also produces their general arrangement in a corresponding triangular outline. One side of the triangle is formed into a large expanding sounding-board, on the construction of which much of the intonation depends. The whole strings are united to it. A base whereon the harp rests solidly is formed at the lower angle; and here are placed several pedals, which, by an ingenious mechanism, produce flats and sharps. It is commonly, but not always strung, with 35 strings, the lowest equivalent to double A or  of the piano forte, and the highest note equivalent to double G or   of the same instrument: thus the compass, which is arbitrary, is considerable. However, most of the modern harps have seven or eight strings of the bass, to increase it still farther, which, in our opinion, is a very questionable expedient, rendering the total number 43. But this is considerably augmented by the operation of the pedals. These are usually seven in number, and are designed according to the effect they produce: the E pedal changes E flat, in which the harp is now invariably tuned, into E natural; the F pedal changes F natural into F sharp, and the G pedal changes G natural into G sharp. In some instruments, the change by simple pressure is to the extent of a semitone; in others of the latest construction, by increasing the pressure on the pedal, the strings affected by it are sharpened another semitone. Three notes are thus obtained from a single string. The action of the pedals, as their name implies, is operated by the feet; four being appropriated for the right foot, and three for the left. All the strings are of catgut, except seven or eight of the lowest, which consist of silk covered with silver wire, as the lowest strings of the violin and violoncello. In the harp the C's are coloured red, and every F is blue, in order that they may be more readily distinguished by the performer: the others are of the ordinary yellowish white of catgut. The whole instrument of the largest size is nearly six feet high, and in Britain costs 100 guineas.

The name of the harp is said to be of Saxon origin; and we can probably trace it to the tenth century; for the author of the life of St Dunstan, who is supposed to have been a cotemporary, observes, "Sumpsit secum ex more citharam suam, quam lingua paterna *hearpam* vocamus." (*Acta Sanctorum*, tom. iv. p. 350.) Venantius Fortunatus, a continental author of the seventh century, uses this expression, "Plaudat tibi, Barbarus *harpa*;" which has been conjectured to apply to Britain. The harp is called *Telyn* in Welsh, and *Clarsach* in Irish.

We can scarcely ascertain, at the present day, under what form this instrument first appeared in these kingdoms; but it was undoubtedly well known in Wales and Ireland. Nor were the English and Scotch strangers to it; though its music was less cultivated among them. An ancient Irish harp which has had 28 strings, and is 32 inches high, is reported to have belonged to a certain king, Brian Boromh, who was killed in battle in the year 1014. His son having retired to Rome, presented his father's harp and crown to the Pope, on purpose to obtain absolution for a murder he had committed; and both remained in the Vatican until the harp was sent by the reigning Pope to King Henry VIII. and, after passing through the hands of various owners, it was, in 1732, deposited in the library of Trinity College, Dublin. That such an instrument was actually at Rome in the time of Adrian IV. between 1154 to 1159, seems established from record; but the presumption of this particular harp remounting to so very ancient a period of Irish history as 1014, rests only on a very slight foundation. Two harps of considerable antiquity have lately been seen in Scotland; one of which, in size, appearance, and structure, narrowly resembles the Irish harp. Both are preserved in the family of Robertson of Lude; and the history of the oldest can be traced to about the year 1460. It is 38 inches and a half in height, and has had 30 pins, originally of brass, with as many corresponding string holes, all neatly ornamented. The other is ascertained to have belonged to Queen Mary, and is altogether of a more modern fashion and smaller dimensions. It is 31 inches high; the sounding board is only 11 inches and a half broad at the base, whereas that of the former is 16; and there have been 28 strings, the shortest two inches and a half long, while the second and third of the Caledonian harp have not exceeded two inches. The longest string of the latter is only 21 inches and a half in length; that of Queen Mary's 24. It is said that Mary having carried this instrument along with her in an excursion to the Highlands, in the year 1563, presented it to a lady who was married into the family of Lude. It was formerly ornamented with the Queen's portrait, and the Scotish arms executed in gold, of which and other jewels it was despoiled during the rebellion of 1745.

None of the harps we have named exhibit pedals, which are reported to have been invented by M. Simon at Brussels, between 1750 and 1760. The principal object of the pedals is to diminish the number of strings; for although the most grateful music certainly does not consist in the greatest variety of notes, a considerable range becomes necessary to adapt an instrument to all compositions. Probably the strings of the harp were originally very few; indeed, in this respect its structure is altogether arbitrary; and the number has been different at different eras and in different countries, as is proved by the examples already given. In France, a harp is spoken of in the 14th century with 25 strings: in England, one of the same century, or perhaps earlier, is represented with only 14, and one of the 16th is described to have had 33. It will be observed, that we have hitherto spoken of the strings of a harp with a single row: and they have even been greatly augmented beyond these numbers; but some ingenious mechanics have adopted a second or third row, for the purpose of multiplying the notes. Galileo, in a work written about the year 1582, speaks of harps with 54, 56, or 60 strings used in Ireland, from which island the harp of Italy was introduced; and having obtained one from an Irish gentleman with two rows of strings, consisting in all of 58, he found they were disposed in the same manner as a harp of the same construction introduced a few years previously into his native country. Mersenne represents a harp with 75 strings, arranged in three rows. The Welsh are said to have had one similar; and the number has sometimes been increased to 100. The introduction of pedals, however, has superseded the necessity of such a variety of single notes.

The harp was generally strung with brass or steel wire. The Western Islanders or Highlanders of Scotland had a particular kind of harp strung with the tendons of animals; and the Welsh sometimes used horse hair. We are quite uncertain regarding the real compass of the most ancient harps, or the manner in which they were tuned.

Diodorus Siculus says, that the instruments used by the Gallic bards resembled lyres; but it is doubtful whether or not this was the harp, and there is very little certainty regarding its origin in these islands. Its most ancient appearance is of very rude and imperfect form, though considerably diversified; but the strings seem invariably to be very few. Performers too are frequently represented as holding it in one hand while they are playing with the other. Mr Ledwich conceives it was introduced into Ireland in the fourth or fifth century, from the close connection of the Irish "with the Saxons and other rovers from the Baltic shores, who conjunctly ravaged the coasts of Gaul and Britain in those ages." In Scotland it appears sculptured on a very ancient monument near the church of Nig in Ross-shire, engraved by Mr Cordiner; and ancient sculptures or drawings of it are to be seen in England, though frequently with a reference to religious matters. Probably the harp was not used in Scotland to any extent, though it was known to individuals; and, subsequent to the date of the instruments before alluded to, there is recorded, in a curious account of an insurrection in 1594, a prophecy regarding the Earl of Argyle's harp being heard in the district of Buchan. In Ireland and Wales, the case was different; for the harp seems to have been carefully and extensively cultivated; at least in as far as the rudeness of the people would admit. Giraldus Cambrensis bears the most unequivocal testimony to their powers, and the quality of their music; affirming, that the Irish were incomparably the most skilful of any nation in music, and not of that dull and languid description to which the inhabitants of Britain were accustomed, but what required much rapidity in execution. Probably their abilities greatly declined; for we afterwards find it observed, that Crusus was to be considered as almost the only harper about 1584. In Wales still greater attention was paid to the instrument, and Giraldus is alike lavish of his praises on the performers. There was even a triennial congress, whither all the most distinguished musicians repaired to compete in skill; and there is still preserved a small silver harp about six inches and a half high, which was conferred on the victor. The privilege of bestowing this badge seems to have been vested in the family of Mostyn. The congress was held by royal authority at some of the royal residences in Wales; and, besides others, we read of a mandate issued by Henry VIII. in 1523, for the purpose of instituting order and government among the professors of poetry and music, and regulating their art and profession according to the old statute of *Gryffyd ab Cynan*, Prince of Aberffraw. Another was assembled by order of Queen Elizabeth in 1568 at Caerwys, where degrees were to be bestowed according to merit; but those not qualified were enjoined to betake themselves to some honest livelihood and profession, under pain of being apprehended and punished as vagabonds. At that time 55 degrees were conferred, 17 for vocal, and 38 for instrumental performance. At length the institution fell into total disrepute, and the harp seems to have become obsolete; for a traveller in Wales between 1780 and 1790 observes, that the only harp he heard in all the country was at Conway. An attempt was lately made to revive the Eistedfodd, as it was called, after several considerable intervals of repose; and at a meeting, one of the last that was held, 12 minstrels attended, (*Gent. Mag.* vol. lxii. p. 96.) And, we believe, a similar congress was unsuccessfully attempted in Ireland during the year 1785, where only indifferent performers appeared. The art of playing upon the harp, however, is at present considered an elegant accomplishment, particularly in youthful females; and it has gained much ground in Britain within these 20 years. At present it is sometimes to be heard at public concerts; and we have understood, that the combination of a number of harps has lately been introduced into an orchestra in Paris. The harp, however, can never be more than a chamber instrument: it labours under many defects, notwithstanding all the modern mechanical improvements which it has received; whence we may reasonably infer, that the excellencies of the ancient Welsh and Irish music, as performed upon that instrument, are highly exaggerated. Complicated music does not belong to an uncivilized people. Their tunes are but a kind of whining chant; and the further we ascend with those best known to us, they are found the more inharmonious. Yet enthusiasm can figure any thing, as at this day we see savages dance in extacy to beating on a wooden drum. The minstrels too, who in modern times have been regarded with admiration, and who held a prominent part in the musical performances of old, were nothing but a worthless vagrant race, generally proscribed as vagabonds. See Galileo *Opere*, tom. iii.; Mersennus *Harmonicorum*, p. 68; *Giraldus Cambrensis*, cap. 12; Denon *Voyages*, tom. i. p. 237, tom. ii. planche 135; Bruce's *Travels*, vol. i. p. 133; Carter's *Specimens of Sculpture and Painting*, vol. ii. p. 11, 16, 42, 43; Cordiner's *Antiquities of Scotland*, plate 1; Walker's *Memoir of the Irish Bards;* Jones' *Relics of the Welsh Bards;* Gunn's *Historical Enquiry;* Evans' *Tour in North Wales;* Pennant's *Tour in*

Wales; Strutt's *Manners of the People of England*, vol. i. p. 50, plate 17, 19; Strutt's *Dress and Habits of the English*, vol. i. plate 57; and ÆOLIAN HARP. (c)

HARPOON. See WHALE FISHERY.

HARQUEBUSS. See GUNMAKING.

HARRIS, JAMES, one of the most celebrated philologists of modern times, was born at Salisbury on the 20th of July, 1709. His father was a gentleman of independent fortune of the same name, and his mother sister to the Earl of Shaftesbury, author of the *Characteristics*. He was educated in early life under Mr Hele at the grammar school of his native city. At the age of 16 he was removed to Oxford, where he passed the usual number of years as a gentleman commoner of Wadham college, and was then entered at Lincoln's Inn for the purpose of studying law as a part of liberal education. Having, in his 24th year, succeeded, by the death of his father, to his patrimonial property, he followed more completely his own inclinations, by devoting himself to the study of Grecian and Roman literature. He studied profoundly the philosophical writings of the ancients, and acquired a great partiality for the philosophy of Aristotle. His studies were conducted in his house at Salisbury, where his habit was to rise very early for the purpose of prosecuting them in quiet, and to mingle occasionally through the day with the society of that city. He also officiated with great credit as a magistrate for the county of Wilts.

His first work, which appeared in 1744, was a volume containing three treatises; the first on art, the second on music, painting, and poetry, and the third on happiness, which contained some sound moral observations, and were adorned with elegant literature. In 1745 he married Miss Clarke, daughter of John Clarke, Esq. of Sandford in Somersetshire, by whom he had five children. Two of these died young; but two daughters and his son, now Lord Malmesbury, survived him.

Persevering in his favourite studies, he published, in 1751, his *Hermes, or Inquiry concerning Universal Grammar*—a subject to which his attention had been particularly directed by the *Minerva* of Sanctius. The *Hermes* was received with great applause, and placed the author in the highest rank of philosophical grammarians. But the credit which that work derived from having remained so long unchallenged, was at last shaken by the severe animadversions on it, which were published by Mr Horne Tooke in his celebrated *Diversions of Purley*. This author has convicted Mr Harris of some incongruities; and has, in his turn, laid the world under deep obligations by furnishing valuable materials for the correction and improvement of dialectic science: (See our article GRAMMAR, *passim*.) How Mr Harris would have felt had he lived to see himself so contumeliously treated as he is in the work now mentioned, is a question of personal patience, and neither justice nor good nature would delight in seeing any man of worth subjected to such a trial. But now that both of these authors are out of the reach of each others opposition, as well as the partiality of their respective friends, neither of them appears sufficiently perfect to be adopted as a guide, and both are too respectable to be treated with contempt. Mr Harris had the undoubted merit of delighting such of his cotemporaries as took an interest in the subject. Although, when the import of the words in which his theories are expressed is severely scrutinized, we find them sometimes inconsistent; candour will still endeavour to appreciate the truths which they imperfectly express, and will not fail to find out, in the most unmeaning phrases, some just views which the author aimed to unfold. The difficulty of expressing new opinions on a new subject, in which language is employed in explaining its own nature, may have given rise to some faults in the theoretic dissertations of Mr Harris; but it is no small praise, that his errors required the acuteness of Mr Tooke to discover them, and it must be acknowledged, that the latter has not done justice to his merit. The works of these two authors may be profitably employed for correcting one another, and extending jointly the limits of the science. The views of Mr Harris are on the whole pleasing; and the manner in which they are exhibited, shews an elegant and scientific mind. His writings are not disfigured by wanton satire, expressions of personal antipathy, or querulous moroseness, paradoxical turns of phrase, or an inclination to sport with the feelings of one part of his readers, and carry off by force the admiration of others. Trusting to the interesting nature of his subject, he does not go in quest of spurious sources of animation. After bestowing much labour on the investigation of his subject, he presents his readers in a respectful manner with the best views which he is able to form. He cherishes throughout a spirit of philosophical inquiry, free from any character of extravagance, and possessed of an admirable tendency to generate a placid satisfaction, and a chaste consistency of feeling.

From the time of his marriage till the year 1760, Mr Harris lived entirely in Salisbury during winter, and retired in the summer to his country house at Durford, in the neighbourhood of that city. Besides attending to the pursuits of literature and the duties of a magistrate, he devoted an adequate proportion of his time to the sacred task of superintending the intellectual and moral education of his children; and he zealously promoted a refined taste in music and other elegant pursuits in the circle of society in which he lived.

In 1761, he was elected member of parliament for the burgh of Christchurch, which seat he retained till his death. In the following year, he was made one of the lords of the admiralty; and in two years after a lord of the treasury. In 1765, he went out of office with the ministry with which he was connected. In 1774, however, he was, much to his gratification, appointed secretary and comptroller to the Queen.

During the hours of leisure which the duties of public life allowed him, he prosecuted, with great regularity, his literary labours. In 1774, he published his *Philosophical Arrangements*, a work in which he displayed all his former admiration of the Peripatetic logic, and combated the doctrines of chance and materialism, animated by a zealous regard for the happiness of mankind,—an object of which, many who have espoused the opposite side of these questions, have betrayed an unfeeling neglect, by the style and manner in which they have published their opinions.

In 1780, the same year in which he died, he printed for the use of his circle of private friends a work, which was published immediately after his death, entitled *Philological Inquiries*, containing a popular summary of the conclusions to which the philosophical investigations of the ancients conducted them, accompanied with pleasing illustrations and examples. It contains also some affectionate expressions of personal attachment to his friends, and, on the whole, furnishes a good example of talents retaining at a very advanced age their former vigour, as well as of candour and benevolence continuing undiminished. His health, however, was now much impaired, and he died on the 22d of December 1780, in the 72d year of his age, beloved and regretted by all who knew him.

His private character appears to have been thoroughly amiable. With a mind well disciplined to severe thought, he united an unrestrained freedom and cheerfulness of character, which inclined him to take a ready part in all the subordinate interests and common amusements of life. He exhibited on all occasions a temper the most humane, gentle, and forgiving. As a critic, he was candid and indulgent; and, with a sagacity which enabled him to discern deformities, he had a sense of justice and of gratitude which made him chiefly delight in acknowledging literary beauties. Those who dispute the accuracy of some of his conclusions, would do well to copy the tender solicitude which he expressed for the general interests of his species, and the delicacy with which he communicated to the world the fruits of his researches.

His son Lord Malmesbury, published an edition of his works in two quarto volumes, to which he prefixes a brief account of his life. He seems to value his father's memory, chiefly for the steady resistance which he made to those opinions on general subjects which have prevailed in modern France, and which, from their harsh collision with previously existing systems, and, as he thinks, from their intrinsic repugnance to the interests of society, gave rise to that political discord, and those consequent ravages of war, with which Europe has in our age been visited. (*H. D.*)

HARRIS. See INVERNESSHIRE.

HARRISON. See HOROLOGY and LONGITUDE.

HARRISON'S TEMPERAMENT of the musical scale. The late Mr John Harrison, who laboured so successfully in improving chronometers, about the year 1748, conceived the idea of a tempered system of intervals, in which the interval of the major third should bear the same proportion to the octave as the diameter of a circle to its circumference. On reference to Mr Farey's corollaries regarding regularly tempered douzeaves in the *Philosophical Magazine*, vol. xxxvi. page 374, the temperaments and wolves of this system may easily be calculated, and these applied to the respective intervals will stand as follows, viz.

11 of the Vths, viz. on C, G, D, A, E, B, ♯F, ♯C; and on F, ♭B, and ♭E, each of the value	$354.69244\Sigma+7f+31m$	=	$3901.61684\Sigma+77f+341m$
And the wolf fifth on ♯G, ...		=	$382.38316\Sigma+7f+30m$
Make 7 octaves, each	$612\Sigma+12f+53m$	=	$4284.00000\Sigma+84f+371m$
8 of the IIIds, viz. on C, G, D, A, and E; and on F, ♭B, and ♭E each,	$194.77762\Sigma+4f+17m$	=	$1558.22096\Sigma+32f+136m$
And 4 wolf IIIds, viz. on B, ♯F, ♯C, and ♯G, each	$222.44476\Sigma+4f+19m$	=	$889.77904\Sigma+16f+76m$
Make 4 octaves, each	$612\Sigma+12f+53m$	=	$2448.00000\Sigma+48f+212m$
9 of the 3ds, viz. on A, E, B, ♯F, ♯C, and ♯G; and on D, G, and C, each	$159.92268\Sigma+3f+13m$	=	$1439.30412\Sigma+27f+117m$
And 3 wolf 3ds, viz. on F, ♭B, and ♭E, each	$132.23196\Sigma+3f+14m$	=	$396.69588\Sigma+9f+42m$
Make 3 octaves, each	$612\Sigma+12f+53m$	=	$1836.00000\Sigma+36f+159m$

The fourths, minor sixths, and major sixths, complements to the above Vths, IIIds, and 3ds, will be each of them as much tempered *sharp* as these are tempered *flat* respectively. It appears from the preface to the first edition of Dr Smith's *Harmonics*, that Mr Harrison adjusted frets on the finger-board of a base viol according to this system, and that Mr Harrison declared himself much pleased with the "extremely fine harmony" of its consonances. It is, however, to be regretted, that Dr Smith did not himself hear, and give us his opinion, on the harmony thus produced by Mr Harrison. Several years afterwards, Mr Maxwell, as he informs us p. 249 of his "Essay on Tune," did hear and attend to Mr Harrison's performance on his six-stringed viol thus fretted, and Mr Maxwell by no means approved the harmony thereof. In 1775 Mr Harrison gave some account of his musical scale in his work on chronometers. (ϛ)

HARROW. See AGRICULTURE, vol. i. chap. vi. sect. ii.

HARROW ON THE HILL, is a village of England in Middlesex. The hill on which it stands is the highest ground in the county, and has an insulated appearance, being visible from great distances almost in every direction. This village is celebrated for its free school, which is now universally allowed to be one of the best seminaries in the kingdom. It was founded in 1592 by John Lyon, a wealthy yeoman of Preston in this parish. He allotted £20 for two exhibitions to Caius College, Cambridge, and two to Oxford. This sum, however, has been doubled. The number of scholars at Harrow school is generally about 150. The rent of Mr Lyon's estates amounted lately to £669, which is disbursed in paying the salaries of the masters, the exhibitions already mentioned, in educating poor children, relieving decayed house-keepers, repairing roads, &c. The church of Harrow, which contains several sepulchral monuments, is partly of ancient architecture. The lower part of the tower, and the columns between the nave and aisles, are supposed to have been built by Lafranc in the time of King William I.

The view from Harrow is very fine. Towards the east it is terminated by the metropolis; to the south by the Surrey hills; to the north is a view of Harrow Weald, with the village of Stanmore and Bentley Priory, the seat of the Marquis of Abercorn; and to the south-west is seen Windsor Castle, with a considerable part of Berkshire and Buckinghamshire. On the top of the hill is a well of excellent spring water, which is never dry even in the hottest summers. In 1811 the number of houses in the town, including the hamlets of Roxeth and Sudbury, was 283, and the population 1689. See Lyson's *Environs of London*, 4to. vol. ii.

HARROWGATE is the name of a celebrated watering place in England, in the West Riding of Yorkshire. It is situated in the forest of Knaresborough, about three miles south-west of the town of Knaresborough. The village is divided into High and Low Harrowgate, and consists principally of the inns and lodging houses for the accommodation of the numerous invalids who flock hither from every part of the united kingdom. Before the mineral springs were discovered, Harrowgate was a miserable hamlet; and it was not till 1687 that the first inn, called the Queen's Head, was erected. Before the year 1700, there were three good inns in the village, and it now contains eight spacious inns, viz. the Grandby, the Dragon, the Queen's Head, and the Hope Tavern, at High Harrowgate; and the Crown, the White Hart, the Crescent, and the Bell, at Low Harrowgate: beside numerous lodging houses for those who wish for a more retired life. The Crown Inn at Lower Harrowgate, is a long row of plain buildings. The public hall or promenade is a large and elegant apartment with an organ at one end. The Crescent is situated behind the Crown Inn in a less public situation.

The chalybeate springs, which are two in number, are both at High Harrowgate. The oldest of these, called the Old Spa, was discovered by Captain Slingsby in 1571, and is situated opposite the Granby Inn. It was covered in 1786 with an elegant dome, erected at the expence of Lord Loughborough, who also laid out an extensive plantation on his property here, which affords an agreeable shade to a walk eight feet broad, and two miles long. The other chalybeate spring is about half a mile west of the Old Spa, and is called the Tewit well, from the birds called tewits which frequent it.

The sulphureous springs, which are two in number, are situated at Lower Harrowgate, and are inclosed with stone buildings, one of which, near the Crown Inn, is a temple of the Tuscan order, 24 feet in diameter, consisting of a cupola supported by 12 columns. The water of this spring is extremely offensive to the smell and the taste. When taken in small quantities, it is an excellent alterative; but when copiously drunk, it is strongly purgative, and has been found very efficacious in cutaneous diseases and scrophula, in destroying worms, in removing chronic obstructions, and in all disorders of the stomach. The second sulphureous spring was discovered in the gardens of the Crescent in 1783. It is of an intermediate quality between the chalybeate and sulphureous waters.

The buildings at Harrowgate are rapidly increasing every year. It now contains more than 1500 inhabitants. See *Beauties of England and Wales*, vol. xvi. p. 652.

HARTFORD is a town of the United States of America, in the state of Connecticut, and the capital of the county of the same name. It is situated in a pleasant and fertile country, on the west bank of Connecticut river, about 50 miles north-west from its mouth. The town consists chiefly of a single street parallel with the river, and about 60 rods from it. Nearly one half of the houses are of brick, and many of them are three stories high, and well built. The principal public buildings are a handsome state house, two congregational churches, one of which is of brick, and is among the most elegant in New England, one Episcopalian, one Baptist church, and a bank, which was incorporated in 1792. A woollen manufactory has been established at Hartford. The number of houses is about 600. The population of the town in 1800 was 5347, in 1810, 6003, and that of the city in 1810 was 3995. See Morse's *Geography*.

HARTLEPOOL, a town of England, in the county of Durham, is situated on a promontory nearly encircled with the German Ocean, which forms a capacious bay on the south side of the town. It is built on the western slope of a hill, and consists of a principal street, a back street, and several cross streets. The chief buildings are a chapel of irregular structure, a town hall, a free school, and a custom house. The town is surrounded with ancient fortifications, which are described at great length by Hutchinson in his *History of Durham*. Hartlepool is much frequented in the summer months for bathing, but at other seasons it is inhabited principally by the fishermen. Within a few yards of the Watergate, a chalybeate spring has lately been discovered. It is covered by the sea at low water. About five miles north of the town are the singular rocks called the Blackballs: (See DURHAM, vol. vii. p. 205.) A life boat has lately been established here by subscription. On the moor near the town are two batteries mounted with cannon, beside an intrenchment. In 1811 the township contained 242 houses, and 1047 inhabitants. See Hutchinson's *History of Durham*, and the *Beauties of England and Wales*, vol. v. p. 119.

HARTLEY, DAVID, was born on the 30th of August 1705. He was the son of a respectable clergyman, vicar of Armley, in the county of York, where he died, leaving behind him eight children. The subject of this article was brought up by a Mrs Brooksbank, who lived near Halifax. He received the first rudiments of his education at a private school, and his academical education at Cambridge. He was admitted at Jesus College at the age of fifteen years, and was afterwards elected a fellow of that society, and took the degree of M. A. He was originally designed for the church, and proceeded for some time in his thoughts and studies towards that object; but he was restrained by some scruples, which made him reluctant to subscribe the thirty-nine articles. He continued, nevertheless, a member of the church of England, conforming to its public worship. This he did upon the principle, that the church of England maintains, in substance, the practical doctrines of Christianity, and that it was not incumbent to separate himself from its communion on account of some articles, which he regarded as speculative and abstruse. Having, it would appear, from conscientious scruples, relinquished the profession of his first choice, he applied his talents to the medical profession, in which he arrived at considerable eminence for skill and industry, but still more for philanthropy. He exercised the healing art with equal attention and fidelity to the poor and the rich. He visited the humblest recesses of poverty and sickness. He was not unmindful, that bodily sickness renders the mind more impressible with moral and religious truths, and embraced opportunities, in the course of his medical practice, of exercising mental charities to afflicted minds, as well as of employing his knowledge of the healing art to the restoration of bodily health.

He was industrious in acquiring all collateral branches of knowledge, and lived in personal intimacy with the learned men of his age. Dr Law, Dr Butler, Dr Warburton, afterwards Bishops of Carlisle, Durham, and Gloucester, and Dr Jortin, were his intimate friends. He was much attached to Dr Hoadley, Bishop of Winchester, whose opinions on religion and politics seem to have been very similar to his own. Dr Hales, and Dr Smith, master of Trinity College in Cambridge, with other members of the Royal Society, were his companions in the sciences of optics, and other branches of natural philosophy. Mr Hawkins Browne, the author of an elegant Latin poem, *De Animi Immortalitate*, and Dr Young, the moral poet, stood high in his esteem.

Hartley.

Dr Byrom, the inventor of a scientific short-hand writing, was much respected by him for useful and accurate judgment in philology. Mr Hooke, the Roman historian and disciple of the Newtonian chronology, was amongst his literary intimates. The celebrated poet Pope was likewise admired by him as a man of genius, and a true poet; yet he regarded the celebrated Essay on Man as tending to insinuate, that the divine revelation of the Christian religion was superfluous, in a case where human philosophy was adequate. He suspected the secret influence of Lord Bolingbroke, as guiding the poetical pen of his unsuspecting friend, to deck out in borrowed plumes the plagiarisms of modern ethics from Christian doctrines. From his earliest youth he was devoted to the sciences, particularly to logic and mathematics, which last he studied under the celebrated Professor Saunderson. He published, 1. *A View of the present Evidence for and against Stevens's Medicines as a solvent for the Stone*, London 1739, 204 pages 8vo, dedicated to the President and Fellows of the Royal College, London. His own case is the 123d in the book; yet he is said, after all, to have died of the stone, after having taken above two hundred pounds weight of soap; and it must be acknowledged, though with regret, that that celebrated medicine has no power of dissolving stones in the kidneys or bladder. 2. Dr Hartley is said to have written in defence of inoculation against Dr Warren of St Edmund's Bury; and some letters of his are to be met with in the *Phil. Trans.* 3. But his most celebrated work is entitled, *Observations on Man, his Frame, his Duty, and his Expectations*, in two parts; part the first, containing observations on the frame of the human body and mind, and on their mutual connections and influences; part the second, containing observations on the duty and expectations of mankind; London, 1749. The author gives the following account of the origin and progress of the work. "About eighteen years ago, I was informed that the Rev. Mr Gay, then living, asserted the possibility of deducing all our intellectual pleasures and pains from association. This put me upon considering the power of association. Mr Gay published his sentiments on this matter, about the same time, in a dissertation on the fundamental Principle of Virtue, prefixed to Mr Archdeacon Law's translation of Archbishop King's *Origin of Evil.* From inquiring into the power of association, I was led to examine both its consequences, in respect of morality and religion, and its physical cause. By degrees, many disquisitions foreign to the doctrine of association, or at least not immediately connected with it, intermixed themselves. I have here put together all my separate papers on these subjects, digesting them in such order as they seemed naturally to suggest, and adding such things as were necessary to make the whole appear more complete and systematical." The author, aware that he had thus laid himself open to the charge of having first adopted a theory, and afterwards accommodated his observations in subserviency to it, adds, that "he did not first form a system, and then suit the facts to it; but was carried on by a train of thoughts from one thing to another, frequently without any express design, or even any previous suspicion of the consequences that might arise; and that this was most remarkably the case in respect of the doctrine of *Necessity;* for I was not at all aware, that it followed from that of association, for several years after I had begun my inquiries; nor did I admit it at last without the greatest reluctance."

In regard to the doctrine of necessity, justice to the author requires that his note of explanation should be here given, viz. "that he no where denies practical free-will, or that voluntary power over our affections and actions, by which we deliberate, suspend, and choose, and which makes an essential part of our ideas of virtue and vice, reward and punishment." To the doctrine of associations he has added *vibrations*, and endeavoured to establish a connection between these, and to shew the general use of these in explaining the nature of sensations. In the introductory remarks to the second part of the work, "*On the Duty and Expectations of Man*," he says, that "the contemplation of our frame and constitution appeared to him, to have a peculiar tendency to lessen the difficulties attending natural and revealed religion, and to improve their evidences, as well as to concur with them in their determination of man's duty and expectations; with which view he drew up the foregoing observations on the frame and connexion of the body and mind: And in prosecution of the same design, he goes on in this part, from this foundation, and upon the other phenomena of nature, to deduce the truths of natural religion; laying down all these as a new foundation whereon to build the evidences for revealed religion, to inquire into the rule of life resulting from the frame of our natures, the dictates of natural religion, and the precepts of Scripture. And, lastly, To inquire into the genuine doctrines of natural and revealed religion, thus illustrated, concerning the expectations of mankind here and hereafter.

The intentions of the author seem to have been upright and pious, and considerable ingenuity, as well as acquaintance with the human frame, are displayed throughout the work. Yet few, it is believed, will be found to assert that his system throws any light on the mysterious union of matter and mind, or that his *reduction* of all the operations of the human mind to association of ideas, has tended in any degree to simplify the subject. "The philosophy of mind (observes Professor Stewart) has its alchemists; men, whose studies are directed to the pursuit of one single principle, into which the whole science may be resolved; and they flatter themselves with the hope of discovering the grand secret by which the pure gold of truth may be produced at pleasure? Of such metaphysical alchemists, Hartley is clearly entitled to the first place. But all the generalizations of his system are verbal only, and it succeeds in bringing all our mental operations under the head of associations, only by using the term in such an unprecedented latitude, as to make it comprehend all sorts of mental operations, and every kind of connection of ideas. Every thing, according to Hartley, of which we are conscious, excepting only our sensations, may be called *ideas;* and every kind of relation between them he terms an association, so that the connexion betwixt twice two and four, is merely an association of ideas, and that all mathematical relations are of the same denomination. This, it is evident, is not a discovery in philosophy, but an innovation in language." (*Philosoph. Essays.*) It is said that he did not expect that his work would meet with any general or immediate reception in the philosophical world, or even that it would be much read or understood; but that at some distant period it would become the adopted system of future philosophers. There seems no probability of this expectation being realized. The prevailing systems of Reid, Stewart, &c. the inductive philosophy of mind, seems to bid much fairer for general adoption. Although Hartley cannot be recommended as a guide, either in philosophy, or in religion, his private and personal character seems to have been amiable and exemplary. His thoughts were not immersed in worldly pursuits or contentions, and therefore his life was not eventful or turbulent, but placid and undisturbed by passion or violent ambition. From his earliest youth, his mental ambition was pre-occupied by the pursuits of science. His hours of amusement were likewise bestowed upon objects of taste and sentiment. Music, poetry, and history, were his favourite recreations. His natural temper was cheerful and social. He was addicted to no vice in any part of his life. The virtuous principles which are instilled in his works, were exemplified in his conduct. His person was of the middle size, and well proportioned; his complexion fair, his features regular and handsome. His countenance open, ingenuous, and animated. He was peculiarly neat in his person and attire. He was an early riser, and punctual in the employments of the day; methodical in the disposition of his library, papers, and writings, as the companions of his thoughts, but without any pedantry, either in these habits, or in any other part of his character. His behaviour was polite, easy, and graceful, flowing from benevolence of heart. His whole character was eminently marked by simplicity of manners, and uprightness of conduct. The dispositions of his heart shine very evidently through his works, and the conclusion of the work on Man, in which he addresses various classes of the community, and exposes prevailing vices, does much honour to his moral and religious character, and evince an affectionate concern for the best interests of his country, and of mankind. He died at Bath on the 28th of August 1757, at the age of fifty-two years. He was twice married, and left issue by both marriages, two sons, and a daughter. His eldest son got a travelling fellowship, and his younger son was entered at Oxford in Michaelmas term, 1757.—*See a Sketch of the Life and Character of Dr Hartley, prefixed to Notes and Additions to the work on Man.* By Herman, A. Pistorius, rector of Poseritz in the island of Rugen, London 1791; and Dodsley's *Ann. Register*, vol. xviii.

HARTZ, or Harz, a tract of mountainous country, situated in the kingdom of Hanover. It is about 70 miles long, and 20 broad. The forests of the Hartz have about one-third of hard wood, and two-thirds of soft wood. An insect belonging to the order Coleoptera, nearly allied to the *Dermestes typographus*, has lately committed great ravages in these forests. It infests fir trees, and in one tree 80,000 larvæ have been found. The principal minerals are lead, copper, silver, zinc, iron, green vitriol, blue vitriol, white vitriol, and sulphur. The silver mines, which are said to have been discovered in the year 968, were the first that were opened in Europe. The annual product of the lead, silver, and copper mines, is stated at 157,994 dollars.

The Editor is indebted to Professor Jameson for the following account of the mineralogy of the Hartz mountains.

This interesting tract of country is composed of primitive transition, flœtz and alluvial rocks; but hitherto no volcanic substances have been met with in it.

A. *Primitive Rocks.*

These are granite, primitive greenstone, horn-rock, quartz-rock, primitive flinty slate, primitive clay slate, and primitive limestone.

1. *Granite.* This rock is supposed to form the central part of the Hartz, and consequently to support all the other mineral strata of this part of Germany. It is occasionally traversed by veins of quartz, schorl, and hornstone. At its line of junction with the superincumbent strata, intermixtures of the rocks are to be observed, and even veins of the granite shoot from the massive rock into the superincumbent ones. These facts are differently explained by the Neptunian and Plutonian speculators. The Neptunists consider them as illustrative of the *cotemporaneous formation* of the two rocks; while the Plutonists view them as irrefragable proofs of the granite having been projected in a fluid form from the interior of the earth amongst *previously existing strata.*
2. *Primitive greenstone.* This rock rests immediately on the granite, and sometimes beds of it occur in the clay-slate. Like the granite, it is magnetical, although it contains no disseminated magnetic ironstone or magnetical pyrites.
3. *Horn-rock,* (Horn-fels.) Hitherto mineralogists have not attended to this rock. It is an intimate mixture of splintery quartz, and compact felspar, in which sometimes the one, sometimes the other mineral predominates. It is occasionally coloured black with schorl. It occurs resting upon granite, and frequently intermixed with that rock at the line of junction.
4. *Quartz-rock.* It is either splintery, or composed of granular concretions. It rests either upon the granite, or occurs in beds alternating with greenstone or horn-rock.
5. *Primitive flinty slate.* This rock occurs but sparingly in the Hartz, and is generally disposed in beds, alternating with horn-rock and clay-slate.
6. *Primitive clay-slate.* This rock forms beds in flinty-slate, primitive limestone, and greenstone.

Metalliferous venigenous formations in primitive clay-slate.

The following principal formations may be distinguished.

a. The veins of this formation contain principally galena or lead glance, native arsenic, red silver ore, with much calcareous spar, and a small portion of quartz.

b. This formation is almost entirely composed of galena or lead glance, with a very small portion of native arsenic, red silver ore, grey copper ore, and blende.

c. In this formation, like the preceding, galena is the predominating ore, and is associated with a small quantity of grey copper ore, iron pyrites, copper pyrites, red iron stone, brown iron ochre, and red silver ore.

7. *Primitive limestone.* It occurs but seldom, and in beds, in clay-slate.

B. *Transition Rocks.*

The following rocks of this class are met with in the Hartz, viz. limestone, greywacke, clay slate, whet slate, alum slate, transition flinty slate, transition trap, and transition porphyry.

1. *Limestone.* It occurs in beds, often of considerable thickness, in greywacke, and transition clay slate.
2. *Greywacke.* Greywacke and clay slate are by far the most abundant rocks in the Hartz. It sometimes contains glance coal, (*blind coal,*) and mineral pitch; and occasionally petrifactions of species of the genera hysteriolites, and trochites.
3. *Clay slate.* This rock is distinctly stratified, and

sometimes occurs in elliptical and globular concretions, which have a concentric lamellar structure. It alternates with greywacke, and both rest on the primitive rocks already described.

Both greywacke and clay slate contain very considerable metalliferous formations. The following are the principal ones.

a. A very thick bed of copper pyrites, iron pyrites, galena or lead glance, and brown blende, with compact heavy spar, and a very small quantity of quartz, and calcareous spar.

b. Veins of galena or lead glance, of which the following formations have been ascertained.

α. Galena, associated with much calcareous spar, and splintery quartz, and small portions of iron pyrites, sparry iron stone, grey copper ore, and brown spar.

β. Galena, associated with sparry iron stone, calcareous spar, heavy spar and quartz; with a minute portion of grey copper ore, brown blende, iron pyrites, and copper pyrites.

γ. Galena, with splintery quartz, and a smaller portion of calcareous spar, sparry iron stone, iron pyrites, and copper pyrites. In the upper parts of the veins, the calcareous spar is sometimes dissolved and carried away. The galena, or lead glance, is converted into white, black, and earthy lead ores; by the decomposition of the copper and iron pyrites, there are formed varieties of ochry brown iron stone, malachite, azure copper ore, and copper green, and by the decomposition of the sparry iron stone, compact and fibrous brown iron stones, and ores of manganese.

δ. Galena, with much brown blende, splintery quartz, and calcareous spar; and occasionally small portions of copper and iron pyrites.

ε. Galena, with amethyst, large foliated calcareous spar, copper pyrites, and brown blende.

c. Veins of copper ore, which are distributed in the following formations.

α. The principal vein-stone, of the veins of this formation, is quartz, which occurs in such quantity as occasionally to fill up the veins from side to side. It is in granular concretions, which are so loosely aggregated, that they can be separated by the mere pressure of the finger; hence in mines in this formation the quartz is dug out by shovels. This condition of the quartz in these veins shews us the possibility of sandstone, and even of sand being in many cases original chemical formations, and not mechanical deposites. The ores associated with the quartz are copper pyrites, malachite, copper green, copper black, tile ore, and brown iron-stone. There sometimes occur imbedded in the loose sandy quartz, blocks of compact quartz, also portions of heavy spar, and small strings of brown spar and red iron stone; and rarely fluor spar.

β. This formation consists of azure copper ore, and copper-green with much fluor spar, and sometimes small portions of brown spar, and red iron-stone.

γ. Copper pyrites, and splintery quartz, with small portions of calcareous spar, iron pyrites, and galena or lead glance, are minerals of this formation.

d. Veins of iron-stone, of which the following formations are known to the miners.

α. Red hematite, and heavy spar.

β. Compact red iron-stone, with much calcareous spar.

γ. Compact red iron-stone, with much quartz, and a small portion of iron flint.

δ. Compact, fibrous, scaly, and ochry red iron-stone, with specular iron ore or iron glance, and quartz, and calcareous spar.

ψ. Sparry iron-stone, in the lower part of the veins, but brown iron-stone in the upper parts.

e. Veins of manganese occur but rarely; and of this metal the only formation in the Hartz is that in which compact grey manganese ore is associated with heavy spar.

4. *Whet slate.* This mineral occurs in thin beds in the clay slate.

5. *Alum slate.* It occurs in beds in clay slate.

6. *Transition flinty slate.* It occurs in beds in grey wacke and clay slate. It passes into clay slate; and in the mountains of the Hartz we find all the intermediate varieties between perfect flinty slate, and well characterised clay slate. It is worthy of remark, that this mineral, which, according to the Huttonian view, must have been in a state of fusion, occurs inclosed in clay slate, and exhibiting the gradation we have just mentioned.

7. *Transition trap.* The trap rocks, which are greenstone, and amygdaloid, alternate in beds with grey wacke, and grey wacke slate.

8. *Transition porphyry.* The transition porphyries have a basis either of clay-stone, felspar, or hornstone, and occur in beds in grey wacke, or in masses resting upon it.

C. *Flœtz Rocks.*

Flœtz rocks surround the Hartz on every side, and are spread from thence over the hilly parts of Lower Saxony. The following are the flœtz rocks met with in the Hartz: Old red sand-stone, clay porphyry, alpine lime-stone, older gypsum, variegated sandstone, newer gypsum, and third flœtz sandstone.

1. *Old red sand-stone, or the first flœtz sand-stone.* This well known rock, the *dunstone* of English mineralogists, occurs in considerable abundance, and in this country contains beds of coal.

2. *Clay-stone porphyry.* This rock occurs in beds which alternate with the red sand-stone. The beds vary in thickness from a few inches to many fathoms. It passes into the bounding sandstone, a fact illustrative of the cotemporaneous formation of the two rocks. *

3. *Alpine lime stone, or first flœtz lime-stone* This limestone occurs in considerable abundance, and generally rests on the red sand-stone.

4. *Older gypsum, or first flœtz gypsum formation.* This formation, which is principally composed of foliated granular gypsum, and compact gypsum, also contains selenite, rounded cotemporaneous portions of radiated gypsum, stinkstone, and sometimes fibrous gypsum. It rests on the preceding formation.

5. *Variegated, or second flœtz sandstone.* This formation, which is probably identical with the *red ground* of English mineralogists, rests upon the older gypsum.

6. *Newer gypsum, or second flœtz gypsum formation.* The principal rocks in this formation are foliated granular, fibrous, and radiated gypsum. It rests on

* It may be noticed, that German mineralogists mention the occurrence of porphyry and trap rocks in red sand-stone as a new discovery, although both these facts were stated so early as the year 1800, by Professor Jameson, in his *Mineralogical Travels*, a work known to continental writers by the translation of it which appeared in Germany many years ago.

the variegated sandstone, and sometimes even alternates with it.

7. *Third flœtz sandstone.* This sandstone has generally a grey or white colour, and contains subordinate beds of slate clay, indurated marl, and coal. It appears to rest upon the newer gypsum and the variegated sandstone.

D. *Alluvial Rocks.*

The rocks of this class are calc-tuff, loam, clay, brown coal, bog iron ore, peat, and rolled masses, of different kinds.

The following works may be consulted, as affording accurate and extensive details in regard to the natural history of the Hartz.

1. *Erfahrungen von innern der gebirge nach beobachtungen gesammlet und herausgegeben* von F. W. H. von Trebra. Fol. 1785.

2. *Beobachtungen über den Harzgebirge nebst einem Profilrisse als ein Beitrag zur mineralogischen naturkunde* von G. S. O. Lazius. 2 vols. Hanover, 1789.

3. *Bemerkungen über den Harz* von J. C. Friesleben, 2 vols. Leipzic, 1795.

4. Hausmanns *Norddeutsche Beiträge.* 1806.

5. *De la richesse mineral,* par A. M. Heron de Villefosse. 4to. 1816.

See the article Brocken, vol. iv. p. 753. (*r*)

HARVEY, William, M. D. the celebrated discoverer of the circulation of the blood, was born at Folkstone in Kent, on the 1st of April 1578, was educated at the school of Canterbury, and sent to Cambridge in 1593, where he studied six years as gentleman commoner of Caius College. His medical studies were prosecuted at the university of Padua, where the most eminent of his instructors was Fabricius ab Aquapendente. This anatomist explained to him the structure of the valves of the veins; a subject which he had greatly improved, and which afterwards led Harvey to views unparalleled by any in physiology for their beauty and profundity. At Padua he took the degree of M. D. and returned to England in his 24th year. At 30 he was elected Fellow of the Royal College of Physicians of London; and in about a year after succeeded Dr Wilkinson as physician to Bartholomew's hospital. On the 4th of August 1655, he delivered, by appointment of the College of Physicians, the Anatomical and Surgical Lecture of Lumley and Caldwell; and there is reason to believe, that on this occasion he gave a modest intimation of his great discoveries; as he left a manuscript, *de Anatomia Universa,* dated about this time, which contains the outlines of his doctrines. Twelve years elapsed before he published them to the world. His fame, in the mean time, gained ground; and the estimation in which he was held by his professional brethren gave it solidity, as well as brilliancy.

It was in 1628 that he published his *Exercitatio Anatomica de Cordis et Sanguinis motu,* at Frankfort, a centre from which it was most readily diffused through Europe, by means of the great book fairs which were annually held in that city. In no point of view can this work be too highly praised as a specimen of the most ingenious and solid speculation, and of striking experimental inquiries, arranged in luminous order, and accompanied with apposite illustrations. It still continues unrivalled for importance as an original publication. An account of the great doctrines which it establishes is given in our article Anatomy (*History of,*) to which we beg leave to refer.

But illustrious as the merit of Harvey was, and respectably as it was supported by the cordial admiration of his colleagues, his opinions were represented by a herd of opponents as precipitate innovations; and the inference drawn by the confiding multitude was, that the author of them could not be a safe medical practitioner. His practice as a physician actually fell off, furnishing a striking proof of the precarious and humbling conditions of a medical reputation. The bigotted abettors of old established systems, after injuring his name by whispers and innnendos, attacked him at last by controversial writings, and thus put it in his power to vindicate the truths which he had discovered, and refute the Galenian errors which had maintained their ground for ages.

Dr Primrose of Oxford was his first opponent. He maintained that the blood was carried to the different parts of the body, not by the impulse of the heart, but by the power which all the living organs have to attract the substances fitted for their nourishment. Four years after this, he was attacked by Æmylius Parisanus, a physician of Venice, with great pomp of words, in a barbarous and obscure style of eloquence, in which he supported a strange medley of ancient opinions and peculiar original dogmata. Dr Harvey was saved the irksome task of replying to a tortuous and confused tissue of unmeaning words, by the zeal of his liberal admirer and genuine friend Sir George Ent, a physician of the highest reputation, who, in an *Apology for the Circulation of the Blood,* replete with learned and acute argument, and enlivened with eloquence and wit, completely exposed the futilities of that author.

In a few years after this he met with a more able and liberal minded opponent in Riolan of Paris, who had entertained a fanciful doctrine of his own upon the motion of the blood, which could not stand if Harvey's views were established. In answer to Riolan, Harvey wrote two treatises called *Exercitationes.* Every modern anatomist who looks back to these disputes, smiles not only at the obstinacy with which the true doctrine of the circulation was resisted, but at the gross ignorance betrayed by its opponents, in particulars of anatomical structure which are now familiar to the youngest tiro in the science. Riolan soberly maintained that in the adult subject the left auricle of the heart was a solid mass, possessing no cavity capable of containing blood.

Dr Plemp, professor at Louvaine, was another adversary; but, finding that the experiments with which he intended to assail the doctrines of Harvey contributed powerfully to their support, he with manly candour ranked himself among his converts.

Harvey, in his first publication, did not acknowledge any regular continuation or anastomosis betwixt the small arteries and the veins, furnishing a tubular passage for the transmission of the blood, but believed that this fluid was first diffused by the terminations of the arteries among the interstices in the texture of the different organs, and was from these absorbed by the veins; and it was not without apparent reluctance that he was afterwards induced in this particular to admit the doctrine which is now universally established.

After the great discovery of Harvey was placed beyond the reach of controversy, attempts were made to detract from his merit, by showing that it was not original. Obscure passages and accidental expressions in the writings of ancient and modern authors were distorted by miserable envy, for the purpose of proving that Harvey, now acquitted of heresy, was chargeable with plagiarism. A singular circumstance occurred to give a temporary triumph to calumny. Harvey, having maintained some degree of intimacy with the Venetian

Harvey.

ambassador at the court of London, who had heard and admired his lectures, gave him a physiological manuscript just before his departure, which the ambassador presented to Paulus Sarpius, a learned monk of his own country. After the death of this religious person, when his manuscripts were explored, a story was circulated that the discovery of the circulation belonged to Paulus, who had communicated it either to Fabricius or to Harvey. This unfavourable impression was easily credited, and a considerable time was required before it could be effaced.

Harvey, however, was not one of those ill-fated men of genius, who are denied all due honour till the enjoyment of it is put out of their power by death. He was caressed at court, and warmly esteemed by his scientific brethren. By what means, or at what period he was introduced to royal notice, we are not informed; but a letter from James I. of England was found among his papers, dated 1623, *i. e.* 15 years after he had connected himself with the London College, from which it appears that he had been for some time extraordinary physician to the king, and had been actively employed about the royal person. Seven years after this, in the reign of Charles I. he was promoted to the office of physician in ordinary. He was also employed to accompany the young Duke of Lennox in his continental travels.

During the civil wars, Harvey accompanied the king in his different military movements; and, after the battle of Edgehill, retired with the royal family to Oxford. In three years after this, he was appointed warden of Merton college, instead of Nathaniel Brent, who had revolted to the Presbyterian cause.

The circulation of the blood was not the only subject in which Harvey was eminent. He also made important discoveries on the subject of generation; and, at the age of 73, at the pressing request of Sir George Ent, published his work entitled, *Exercitationes de generatione Animalium*, which contained many experiments on incubation, and the reproductive functions of viviparous animals, ingeniously contrived, and executed with much labour. One of his favourite conclusions was, that impregnation is not accomplished by the contact of the semen of the male with the embryo in the body of the female, but by a peculiar stimulus communicated by it to the vagina, and by sympathy to the other female organs, and which he compared to contagion for the peculiarity of its effects;—a conclusion which he considered as supported by this fact, that a single impregnation of a female fowl was sufficient to impart a prolific quality to *ova* not yet formed.

Harvey dissected the body of Thomas Parr, so celebrated for longevity, having lived to the age of 153, and his account of the appearances which he found is delivered in his own words in the editions of his works.

Several letters written by him to men of science are also preserved and published, all of which breathe the same chaste philosophical spirit; and the latest of them shew that he retained, in extreme old age, the same admirable vivacity of intellect for which he was distinguished through life. His *Anatomia Universalis*, and some other writings not intended for publication, are preserved in manuscript in the British museum. Some of his manuscripts, however, and most particularly those containing his extended views and experiments on generation, were, to the great detriment of science, destroyed by the licentiousness of the Parliamentary troops, when they occupied his house in London.

When Charles I. fled from Oxford, Harvey went to London, where he practised but little as a physician, spending a great part of his time in a rural retreat at Lambeth.

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Having now attained to the summit of professional eminence, he received, in 1652, a splendid testimony of the esteem entertained for him by the College of Physicians. A bust of him was executed by their orders, and placed in their hall, accompanied by a complimentary inscription. He, in his turn, gave a proof of his affection for that learned body, by presenting them with a hall, and his excellent library.

In two years after, when Dr Prujean resigned the situation of president of the college, Harvey was chosen his successor; but, on account of his age and infirmities, he delicately declined that honourable charge. He continued till a very late period of his life to officiate as a lecturer. He attended the meetings of the college when important business was agitated; and, in the year 1656, he bequeathed to them his patrimonial property. Loaded with various increasing infirmities, he died on the 3d of June of the following year, aged 79, and was buried at Hampstead, where a monument, with a figure and suitable epitaph, is erected to his memory.

The College of Physicians, in 1766, published a beautiful edition of his works in one large quarto volume, to which is prefixed an account of his life by Dr Lawrence. Harvey wrote with great perspicuity, and a flowing eloquence. His works are not in the slightest degree tainted with a spirit of hostility. His controversial antagonists, even those who wrote with petulance and asperity, are treated by him in temperate and civil language. His candour, cheerfulness, and goodness of heart were conspicuous in his whole life, as well as in his writings, and exhibit a worthy pattern for future imitation. (*H. D.*)

HARWICH is a town of England, in the county of Essex. It is situated at the north-east extremity of the county, on a point of land bounded on the east by the sea, and on the north by the estuaries of the Stour and the Orwell. The town consists of three principal streets, with various lanes branching off in different directions. The chief buildings are the chapel, built by the Earl of Norfolk about the beginning of the 13th century; the townhall, rebuilt about 53 years ago; the school-house, and the custom-house. Its market place is inclosed, and is neat and clean. The town is walled in, and the streets are paved with a kind of clay from a petrifying spring in the neighbourhood, which makes it as hard as stone.

The inhabitants of Harwich are principally employed in ship-building and other maritime occupations. Several third rates and other large vessels have been built here. The harbour, which is independent of the bay, is spacious, deep, safe, and convenient; and a light-house has lately been erected on a hill below the town for guiding vessels into it.

The North Sea fishery gives employment to about 3000 tons of shipping, and 500 sailors belonging to this port. The people too receive much support from the Dutch packet boats, which, in time of peace, carry on a great intercourse between Harwich and the continental ports.

During the bathing season, Harwich is frequented by much company, who find here tolerably good accommodation. Bathing machines have been for some time introduced; and there are two hot and two cold salt water baths, with a steam or vapour bath, and a large bathing place, with a machine for throwing the hot or cold water on any part of the body. The buildings, which have commodious dressing rooms, stand in a

Harwich. Hasselquist.

large reservoir containing many hundred tons of sea water, which is renewed every tide, so that the baths are continually supplied with fresh sea water by a contrivance on the principle of a natural syphon.

On the opposite side of the bay in Suffolk stands Landguard fort, which is built on a point of land united to Walton Colness, but so encircled by the sea at high water as to become an island nearly a mile from the shore. It completely commands the entrance to the harbour of Harwich, and was erected for this purpose in the reign of James I.

Harwich was made a burgh in the reign of Edward II. It is governed by a mayor, 8 aldermen, 24 burgesses, a recorder, &c. and sends 2 members to parliament.

The following is the population, &c. of the burgh of Harwich for 1811.

Number of inhabited houses	564
Do. of families	910
Do. employed in agriculture	72
Do. in trade and manufactures	178
Males	1519
Females	2213
Total population in 1811	3732

See Morant's *History, &c. of Essex;* Dale's *History of Harwich and Dover Court;* and the *Beauties of England and Wales,* vol. v. p. 330. For an account of Harwich Cliff, see Essex, vol. ix. p. 206, col. 2.

HASSELQUIST, Frederick, a celebrated Swedish botanist, was born at Toernvalla in East Gothland, on the 3d Jan. 1722, old style. Having been left an orphan at an early age, he was for some time supported by his maternal uncle; but upon the death of this his only friend, he was obliged to support himself by teaching, even for some time after he entered the university of Upsal in 1741. In 1746, he procured a royal stipend or scholarship, and such was his progress in botanical acquirements, that he became a favourite pupil of Linnæus; and was inspired with such an ardour to examine the botany of distant countries, that though affected with a pulmonary complaint, he resolved to examine the natural history of Palestine. In 1749, he read lectures on botany in Stockholm; and having received the offer from the Levant Company of a free passage to Smyrna, he set sail on the 7th August, and arrived in that city on the 27th of Nov. 1747. During the winter, he made an excursion to Magnesia, and on the 13th May he arrived at Alexandria, and afterwards visited Rosetta and Grand Cairo. In March 1751, he proceeded to Damietta, from which he sailed to Jaffa, where he began his examination of the natural history of Palestine. On the 23d May he set sail for Cyprus, and after visiting Rhodes and Stanchio, he returned to Smyrna in the end of July. His laborious exertions had now begun to impair his strength, and though he tried a milk diet, and a winter's repose at Smyrna, yet his health gradually declined, and he died on the 9th February 1752, in the 31st year of his age.

During his travels and illness, Hasselquist had unfortunately contracted a debt of about £350 sterling, and upon his death his collections and MSS. were seized by his creditors at Smyrna. As soon as the Queen of Sweden was informed of this event, she redeemed that valuable deposit, and put it under the care of Linnæus. The MSS. papers of Hasselquist were published in 1757 in Swedish, under the title of *Iter Palestinum,* in one vol. 8vo. with a biographical preface by Linnæus, and his correspondence with the author. His work has been translated into several languages, and appeared in English in London in 1766. Hasselquist is also the author of several memoirs in the Transactions of the Academies of Upsal and Stockholm from 1750 to 1752. See the preface to his *Iter Palestinum;* Haller's *Bibliotheque Botanique;* and Rees's *Cyclopædia.*

Hastings.

HASTINGS, is a burgh and market town of England, in the county of Sussex. It is situated near the eastern extremity of the county, in a valley that forms a beautiful amphitheatre, sloping on the south to the sea, and flanked on the east and west by lofty hills. The town consists of two parallel streets, the High Street and Fish Street, running north and south, and separated by a rivulet called the Bourne, which supplies nearly the whole town with water, and runs into the sea. The town is well paved, and contains many handsome houses. The principal public buildings, are the two churches of All Saints and St Clement's, the town-hall and market-place, and a custom-house with an establishment of 12 riding officers. The two churches are very ancient buildings. St Clement's is large and lofty. The town-hall was built in 1700, and has the market-place under it. There are here two excellent free schools, founded for the education of 130 scholars; and also a barrack for foot soldiers. The remains of an ancient castle are still visible on a high rocky cliff to the west of the town. The ruins resemble in form two sides of an oblique spherical triangle, having the angles rounded off. The base or south side towards the sea completes the triangle, and is formed by a perpendicular crag about 400 feet long. The east side is a plain wall about 300 feet long, and the north-west side is about 400 feet, the whole area being about 1⅕th acre. The walls are about eight feet thick. A little to the west of the crag, are the remains of a priory of Black Canons.

Hastings is one of the cinque ports. It had formerly a good harbour and a considerable trade; but as the harbour is choked up with sand, it now carries on merely a small coasting trade with London. Immense numbers of mackarel, herrings, soles, &c. are caught here, and forwarded by land carriage to the London market. The only way to secure ships is to draw them up on the beach, which is here called the Stade. At the west end of it is a fort mounting eleven 12-pounders. Boat building is carried on here to a considerable extent; and considerable occupation is given to the inhabitants by a lime company, which employs nine sloops of 40 tons burthen, in bringing the chalk from the Holywell pits at Beachy Head, from April to November. About 120,000 bushels of lime are annually made at the kilns, which are situated to the west of the town.

Like other towns upon the coast, Hastings draws considerable advantages from sea-bathing. Twenty bathing machines stand to the west of the town, close to a newly formed walk called the *Parade.* The beach is here admirable; and convenient warm baths have been established some time ago by subscription. At the distance of two miles from the town is a large broad stone, on which William the Conqueror dined when he landed here. It is called the "Conqueror's Table."

The following is the statistical abstract for the town in 1811:

Number of inhabited houses	665
Do. of families	789
Do. employed in agriculture	45
Do. in trade and manufactures	479

Males	1739
Females	2109
Total population in 1811	3848

East Long. 41′ 25″, North Lat. 50° 52′ 10″, according to trigonometrical observations. See the *Guide to the Watering Places* 1805, and the *Beauties of England and Wales*, vol. xiv. p. 184.

HASTINGS, Battle of. See England, vol. viii. p. 598, col. 2.

HAT, is the name of a piece of dress worn upon the head by both sexes, but principally by the men. The use of hats seems to have been first introduced among the ecclesiastics in the 12th century, and it was not till the year 1400 that they seem to have been pretty generally adopted.

As the art of making common hats does not involve the description of any curious machinery, or any very interesting processes, we shall not enter into minute details upon the subject. It will be sufficient to convey to our readers a very general idea of the method which is employed.

The materials employed in making hats, are the fur of hares and rabbits freed from the hair, together with wool and beaver. The beaver is reserved for the finest hats. The fur is first laid upon a *hurdle* made of wood or wire, with longitudinal openings; and the operator, by means of an instrument called the *bow*, (which is a piece of elastic ash, six or seven feet long, with a catgut stretched between its two extremities, and made to vibrate by a bowstick,) makes the vibrating string strike and play upon the fur, so as to throw the fibres together, while the dust and filth descend through the chinks of the hurdle. A sieve or searce has sometimes been used for the same purpose.

After the fur is thus driven by the bow from one end of the hurdle to the other, it forms a mass called a *batt*, which is only half the quantity sufficient for a hat. The *batt* or *capade* thus formed, is rendered compact by pressing it down with a *hardening skin*, (a piece of half-tanned leather,) and the union of the fibres is increased by covering it with a cloth, and allowing the workman to press it together repeatedly with his hands. The cloth being taken off, a piece of paper, with its corners doubled in, so as to give it a triangular outline, is laid above the batt. The opposite edges of the batt are then folded over the paper, and being brought together and pressed with the hands, they form a conical cap. This cap is next laid upon another batt, ready hardened, so that the joined edges of the first batt rest upon the new batt. This new batt is folded over the other, and its edges joined by pressure as before; so that the joining of the first conical cap is opposite that of the second. This compound batt is now wrought with the hands for a considerable time upon the hurdle, being occasionally sprinkled with clear water till the hat is *basoned* or rendered tolerably firm.

The cap is now taken to a wooden receiver, like a very flat mill-hopper, consisting of eight wooden planes, sloping gently to the centre, which contains a kettle filled with water acidulated with sulphuric acid. In this liquor the hat is occasionally dipped, and wrought by the hands, and sometimes with a roller, upon the sloping planks. The hat is thus fulled or thickened for four or five hours; knots or hard substances are picked out by the workman, and felt is added by means of a wet brush to those parts that require it. The beaver is laid on at the end of this operation; and in the case of beaver hats, the grounds of beer are added to the liquor in the kettle.

The hat is now to receive its proper shape. For this purpose the workman turns up the edge or rim to the depth of about $1\frac{1}{2}$ inch, and then returns the point of the cone back again through the axis of the cap, so as to produce another inner fold of the same depth. A third fold is produced by returning the point of the cone again, and so on till the whole resembles a flat circular piece, having a number of concentric folds. In this state it is laid upon the plank, and wetted with the liquor. The workman pulls out the point with his fingers, and presses it down with his hand, turning it at the same time round on its centre upon the plank, till a flat portion, equal to the crown of the hat, is rubbed out. This flat crown is now placed upon a block, and by forcing a string, called a *commander*, down the sides of the block, he forces the parts adjacent to the crown to assume a cylindrical figure. The rim now appears like a puckered appendage round the cylindrical cone; but the proper figure is now given to it by working and rubbing it.

The hat being dried, its nap is raised or loosened with a wire brush or card, and sometimes it is previously *pounced* or rubbed with pumice, to take off the coarser parts, and afterwards rubbed over with seal-skin. The hat is now tied with a pack-thread upon its block, and is then dyed, by being first boiled with logwood, and afterwards immersed in a saline solution, consisting of a mixture of green copperas and blue vitriol.

The dyed hats are now removed to the stiffening shop. Beer grounds are now applied on the inside of the crown, for the purpose of preventing the glue from coming through; and when the beer grounds are dried, glue, (gum Senegal is sometimes used,) a little thinner than that used by carpenters, is laid with a brush on the inside of the crown, and the lower surface of the brim.

The hat is now softened by exposure to steam, on the *steaming* bason, and is then brushed and ironed till it receives the proper gloss. It is then cut round at the brim by a knife fixed at the end of a guage, which rests against the crown: The brim, however, is not cut entirely through, but is torn off so as to leave an edging of beaver round the external rim of the hat. The crown being tied up in gauze paper, which is neatly ironed down, is then ready for the last operations of lining and binding.

Straw hats.

Hats are frequently made of straw, or of the chips and shavings of wood woven or plaited together, to form ribbons of narrow widths; and these are wound spirally round a block, and sewed together in a cylindrical form, so as to form the hat. The rim or border is made in a similar manner, and sewed to the hat afterwards.

The manufacture of straw hats gives employment to vast numbers of the poor inhabitants of Hertfordshire and Bedfordshire. They select the whitest and most regular straws, and cut them exactly into lengths; the straws are then whitened, by inclosing a great number of bundles in a large box, leaving a considerable space in the middle, into which a cup filled with sulphur is placed, and this being lighted, the box is shut close, and covered up with a wet blanket, to keep in the vapour of the burning sulphur, which insinuates itself through all the bundles of straw contained in the box, and renders them whiter, and of a more delicate colour. After this preparation, the straws are split lengthwise into se-

Hat. veral segments, by a wire fitted to the interior capacity of the straw, and having four, six, or eight leaves, sharp on the upper edges, and projecting radially from the wires. The straws will easily split in the proper manner when the wire is forced through them. For the convenience of holding this tool, the wire is bent at right angles, about an inch below the part where the leaves project from it, and this bent part is fixed in a handle. The slips of straw are now softened in water, and plaited together by children, with great rapidity and exactness. The most simple plait is that of three straws; but this is only for very coarse articles, and the slips of the straws are very broad. Sometimes whole straws are employed, being first pinched flat by softening them, and drawing them through the fingers. The most esteemed plait is that of six straws, and is more or less valuable as it is finer or coarser; and after the plait is finished, it is passed several times between a pair of small wooden rollers, to render the ribbon flat and solid. Of these ribbons the hat is formed, by winding them in a spiral direction, round a proper shaped wooden mould or block with a little overlap, and sewing them fast together; and when it is thus finished, the whole is passed over with a hot iron, to smooth down the seams, and the block is then taken to pieces, to withdraw it from the hat.

The Society of Arts have lately published a description of a machine for ironing down the hats upon the block. For this purpose the block is fixed upon a vertical spindle, so as to turn round horizontally; and the pressure is given by a heated steel plate, fixed in the middle of a long lever, the fulcrum of which is supported with an universal joint, at the top of an iron stem rising up from the table upon which the machine is placed. The opposite end of the lever has a handle with which the workman presses the steel plate down upon the straw, and rubs it sidewise to smooth it down, at the same time he turns the block and hat round upon its spindle, by means of cross arms provided for that purpose, to present every part to the action of the steel. An iron box is formed just over the steel plate to receive a red hot heater, and this is kept in by a lid. It is stated as a great advantage of this machine, that the pressure of the lever being considerable, the hot steel plate can be quickly passed over the straw, and does not therefore injure the colour.

The importation of straw hats from Germany and Italy is very considerable. They have the reputation of producing the best articles of that kind at Leghorn, from whence more than 12,000 dozen have been imported in one year. Mr Corstoul, in a memoir to the Society of Arts, has shewn the practicability of producing an adequate substitute for this article in England, by plaiting the straw of rye, which he cultivated on a poor sandy soil in Norfolk, sown at the rate of two bushels per acre. He found that the produce of four square yards, when manufactured, was ten yards of Leghorn plait, of four different qualities, and weighing one ounce.

Thomas's machine for weaving chip hats. PLATE CCCXXXVIII.

Chips or shavings of wood are also used for making hats; and some hats of this substance are woven altogether in one piece, or they are woven in wide pieces, which are afterwards made up into the figure of the hat. Sometimes the chips are only used as the fabric of the hat, and are woven in with silk, which also covers the chips, and forms the exterior surface. A patent was granted in 1808 to Mr Thomas, of London, for an ingenious machine which weaves the whole hat in this way, and of the intended figure, without any seams. Fig. 7. is an elevation, and Fig. 8. a section of this machine, in which A is the block or mould upon which the hat is to be formed, and so put together in pieces as to separate for the purpose of taking off the hat. It is fixed upon a square stem B, which rises and falls in a square tube D, by the action of a pinion *a* upon a rack which is fixed to the stem. The tube D is supported upon a pivot at the lower end, and is embraced at about half its length by a collar E, in the frame or pedestal EFF, which sustains the whole machine, but permits it to turn round upon the pivot, that the workman, who sits with the machine before him, may bring every part of the block towards him. He can turn it round by applying his foot to the circular board or wheel *c c*, which projects from the axle or tube D at the lower end. The top of the tube D carries a cylindrical wooden box G, large enough to contain the block A without touching it; and upon the upper edge of this cylinder is fixed a projecting flaunch or circular plate. Around the circumference of the plate, a circle is described, and a row of holes pierced at equal distances, so as to divide the circle into 72 parts, and each hole receives a wire *h*. Immediately within the row another circle is made, and divided into the same number of holes; but the wires *i* which pass through these latter holes are interspaced between the former. Each wire has an eye formed through its upper end, for the reception of a slip of chip, marked *k l*, of which there will be 144 in number, radiating from the centre of the block, to which they are all made fast by a plug; and after passing through the eyes of the wires *k* and *l*, the slips hang down, and have small leaden plumbets *m, m* appended to them, to stretch them straight. PLATE CCCXXXVIII. Fig. 7, 8.

The lower ends of the wires *i* are all jointed to a circular ring of wood *o o*, which fits upon the external surface of the cylindrical box G, and slides freely up and down thereupon; in like manner the interior wires *k* are jointed at the lower ends to a similar ring *i i*, which is connected with the former ring *o o* by two small cords, which pass over pulleys fixed in the flaunch *g*, and consequently when either the rings *i* or *o* are pulled down the other must be raised up, and *vice versa*. To draw down the lower ring *o*, it has two wires *p, p* (Fig. 7.) joined to it at the opposite sides, and these descend to the treadle *r*, upon which the workman places his foot; and the action of this pressure is to divide the whole number of shreds of chip into two sets *k* and *l*, one of which is depressed, and the other elevated. The weaving is performed by passing a knitting needle filled with silk in the space or angle between *k* and *l*, until it has made a whole circuit round the block or crown of the hat; then, relieving the pressure upon the treadle *r*, the weights *m* cause the wire *h* and ring *i* to descend, and the other set of wires *i*, and their ring *o*, to ascend, by which means the situation of the chips *k* and *l* become reversed, *l* being the uppermost, and *k* the lowest. In this situation the needle is again passed round in the opening between them. This done, the treadle *r* is depressed to restore them to the position of the Figure, and the needle is again passed; and thus the operation is continued until the whole is woven together; the chips radiating from the centre forming the warp, and the silk the weft, running in circular or rather spiral lines, and passing alternately over and under every chip. In some cases two needles of silk are employed, one proceeding in one direction and the other in the opposite direction, or one passing over any chip whilst the other passes under it; and in this way the whole surface of the hat is of silk, the chips being all Fig. 7.

covered. When the crown of the hat is finished in this way, the cylindrical part is done by raising up the block by its rack and pinion; and at last the block is taken to pieces to get the hat off.

For farther information on this subject, see Nollet, *Art du Chapellier*, or *Mem. Acad. Par.* 1765; *Hist.* p. 132; Gerard, *Mem. Acad.* 1770; *Hist.* p. 116; Trousier, in Rozier's *Journal*, vol. xxvii. p. 71; Monge on Felting, in the *Annales de Chimie*, vi. p. 300, or in the *Repertory of Arts*, vol. iii. p. 351; Chaussier, in the *Journal Polytechnique*, or in Nicholson's *Journal*, vol. i. p. 399, or in the *Repertory of Arts*, vol. x. p. 275; Tilstone's patent for making hats of kids hair, in the *Repertory*, vol. i. p. 1; Dunnage's patent for water proof hats, in imitation of beaver, consisting of silk, mohair, cotton, inkle or wool, in the *Repertory*, vol. iv. p. 302. Burns' patent for a new material for hats, in the *Repertory*, vol. ix. p. 167; Dunnage's patent for ventilating the crowns of hats, *Id.* vol. ix. p. 167; Boileau's patent for straw hats, *Id.* vol. xi. p. 97; Chapman's patent for taking off the fur or wool from skins for hats, *Id.* vol. vi. p. 374; Messrs Ovey and Jepson's patent for hats, *Id.* vol. xiii. p. 373; Messrs Walker and Alphey's patent for water proof hats, *Id.* vol. xvi. p. 217; *Transactions of the Society of Arts*, vol. i. p. 29, vol, xxiii. p. 226, vol. xvi. p. 237, and vol. xxv. p. 154; Nicholson's *Journal*, vol. ii. p. 467, 509, vol. iii. p. 22, 23, 73, vol. iv. p. 236; Sarrazin, *Mecanique propre a carder et melanger les laines et poils servant a la fabrication des chapeaux*, in the *Archives des Decouvertes, pour* 1812, vol. v. p. 189; Guichardiere *sur un nouveau moyen de fouler les chapeaux*, in the *Archives des Decouvertes, &c. pour* 1815, p. 198. See also our article ENGLAND, vol. ix. p. 11. for an account of the hat manufacture in England.

HATCHING, is exclusion of the young from the eggs of animals, either by the temperature of the circumambient air, artificial heat, or the incubation of birds.

Nature has adopted some remarkable distinctions in the mode of propagating animals. Some are brought to perfection in the womb of the mother; others, originally concentrated in eggs, are discharged either in that state, where the future concourse of the male is required to excite the vital spark, or where the latent embryo will be unfolded by the simple application of heat. To the first class belongs the offspring of all quadrupeds; the second includes many of the amphibious tribes, especially toads, frogs, and newts; and the third, the whole class of birds, numerous fishes and reptiles, and most of the insect, molluscar, and vermicular tribes. Hatching and incubation have therefore different meanings, or the former, which applies to every kind of evolution of the nascent being, may be said to include the latter. Most animals that produce eggs, leave them simply to the care of nature, and certainly never recognise their offspring after birth, at least with some exceptions, of which there is a prominent example in the crocodile. But in so far as we can yet ascertain, all birds impart their natural heat to their eggs by incubation, and watch the developement and subsequent growth of their young. Some distant analogy may therefore be conceived to subsist between gestation and incubation, in the respective period necessary for each according to the genera and species of animals. The period of gestation is generally, perhaps universally, longer in the larger viviparous tribes; and incubation is protracted, in proportion to the size of the bird. One irreconcileable difference, however, subsists, in there being no known method of accelerating the former, while exclusion of the young from the egg may be promoted, by augmenting the intensity of the temperature. We are yet unacquainted with the process undergone by the egg of the largest of the feathered race, the ostrich: some assert that its exclusion is left entirely to the effects of the sun; while others maintain that it is aided by the incubation of the female. That of the swan requires incubation during 42 days; that of the domestic hen 21; and that of the linnet 14. But we are told, that the period is somewhat abridged in the warmer climates; that the egg of the common fowl has been brought out in 13 days, by the aid of artificial heat; and that by the diminution or interruption of the temperature, it has been retarded for six weeks. It appears, that the heat of 104° of Fahrenheit's thermometer is required to hatch the eggs of all birds, the largest and smallest, and that the surface of the skin of the mother imparts it to that extent. Thus nothing more is required for the evolution of fecundated eggs, than the simple application of any kind of heat.

These facts have been a long time established beyond controversy, whence they could not escape the notice of the ancients, as they now attract the consideration of the most unlearned observers. Instead of abiding by the ordinary course which nature has herself committed to the parent, mankind, for the sake of deriving more profit from their own contrivances, have resorted to the means of hatching birds by artificial heat. The earliest information concerning this process, is probably obtained from Aristotle in these words: "Although incubation be the common method employed by nature for bringing out eggs, it is not exclusive; for we see that in Egypt eggs will be hatched of themselves in the earth, if covered over and heated by litter." And he farther remarks, "that when heated in certain vases wherein they are deposited, they hatch of themselves." Diodorus Siculus expresses his admiration of the contrivance; and Pliny, who lived a century after Diodorus, remarks, that "eggs are excluded of themselves quite naturally, and without the aid of incubation by fowls, as in the dunghills of Egypt." Nevertheless, on comparing this with other passages of his works, it is obvious that Pliny could not have been ignorant, that the application of simple heat was effectual. He and Suetonius relate, that Livia, the wife of Augustus, who had before been married to Tiberius Nero, became pregnant, and desiring, with all the ardour of a youthful female, to discover of which sex her offspring would be, took an egg, that had undergone partial incubation, and kept it warm in her bosom. When obliged to desist, it was always committed to one of her women, that the same invariable heat might be preserved. Her object was successful; and the latter biographer informs us, that "from this egg a cock was hatched with a very remarkable crest." Pliny therefore concludes, "It is probably on such principles, that a method was not long ago devised, of placing eggs in straw heated by a slow fire, a man being occupied in turning them at different intervals until their chickens were hatched." In another work of the ancients, the *Geoponica*, there is a whole chapter ascribed to Democritus, treating of "how it is possible to hatch eggs without the aid of fowls;" and the principle is analogous to the employment of dunghills. The eggs are to be placed in jars, observing to mark the date of deposition on the shell of each, on purpose to ascertain when the 20 days necessary for their exclusion shall have elapsed. Then the shell is to be broken, and the chickens supplied with food. It is unnecessary to insist farther on the practice of the ancients; but as Herodotus passes over that of the Egyptians in silence, some authors have dated its commencement between his era and the age of Aristotle, which were not remote from each other.

This branch of industry though continued to the present day, as we shall have a future opportunity of illustrating, is not peculiar to Egypt. It was adopted at Naples in the fifteenth century, where there was a palace belonging to King Alphonso II. containing an oven that could hatch 1000 chickens. Francis I. of France, is said to have made experiments on the same subject at his chateau of Mont Trichard, in the sixteenth century; and Thevenot, at a later period, affirms that one of the Grand Dukes of Tuscany obtained an Egyptian to superintend his proceedings; and also refers to the same process being adopted in Poland.

The art however seems to have been practised on the most extensive scale in Egypt, to which country we are constantly referred for details on the art of hatching birds by artificial heat. The Royal Academy of Sciences at Paris indeed, esteemed this subject sufficiently interesting for particular inquiry, and from the investigations which they made, as well as from the accounts of various travellers, we have obtained the following information.

A rectangular edifice of brick or clay, called a *mamal*, is constructed, half sunk in the earth. Niebuhr describes one at Cairo, as being in a manner implanted in a hillock. It consists of two stories communicating with each other, and down the middle there is a passage, probably for the attendants. Each side of the passage is partitioned into 5, 6, or 8 chambers, or any other number, as no general rule seems to be preserved, and in these the eggs are deposited. At the outside of one angle of the building there is a furnace or fire-place, and this being filled with a mixture of cow's and camel's dung, the ordinary fuel of that country, the heat is conveyed to both stories by means of flues during 3 or 4 hours daily at different intervals; but after 10 days fire is no longer supplied, the oven being sufficiently heated. Lest the heat should be too great, ventilators are used; but those who conduct the process have no other rule than to render the temperature equivalent to that of the baths of the country, and, if it is greater at first, they affirm, that it will occasion no injury. When the oven is converted to use, the floor of the compartments is covered with a mat, above which there is a bed of straw, and then a layer of eggs. Niebuhr says, a second tier of eggs covers the first. Mr Browne, if we rightly recollect, affirms, that the eggs are deposited in such a manner as not to touch each other. All are turned twice each day, and four times during the night. Towards the eighth or tenth day, they are examined with a lamp, and those which appear unimpregnated are rejected, and in fourteen days the whole are transferred to the upper story. At length, on the twentieth and twenty-first day, exclusion takes place; and as the chickens can subsist two days without food, their owners have sufficient time to receive them, or they are sold to others.

The number of mamals distributed throughout Egypt in the beginning of the last century was 386, according to Father Sicard; and the number of eggs hatched in each is said, by him and other travellers, to amount to 40,000, 50,000, or even 80,000 eggs, a fact almost incredible. But in the arrangements necessary to encourage and preserve such a branch of industry, a circle of several villages must bring to the mamal all the eggs belonging to that particular district. The inhabitants are liable to penalties if they dispose of them elsewhere; and the proprietor of the mamal is also limited by certain restrictions. He is entitled to select those eggs which he deems sufficient, and is responsible for a produce corresponding to only two-thirds of the number. Thus the owner of 3000 eggs receives only 2000 chickens; but as unreasonable profits would sometimes be derived from the surplus, he is entitled to redeem the chickens at a certain price from the proprietor of the oven. Dr Graves, in a paper in the *Philosophical Transactions*, says, that 200 pounds of litter are daily required for heating the mamals; and Pococke observes, that it is scarcely possible to enter them on account of the smoke.

The success of this process is supposed to result more from the nature of the climate in Egypt, where it is practised only during certain seasons, than from any particular ingenuity. Sudden alterations of weather may be destructive of the progeny; and an instance is given, where the occurrence of a shower cooled the atmosphere so much that 4000 chickens, nearly matured, perished in one oven. It is affirmed, that the inhabitants of a village called Bermé, situated on the Delta, are almost exclusively the managers of the process, which is transmitted from father to son, and preserved secret among them. At appointed times, they disperse themselves throughout Egypt to take care of the ovens.

The modern Chinese are well acquainted with the method of hatching chickens by artificial heat. Mr Barrow mentions, that even those families practise it who have a permanent abode on water. They deposit the eggs in sand, at the bottom of wooden boxes, which are placed on iron plates kept moderately warm. Thus, while a new brood is obtained, the old birds continue laying nearly without interruption.

M. de Reaumur, an ingenious naturalist, devoted much time and attention to the subject of hatching eggs by artificial heat, which he seems to have been desirous of introducing into France under the superintendence of a Bermean. He adopted different methods of accomplishing this, which are copiously detailed in a work on the subject, that has been translated into several European languages. Two plans were principally followed; the first, which was analogous to that of the Egyptians, consisted in raising a superstructure above three bakers ovens, for containing the eggs. A small carriage on wheels, or rollers, was formed, in which were several drawers, or shelves, whereon the eggs were placed in successive rows, or strata, that is, one layer on each. The carriage could be brought at pleasure on its wheels to any part of the surface, and the state of all the eggs could be ascertained on pulling out the shelves, or drawers, in which a thermometer likewise lay, for indicating the heat. By means of this simple apparatus, Reaumur succeeded perfectly in hatching chickens; and he acquaints us, that a nun, to whom he entrusted his first experiment, in the oven of a convent, obtained 20 from 100 eggs. He conceives, that a suitable oven, twelve feet square and four feet high, with a stove in the centre, could be erected at little expence, which would necessarily be heated to 104°. Instead of thermometers, the temperature may be ascertained by melting a piece of butter, as large as a walnut, with half as much tallow in a phial. When it flows like a thick syrup on inclining the phial, the proper heat is obtained.

The second, though a less efficacious plan, adopted by Reaumur, consisted in burying casks of eggs in a dunghill, the warmth of which might promote exclusion. Here, however, he was opposed by uncommon difficulties; and he acknowledges that, had the former expedient been first devised, he should never have resorted to the latter. His experiments were originally made by depositing the eggs simply in the dunghill in an oblong cavity, covered by two planks. Most of them advanced favourably during eight or ten days; but after this they became putrid, disseminating an infectious effluvia, and not one produced its young. On employing casks, Reaumur suspended three flat baskets or sieves at intervals within them, containing one or two layers of eggs, along with thermometers. However, the temperature of the dunghill being subject to continual variation, occasioned great embarrassment; and the author conceives that the experiment may be more successful by resorting to several, which may possess different degrees of heat. To preserve it permanently equal is very difficult; and turning the eggs is also attended with trouble. In the course of his experiments, Reaumur found, that, though the temperature should be regularly 104°, the expanding embryo could exist at from 115° to 122°; and that an egg, during the period of total developement, loses about a fifth or sixth of its weight. He found that a humid and mephitic vapour arising from the dunghill injured the nascent young more than heat. He therefore devised a new kind of oven, heated in the same manner as the casks by a dunghill, but resembling the superstructure he had used on the baker's oven. This was a rectangular box or case, six or seven feet long, between 21 and 40 inches broad, and about eight inches high. It was immersed in a dunghill, leaving one end open, and the eggs were placed on a carriage or tablet moved in upon rollers. By observing proper precautions, Reaumur succeeded in hatching about three-fourths of the eggs he employed.

From the brief abstract now given, a general idea may be formed of the two different methods; but M. de Reaumur's work itself must be consulted for the details. As it is not uncommon, we shall proceed to give an account of other expedients suggested or adopted by a more recent naturalist, the author of the *Ornithotrophie Artificielle*; more especially as we do not know that they have ever been alluded to in any English work.

This author employed a circular oven of earthen-ware as a model of his great plan, heated by a cylinder of boiling water passing through its centre and resting on a fire-place below. This model, which proved sufficient for practice, is 28 inches high, by 24 in diameter; and an inch thick in the sides. The top is arched; and some inches below the commencement of the arch are four holes opposite to each other, two inches in diameter, for ventilators; because in all these experiments ventilation must be strictly attended to; as also other four near the bottom, of one inch in diameter, two of which penetrate the sides of the oven horizontally, and two obliquely. All have cork stoppers. There is a door half way up the side of the oven, six or seven inches square, which may be opened to admit the hand for internal operations, with a hole and a cork stopper of an inch diameter in the middle. This oven, which, it will be observed, is of a cylindrical form, is closely luted to an earthen-ware table, two feet and a half square, and two inches thick, with a hole in the centre for receiving the column or cylinder of hot water. Below the table, and between its feet, there is a small stove, also of earthen ware, about ten inches deep and seven in diameter, which, besides a door on hinges like that of a common stove, six inches by five, has other two openings. One of these is in the centre of the top, three inches in diameter, to admit the base of the metal cylinder for water; the other is in that side opposite the door, nearly three inches in diameter, and three inches lower than the former. Its use is to carry off the smoke from a grate of live coal whereon this stove is to be placed. But one of the most essential parts, the one indeed where the chief merit of the contrivance lies, consists in the means of heating the oven by a hollow tin cylinder, three inches in diameter, let down into the hole at the top of the arch above, and resting on the stove below, which is situated on the grate. By the boiling of water contained in it, the requisite heat is obtained; and its degree is regulated by the ventilators. The cylinder must be closely luted to all the three apertures through which it passes, that is, the top and bottom of the oven, and the top of the stove; but it is necessary that about two inches should intervene between the top of the stove and the table or bottom of the oven. A moveable lid of block tin, with a hole of an inch diameter in the centre, covers the top of the cylinder, which projects a little above the oven. In practice, it is found more convenient to increase the cylinder to the diameter of four inches, and some enlargement of the stove is also advantageous. The eggs may be deposited on cards or small shelves, three or four inches broad, ranged around the interior, and separated by intervals of three or four inches high, so as to contain above 300.

Should the reader understand the preceding description, he will easily comprehend the mode of enlargement of all the parts, when real service and operations on an extensive scale are required. A circular brick building, arched above, seven feet eight inches high to the spring of the arch within, seven feet of internal diameter, and 8 inches thick in the wall, is to be erected. Ventilators, as before, are in the sides; and the door is four feet high, glazed in the upper part. Ten successive tiers of shelves, a foot broad, project from the whole internal circumference, leaving an interval of seven inches between them; and as 44 or 45 eggs occupy a foot square, these shelves will contain 8000. The cylinder of water must be a foot in diameter, projecting above the building, and entering a stove below, over a furnace which is now to be sunk in the ground. It is necessary to keep a thermometer constantly immersed in it; and a hygrometer is also required to ascertain the humidity of the interior of the edifice, which is to be lined all over with lambskins, and covered externally by woollen stuffs. Moveable skylights in the roof admit fresh air into the building. The advantage of using hot water is, the equal and uniform diffusion of temperature throughout the oven, which, at the edges of the shelves, should be 106°, and will be indicated by the thermometers deposited there.

After selecting the eggs, they are to be laid on a thin bed of very dry rubbed straw, and turned three or four times daily. The ventilators are to be opened twice a-day. On the sixth day it will be seen on inspection what eggs should be removed as unproductive, and this examination ought to be repeated on the fifteenth. Towards the nineteenth day it is proper to stretch mattings over the edges of the shelves, to guard the young brood, which will appear on the twentieth or twenty-first, from falling over. The period of exclusion is sometimes accelerated or retarded; the operator should continue removing the shells, and aiding the weaker chickens to free themselves; but the remaining eggs are to be withdrawn as unproductive only on the twenty-third day.

With regard to the actual practice which the inventor of these methods followed, it appears that in two experiments on 50 eggs each, when the model was used, the first had but indifferent success, from the heat having been kept too low: but, in the second, chickens were obtained from the whole impregnated eggs, except three or four. Eight broods were attempted in the

Hatching, Havannah.

large oven, each quantity of eggs consisting at a medium of from 2000 to 3000, and the experiments were made at different seasons. At an average the product did not exceed one in six, while in trying natural incubation at the same time about two-thirds of the eggs were hatched. The dryness of the internal air proved injurious, and chickens of larger size were procured, by obtaining an artificial humidity from the evaporation of water in vessels.

It is generally understood, that chickens hatched in this way are not equal in strength and size to those procured by the regular process of nature; many are maimed, and it is said that monstrosities are frequent.

When the young brood has escaped, the heat of the oven may be reduced to 95° or 90°, and they may be fed, though they can subsist a day or two without meat. They may then be consigned in great numbers to the care of capons, trained on purpose. But as capons are very rare in this country, and as on the continent it was found more convenient to prosecute the process without the intervention of other animals, *artificial mothers* have been contrived. These are of different kinds, but one of the best is a low cage, of two or more stages, stuffed within, and lined with feathers: or there is another equally useful, consisting merely of two opposite shelves, near the ground, stuck over with feathers below, under which the animals may creep at pleasure. See Reaumur *Art de faire eclore et d'Elever en toute saison des Oiseaux Domestiques;* and *Ornithotrophie Artificielle ou art de faire eclore et d'Elever la Volaille par le moyen d'un chaleur Artificielle.* (c)

HAVANNAH is the principal town in the island of Cuba. It is situated on the north coast of the island, about 45 leagues from Cape Sable, and 80 coastwise from St Antonio, in a fertile and agreeable tract. It is built in a semicircular shape, the shore forming the chord, and is nearly two miles in circuit. The town is, upon the whole, regularly built, but the squares are irregular, and the streets narrow; some of the principal ones being paved with iron-wood, which is very durable. Near the middle of the town is a spacious square enclosed by uniform buildings. The houses are disfigured with heavy balconies and wooden railings, and are by no means elegant. The town contains 11 handsome and richly ornamented churches, two hospitals, and other public buildings. The Recollects church has 12 beautiful chapels, and in the monastery are cells for 50 fathers. The church of St Clara has seven altars, adorned with plate; and the nunnery contains 100 women and servants. The church of the Augustines has 13 altars, and that of St Juan de Dios 9. The arsenal is a very superb edifice. The harbour, which is about a league in breadth, is capable of containing all the navies of Europe; and it is so safe that they could lie without cable or anchor. There is generally a depth of six fathoms of water in the bay. This harbour is strongly fortified, both by nature and art. The entrance to it is through a very narrow channel, about 1200 yards long, and confined by rocks. The entrance is guarded by platforms and various works, mounted with artillery. The mouth of the channel is also defended by two strong forts. The fort on the east side, situated on a rock, is called the Morro. It is of a triangular form, and is fortified with bastions and 40 pieces of cannon. The other fort on the west side, and adjoining to the town, is of a square form, and is called the Punta. The other forts are El Fuerte, a square fort, mounting 22 pieces of cannon, the battery of the 12 apostles, and the shepherd's battery mounting 14 guns. As the town can only be attacked on the landside, it is strongly defended in that quarter; but the forts are commanded by several eminences, of which an enemy would readily take advantage. The Punta, the El Fuerte, and in a great measure the Morro, are commanded by the Cavannas, on a part of which the Morro is built. The north side of the eminence on which the church of the suburb called Guadaloupe is built, flanks the Punta gate, while its south-east side commands the dock-yard. It is said that the works cover such a vast extent, that 15,000 men, who are the most that could be employed, are not sufficient to invest them. There are no fewer than 800 cannon mounted on all the works. An enemy's squadron can only anchor at the foot of the castle of St John D'Ulua. This celebrated fort contains no other water but that of the cisterns, which have lately undergone a great improvement, having been subject to split, from the discharge of artillery. The town was taken by the Buccaneers, under Captain Morgan, in 1669, and on the 13th August 1762 by the English, under Lord Albemarle and Sir George Pocock. The Morro was in this case taken by storm. It was, however, restored to Spain, at the peace of Paris in 1763.

The Havannah is the most important of the Spanish settlements in America, and is considered as the key of the West Indies. All the ships that came from the Spanish settlements, and formerly the galleons and flota, assembled at the Havannah.

There are large dock-yards at the Havannah for building ships of war. The masts, the iron work, and the cordage, are brought from Europe. The other materials are obtained in abundance in the island.

The trade of the Havannah consists in skins, tobacco, wood, sugar, dry confections, and generally of all the productions of the island of Cuba. Humboldt gives the following statement of the trade of the Havannah: Exportation in native produce eight millions of piastres, of which 31,600,000 kilogrammes (69,678,000 lb. avoirdupois), or 6,320,000 piastres in sugar (valuing the chest of sugar at 40 piastres), 525,000 kilogrammes (1,157,625 lb. avoirdupois), or 720,000 piastres in wax (the arroba at 18 piastres), 625,000 kilogrammes (1,378,125 lb. avoirdupois), or 250,000 piastres in coffee (the arroba at five piastres). The exportation of sugar, which was next to nothing before 1760, amounted in 1792 to 14,600,000 kilogrammes, in 1796 to 24,000,000 of kilogrammes, and from 1799 to 1803, at an average, to 33,200,000 kilogrammes annually. In 1802 the harvest of sugar was so abundant, that the exportation rose to 40,880,000, kilogrammes (90,040,400 lb. avoirdupois); so that this branch of trade has been almost tripled in ten years. The customs of the Havannah amounted, between 1799 and 1803, at an average, to 2,047,000 piastres annually; and in 1802 they exceeded 2,400,000 piastres. The total amount of the trade is 20,000,000 piastres.

On the 19th January 1796, the city of the Havannah was honoured with the remains of the illustrious navigator Columbus. In consequence of an order contained in his will, his body was removed from the Carthusian convent of Seville, and deposited along with the chains with which he had been loaded at Cuba, on the right of the high altar of the cathedral of St Domingo. When this island was ceded to the French, his descendants directed that the brass coffin, in which the whole was contained, should be removed to the Havannah, which was done on the 19th January 1796. The coffin was carried down to the harbour in procession, and under the fire of the forts, was put on board a brig, which conveyed them to the Havannah, where it was deposited without any monument. The city is supplied with water by the small river Lageda, which has its origin in the hills on the south-west side of the town. One of the three streams into which it divides itself runs into the sea to the east of the town, while the other two flow through the city. The population of the Havannah has been recently stated at 25,000; but Morse informs us, that an intelligent traveller has lately estimated it at 70,000. There are no fewer than 3000 cabriolets in the town. The position of the house of Don Antonio Robredo at the Havannah, according to the newly published observations of M. Ferber, is West Longitude 82° 5′ 47″, and North Latitude 23° 8′ 16″. See our article Cuba, vol. viii. p. 479—481.

HAVERFORDWEST, called *Hwlffordit*, is a town of South Wales, and the capital of the county of Pembroke. It is situated on the side of a very steep hill on the banks of the river Daugleddy or Cliddy, which forms a bay for packets and vessels, and which is crossed by a good stone bridge. In the upper part of the town there are some good houses; but from the irregularity of the avenues, from the narrowness of the greater part of the streets, and from the confused manner in which the houses are piled one above another on the steep declivity of the hill, it has a very singular and unpromising appearance to a stranger. The principal public establishments are three churches, St Mary's, St Martin's, and St Thomas's, a custom-house, a free school, a charity school, an alms-house, and a good quay, at which vessels of large burden can unload. The castle, when seen from the bridge, has a stately appearance; but since the sessions have been held here, it has been greatly disfigured by part of it being converted into a county gaol. The walls are of great thickness. It was strongly fortified with towers, and is said to have been built by Gilbert Earl of Clare.

At a short distance to the south of the town, is a priory of black canons, endowed by Robert de Haverford, lord of this place. The walk to it from the town is pleasant, and the ruins have a venerable aspect. The chapel is the best preserved part.

The market here is one of the largest and most abundant in Wales, and fish are to be had in the greatest plenty and variety. There is likewise a very large corn market, and there is a great fair for horses and cattle on the 7th of July on St Thomas's day, who is the tutelary saint of the upper town. Near this town there is a cotton mill, which gives employment to about 150 persons. It is the principal manufacture in the county. A considerable number of independent gentry reside at Haverford. The town is a county of itself, and it sends one member to parliament, who is elected by freeholders and burgesses, and inhabitants not receiving alms to the amount of 500. The inhabitants draw their chief support from travellers who go from Milford Haven to Waterford, Wexford, Cork, &c.

The following is the population abstract for the town in 1811.

Number of inhabited houses	630
Number of families	691
Do. employed in agriculture	32
Do. employed in trade and manufactures	290
Males	1257
Females	1836
Population in 1811	3093
Increase since 1801	213

See Malkin's *Scenery, Antiquities*, and *Biography of South Wales*, vol. ii. chap. 26. p. 293.

HAVRE de Grace is a seaport town of France, in the department of the Lower Seine. It is situated at the mouth of the river Seine, in a marshy soil, intersected with creeks and ditches. It is defended by lofty walls, and ditches furnished with sluices, and has a citadel with bastions, which is one of the most regular in the kingdom. It contains two churches, an hospital, poors-house, arsenal, magazines, and storehouses, for the construction and manning of ships. There are no fewer than forty streets, adorned with six fine fountains. Four of these streets terminate in the great square. The harbour, which has a long pier connected with it, is capable of containing from 600 to 700 vessels. It has a depth of water sufficient to hold ships of war of 60 guns. There is here a fine dock-yard, several rope-works, and manufactories for tobacco, lace, starch, vitriol, earthen ware, paper, tiles, and bricks. The tobacco manufactory was established by the French East India Company, and at one time there were 60 tables furnished with a wheel, and attended by seven persons. Each of these made 90 pounds of tobacco in a day, and, including Caudebec, Harfleur, and Fecamp, the annual value of this manufacture was 170,000 francs. It has, however, greatly declined, but still employs about 400 workmen. The rope-works were lately eight in number. There is here also a refinery of sugar, and another of oil, both for burning and painting.

In time of peace, Havre carries on a great trade with the United States of America and the West Indies, and takes a great share in the herring and whale fisheries. About 600 vessels used to return loaded with the merchandise of other countries; viz. 60 from Martinique, 18 from Newfoundland, 40 from Marseilles, 65 from the coast of France from Bayonne to St Malo, 10 from St Maurice, 15 from Lisbon, 20 from Holland, 260 from England, and more than 60 from other countries of the north.

Havre was founded in 1509 by Louis XII.; and, after the battle of Marignon, Francis I. built a large tower to defend the harbour, and gave it the name of Franciscopolis. The walls of the harbour were scarcely begun, when an irruption of the sea destroyed about two-thirds of the town, and almost all the inhabitants, on the 15th January 1525. Twenty-eight fishing-boats were carried into the ditches of the castle of Graville. Population 19,500. East Long. 0° 6′ 38″; North Lat. 49° 29′ 14″.

HAWARDEN, commonly called Harraden, or Hording, is a town of North Wales in Flintshire. It is a thriving place, and is situated on a small river running into Chester New Channel. The streets are well paved, and the houses well built. The church is a plain good building, and is remarkable only for having an annual revenue of about £3000. Between the town and the river Dee, the remains of the castle of Peny Llwch stands upon an eminence. It was a place of great strength, and is supposed to have been built before the Norman conquest. It was demolished by order of the Parliament in 1680. By the exertions of the Glynne family, the form of the castle has been rendered visible, by the removal of great quantities of rubbish. It seems to have been of a pentagonal shape, with a strong square entrance gateway. The keep, or citadel, consisting of a circular tower, nearly entire, was placed at an angle. The deep ditches now form picturesque ravines filled with fine trees. On a mount, called Freeman's Hill, to the west of the church, are traces of an encampment; and at the distance of about two miles from the town, are the remains of Culo castle, a double fortress, with a square area and two round towers. They stand on the edge of a deep wooded dingle, and are covered with ivy. In the neighbourhood of the town, particularly near Buckden hill, there is a manufactory of earthen ware. There is also a large iron foundery, from which articles of cast and wrought iron are sent to Chester, and thence to different parts of the kingdom. Hawarden Park, the seat of the Glynne family, is near the town. The house, built in 1752, is a handsome structure.

The population of the town and parish, in 1811, was—

Number of inhabited houses . . .	832
Number of families	901
Ditto employed in agriculture . . .	398
Ditto in trade and manufactures . .	427
Total population in 1811	4436

See Pennant's *Tour in Wales*, vol. ii. p. 88. 92; and *The Beauties of England and Wales*, vol. xvii. p. 672—683.

HAWICK, is a town of Scotland, in the county of Roxburgh, situated at the confluence of the rivers Tiviot and Slitrig, on the west road between London and Edinburgh. It is distant from Edinburgh 47 miles, from Carlisle 44, and from Berwick 42. The river Tiviot runs close by the town, and the Slitrig runs through it, dividing it into two nearly equal parts, which are connected together by two stone bridges, one of which bears evident marks of antiquity. In August 1767, the Slitrig suddenly rose to a great height, occasioned by a cloud bursting at its source, and in its course swept away fifteen dwelling-houses and a corn-mill. Hawick is a burgh of barony of very ancient origin. It is independent of the superior, and enjoys almost all the privileges of a royal burgh, except that of sending a representative to parliament. The date of its original erection into a burgh of barony is not known, the records of the burgh having been destroyed, and the town itself repeatedly burnt, during the Border wars between the English and the Scots; the last instance of which occurred in the reign of Queen Elizabeth, in the year 1570, and is recorded by Stowe, in his *Chronicles of England*, who says—"The seaventeenth of April, the Earle of Sussex, lieutenant-generall in the North, with the Lord Hunsdon, lord governor of Barwike, and warden of the east marches, and Master William Drewry, high marshal of Barwike, with all the garrison and power of the same, began a journey into Scotland, and the same night came to Warke, twelve miles from Barwike, and so the next morrow entered into Tividale; and, marching in warlike order, they brẽt, (burnt) overthrew, rased, and spoyled all the castels, towers, and villages of their enimies, till they came to the castell of Mosse, standing in a strõg marish belõging to the L. of Buckcluch, which likewise was rased, overthrowne, and brent, and so marched forward, and brent the whole countrey before them till they came to Crailing." After mentioning a great many other places which they burnt, Stowe proceeds thus—"The nineteenth, the armie divided into two partes, the one parte whereof passed the river of Tivite, and brent the castell of Ferniherst, and all other castells and townes belonging to the Lord of Ferniherst, Huntill, and Bedrell, and so passed to Mint, where both the armyes mette agayne, and so brent on bothe sides the river, till they came to a *greate towne called Hawike*, where they intended to have lodged; but the Scottes had unthatched the houses, and brent the thatch in the streetes, and themselves fledde with most parte of theyr goodes; but, by the industrie of the Englishmen, the timber was also burned with the thatch, saving oné little house of stone of Drumlanricke's, wherein my lord lay that nighte."

Drumlanricke's little house of stone is supposed to be that which is now the Tower Inn, belonging to his Grace the Duke of Buccleuch, which has long been celebrated for the excellent accommodation afforded to travellers. The walls of the oldest part of this building are, in some places, no less than seven feet thick It has been lately very considerably enlarged, and is now one of the most commodious inns in the south of Scotland. The oldest charter of the town now extant, is a charter of confirmation granted by James Douglas of Drumlanrick, then baron of the barony of Hawick, in 1537, which declares the town to have been from of old a free burgh of baronie, and proceeds on the narrative, that "the charters and evidents of the said town and burgh, through the inroads of the English and thieves in the by past times of enmity and war, had been lost and destroyed;" and this charter imposes on the grantees thereof the singular burden "of maintaining one lamp or pot of burning oil before the great altar of the parish church of Hawick, in time of high mass, and evening prayers, on all holidays throughout the year, in honour of our blessed Lord and Saviour Jesus Christ, for the souls of the barons of Hawick, founders of the said lamp, and their successors." This charter was confirmed by a royal charter, granted by Queen Mary in 1545. The church is beautifully situated on a circular eminence in the middle of the town, and the church-yard commands a fine prospect of the surrounding country. The town is well paved and lighted, and has a plentiful supply of excellent spring water, which is conveyed to the town in leaden pipes. It has a respectable town-house, in which the burgh and justice of peace courts are held. A new line of road is just now making to the town from the west, which will form a fine approach, and already a very handsome new street is begun to be built along the sides of it. At the west end of the town there is an artificial mound of earth, of a conical form, of considerable height, called the *Mote*, which, according to tradition, was formerly used for holding courts of justice. The mail coach from London to Edinburgh, by Carlisle, passes through the town every day, and it is at present (1816) in contemplation to establish a mail coach between this place and Berwick. The town is governed by two bailies, who, with the advice of the town council, have the sole management of the revenues and affairs of the burgh. The bailies are chosen annually, by a poll of the resident burgesses. The town council is composed of 15 standing councillors, so called from their continuing in office during life, who are elected by the bailies and standing council; and of 14 trades councillors, or quarter-masters, who are chosen annually, two by each of the seven incorporated trades of the burgh. Its revenue, which consists chiefly of the rents of a large common belonging to the burgh, is about £400 per annum. The poor of the town and parish are supported by a rate, one-third whereof is paid by the proprietors within the burgh, and two-thirds by the heritors and tenants of the landward part of the parish. Besides the established church, there are three places of religious worship in the town, viz. the Burgher, Antiburgher, and Relief meeting houses. There is an excellent public library in the town, which was begun in 1760. There was also lately established a subscription library, by the tradesmen of the place, and there are besides two or three circulating libraries. A branch of the British Linen Company Bank has been long established here, and a savings bank was instituted in January 1815, in which there was deposited, during the first year, £870, by 183 different individuals. In 1776, a farming club was instituted in Hawick for the discussion of questions connected with agriculture. It is composed of most of the respectable farmers, and several of the landed proprietors of the district. This club holds its meetings regularly on the first Thursday of every month. It is believed it was the first association of the kind established in Scotland, and it has the merit of having originated many very important improvements connected with agriculture. There is here a weekly market on the Thursday, and four annual fairs, which fall on the 17th May, 17th July, 21st September, and 8th November, besides a cattle tryst at which considerable numbers of black cattle are presented for sale in passing from Falkirk tryst to Newcastle and Carlisle fairs. In 1811, the population of the town amounted to 3036, and the town contained 349 inhabited houses. Since that time no census has been taken, but the population and number of houses during the last five years has very considerably increased; and at present in 1816, (including the population of Damside in the adjoining parish of Wilton, which may be reckoned the suburbs of the town,) it is estimated to exceed 4000. There are in the town three skinneries, one tannery, and two breweries; and a very considerable trade is carried on in the manufacture of carpets, lambs wool stockings, Scots blankets, thongs, and gloves. The manufacture of lambs wool stockings, in particular, from the introduction of machinery, has of late years made very rapid progress, and is still on the increase; it was first begun in 1771. In 1791, there were manufactured only 3505 pairs of lambs wool stockings, and 594 pairs of cotton, thread, and worsted hose. The number of persons then employed in the trade was 14 men, and 51 women who were chiefly employed in spinning the yarn. The yarn, however, is now all spun by machinery. There are at present employed for this purpose 7 carding mills, which all go by water, containing 44 engines, or scribbling and carding machines, 100 spinning jennies, and upwards of 500 stocking frames. The greatest part of the spinning jennies are at present wrought by the hand; but jennies of a new construction, to go by water, have, within the last twelve months, been introduced with success into four of the carding mills. The quantity of wool annually spun into yarn is upwards of 12,000 stones of 24 lbs. to the stone, three fifths of which are manufactured into stockings, and the other two fifths sold in yarn to manufacturers in other parts of the country for the purpose of being made into stockings. The quantity of stockings annually made by the manufacturers in the town exceeds 328,000 pairs. The number of persons in the town and neighbourhood employed in the different branches of this manufacture is about 1000. This place has been long celebrated for its extensive nurseries, carried on by Archibald Dickson & Sons here, and at Hassendeanburn in the vicinity, where they were first begun in the year 1729. The nursery grounds in the occupation of these gentlemen now extend to upwards of 100 acres, cropped with all sorts of foreign and native forest and fruit trees, flowering shrubs, and evergreens, &c. These nursery grounds are very ornamental to the place, extending along the side of the turnpike road to the east and west of the town, for the distance of upwards of a mile and a half. In the cropping and cleaning season, they afford employment for not fewer than 90 men, women, and children; but at other seasons men only are employed in them. A very extensive business in the seed line is also carried on by A. Dickson & Sons. The position of Hawick, as estimated from Captain Colby's observations on Wisphill, is North Lat. 55° 26′, and West Long. 2° 47′.

HAWK. See HAWKING and ORNITHOLOGY.

HAWKES' TEMPERAMENTS of the musical scale. In the years 1798, and 1805, Mr William Hawkes published two pamphlets for recommending the adoption of an irregular douzeave scale, wherein 9 of the Vth, viz. upon C, G, D, A, E, B, ♯F; and upon F and ♭B should each be flattened $\frac{1}{5}$th of a major comma, or be of the value $355.7984272\,\Sigma + 7\,f + 31\,m$; two of the Vths, viz. on ♯C and ♭E perfect, or each $=358\Sigma+7f+31m$; and consequently, the resulting or wolf Vth, on ♯G, $=365.8141552\,\Sigma+7\,f+30m$. Many particulars concerning the notes and temperaments of which system, may be seen in the *Philosophical Magazine*, vol. xxvi. p. 173; xxviii. p. 304; xxx. p. 5; xxxvi. p. 47; and vol. xxxvii. p. 129, in which last page the *beats* of each of its 68 tempered concords are calculated, by Mr John Barraud, brother to the chronometer maker.

In 1807, Mr Hawkes contrived, and in 1808 took out a patent for his methods of extending the scale of organs and piano-fortes to 17 notes in the octave, (see the *Phil. Mag.* vol. xxxvii. p. 325); and in 1810, he published a third musical pamphlet, in which his object (as afterwards explained by letter to Mr Farey, see *Phil. Mag.* vol. xxxvii. p. 321.) was to recommend for the tuning of this his patent instrument, a regular dixseptave system, in which 16 of the fifths, viz. on C, G, D, A, E, B; ♯F, ♯C, ♯G, and ♯D; and on F, ♭B, ♭E, ♭A, ♭D, and ♭G, should be each flattened the 1-318th part of the octave, (or $\frac{1}{6}$th of Mercator's comma), or each of the value $356.068514\Sigma+7f+31m$, and the resulting or wolf fifth ♯A to F, is of course $=367.246346\,\Sigma+7f+30m$. The *beats* of each of the 102 concords in this system, have been calculated by the Rev. C. J. Smyth of Norwich, and published in the *Phil. Mag.* vol. xxxvii. p. 323, to which table we shall refer instead of copying it; because from Mr Liston's *Essay on Perfect Intonation*, p. 23. and 142. it appears, that Mr Hawkes has since (by letter to Mr Liston we have been informed) changed his former opinion, and now recommends the Vths for his patent instruments, to be flattened $\frac{1}{6}$ of a major comma, in which terms Mr Liston has given its temperaments in p. 22. It may be proper, however, to add, that, in this new system, each of the 16 fifths above mentioned, will be $=356.165356\Sigma+7f+31m$, and the wolf fifth on ♯A $=366.181084\Sigma+7f+30m$.

Mr Hawkes' patent piano-fortes are furnished with 24 strings in each octave, although 17 only are of different sounds, that is, all the long keys have two unison strings, from one to the other of which the hammers shift, at the same time that they do so from the 5 short-key notes tuned *flats*, to the five others tuned *sharps*, or *vice versa*; it seems, however to us, that 7 of these strings might probably be dispensed with, by allowing rather more space on each side the long-key strings A, B, C, D, E, F, and G, and making their hammers rather wider, so that after the shifting sidewise of the key-board necessary to cause the short-key hammers to move from ♯A, ♯C, ♯D, ♯F, and ♯G, to ♭B, ♭D, ♭E, ♭G, and ♭A respectively, or *vice versa*, the hammers of the long-keys may still continue to strike the same strings.

The objections which were so forcibly urged in Dr Kemp's *Musical Magazine* against the defect of these instruments, in not being able to give *flat* and *sharp* notes at the same time, or quickly succeeding each other, as composers not unfrequently direct, seem to operate fatally against their introduction to general use. We have lately heard, that the organ which Mr Hawkes caused to be put up, a few years ago, in Christ

Hawking and Haydn.

Church, Blackfriars Road, in Surrey, has been either removed or altered to a common organ. We are aware, however, that this may have arisen from injudicious attempts at tuning this organ, according to one or other of the systems that we have mentioned in this article, instead of applying the MEAN TONE *System*, which alone, or one exceedingly near to it, (in the perfection of its major third), seems applicable to this noble instrument. (ε)

HAWKING, or FALCONRY, is the art of catching wild fowls by means of hawks, or other birds of prey, tamed, and properly tutored for that purpose.

The art of falconry appears to have been known both to the Greeks and Romans. It was in high repute in almost every part of Europe during the 12th century, but after the invention of fire arms, it gradually declined.

Mr Pennant has not been able to find any accounts of the art of falconry in England before the year 760, in the reign of King Ethelbert, who sent to Germany for a brace of falcons that would fly at cranes. The art was much practised till the Usurpation, when it fell into disuse.

The birds which are generally trained to this art, are the jer-falcon, the peregrine, and the goshawk. By starving them, and keeping them awake, and never leaving them alone, they are rendered quite tame; and, by a regular system of severe instruction, they become so familiarized to the falconer, that they obey all his commands. They are taught to settle on his fist, to spring at game, and to bring back the prey to the falconer. For an account and other particulars of the history of falconry, see Beckmann's *History of Inventions*, vol. i.; and Shaw's *General Zoology*, vol. vii. part i. See also ORNITHOLOGY.

HAYMAKING. See AGRICULTURE, vol. i. chap. ix. sect. ii.

HAYDN, JOSEPH, the most celebrated composer of music among the moderns, was the son of a wheel-wright, and born in 1732 at Rohrau in Austria, 36 miles from Vienna towards the Hungarian frontier. His father, though ignorant of the principles of music, which are much more generally disseminated among the lower ranks of Germany than in Britain, played a little on the harp, which was accompanied by the voices of himself and his wife. Joseph having been conducted, at a very early age, by a relation to Haimbourg, was instructed in the elementary parts of education; and a chapel-master of Vienna, having accidentally heard his voice, took him, when only eight years old, to replace one of the boys in his choir. Here he remained apparently exposed to severe discipline; and as his voice was constantly improving, the chapel-master became anxious to preserve it. He explained the means of doing so to Haydn, now a youth of about fifteen, who thought of nothing but music; and having gained his ready assent, the day and hour were fixed. But the accidental arrival of his father in Vienna, prevented their purpose from being effected. His voice soon broke, and Reuter, the chapel-master, ashamed of the reproaches which he had incurred, and exasperated at the disappointment, found a pretence for discharging him from the choir on a winter's night, which, from absolute poverty, he was obliged to pass in the street. Next morning being observed by Spangler, a poor but friendly musician, he obtained a lodging from him in a hay-loft, adjacent to a single apartment which his own family occupied, and also a share of their frugal subsistence.

Here Haydn followed the bent of his early propensities, in practising on a wretched spinette; but it is said, that after some time had elapsed, a lady of rank, who had seen one of his compositions, desired to know the author. Haydn's extreme poverty hardly enabled him to obtain sufficient clothing to appear before her; and she had some difficulty in believing that he was the individual for whom she sought. He was compelled to account for his necessities, by relating, in as delicate terms as possible, his adventure with Reuter; and, in testimony of her esteem, she presented him with the works of Matheson, Bach, and other celebrated composers. According to some writers, his patroness was a niece of Metastasio the dramatic author, the real owner of the hay-loft; and they add, that he continued to instruct her in music and singing during three years.

Haydn now earned a scanty subsistence by the exercise of his talents. He was organist to an ecclesiastical establishment, with a salary of £12 yearly. He had occasional employment elsewhere in the same capacity, and he sung, and played on the violin. At about the age of 18, he composed a quartett for Baron Furnberg, and afterwards some trios, which were surreptitiously printed. In the year 1759, his patroness obtained for him the appointment of music master to Count Marzin, with an annual salary of £25; and here he composed the first of those symphonies which have gained him so much celebrity. There appears to be some ambiguity respecting the chronology of Haydn's compositions. His *Opera Prima* consists of six quartetts, wherein all the rudiments of his fine genius are sufficiently developed; but it is reported, that the first time his name appears is to trios and harpsichord sonatas, in a German catalogue of 1763.

In the year 1760, Haydn was appointed sub-chapel master to a German potentate, the prince of Esterhazy, who was himself a skilful musician; and on the death of Werner, who was the principal, and from whose disposition and abilities he derived much advantage, he was promoted to fill his place. In this new situation, he had an ample opportunity, and sufficient encouragement, to pursue his talent for composition in its utmost latitude. Works of various descriptions flowed from his pen in rapid succession; and the particular taste of his patron led to the composition of those which no preceding musician had attempted. He overstepped all the limits which had fettered others; and, in adopting a new and peculiar, though unaffected style, he taught the public the variety of which music is susceptible. Yet this was not accomplished without exciting the jealousy of his cotemporaries. It has been affirmed, that he silenced his adversaries by publishing compositions wherein their own style was introduced, to betray its inferiority. In order to gratify the prince, he composed music with uncommon distributions of the parts or the performers; such as the *Echo*, which consists of a double trio for two violins and a violoncello, each set of performers being in a different chamber, but within their mutual view. Profiting by this singularity of taste, he composed another piece, called the *Adieu*, on occasion either of a quarrel in the orchestra, which induced all the band to give in their resignation, or, what is less probable, because the prince treated some of Haydn's warmest exertions with marked neglect. This was a symphony ingeniously devised, so that one instrument should regularly close after another; and as the music gradually terminated, each performer saw written before him, "Put out your candle, and go about your business." All obeyed in succession, and a solitary instrument finished the whole.

Haydn's time was principally occupied in musical composition; he generally dwelt with the prince of Esterhazy, at Eisenstadt in Hungary, and accompanied him during two or three months of the year, which were spent at Vienna. Here he became acquainted with the Chevalier Christopher Gluck, an eminent composer for the opera, Mozart and others. The former advised him to travel in France and Italy, from which he predicted the greatest advantage in dramatic compositions; but the moderate finances of Haydn seem to have deterred him from following his counsel. His fame, however, had extended far beyond the sphere of his residence; and he was employed to compose an instrumental oratorio on the seven last sentences of our Saviour, for some religious ceremony, in a cathedral at Cadiz, which was hung with black, while a single lamp glimmered over the audience. Twelve years later, Haydn, without changing any of the instrumental parts, had words adapted to it. Many of his compositions are quite unknown in Britain, particularly a multitude of pieces for the bariton, a kind of small violoncello, with five strings above the bridge, and others behind the hand, to be touched by the thumb, played on by the Prince of Esterhazy, and to which the inhabitants of this country are strangers.

By the advice of Baron Van Swieten, Haydn visited London; and his residence there may be regarded as one of the most fortunate periods of his life. His great and steady patron the prince of Esterhazy had died in the same year, 1790; and while he left him his usual salary, he also dispensed with his discharging the duties of the situation. He seems indeed to have held him in great estimation; for when Haydn's house at Eisenstadt was burned down during his absence at Vienna, the prince directed another to be built, having exactly the same size, appearance, and accommodation.

In London Haydn experienced the most gratifying reception; he remained there eighteen months, and returned to the continent in the year 1794. He now began to be treated with those honourable distinctions due to his transcendant genius. He was created Doctor of music by the University of Oxford, and other literary and musical associations soon followed the example. At this time a concert on a liberal and expensive plan was established by Salomon, the late leader of the opera, where all the first performers were engaged; and each performance was announced to commence with an overture, expressly composed for it by Haydn. Twelve symphonies, which stand unrivalled, were thus produced; and, as is well known, these were afterwards ingeniously reduced to quintetts by Salomon. Some of them, or the whole, have since been adapted as trios for the piano-forte, violin, and violoncello. Haydn also composed and published several other works while in London; several of which are dedicated to the amateurs of this island: and a still more essential result was, the universal diffusion of a taste for his music.

During his absence from Germany, a tablet, or obelisk, had been erected in honour of him at Rohrau, the place of his nativity, by Count Harrach; and on returning to the continent, he composed the oratorio of the *Creation*, in 1795, which is esteemed among the finest and most elaborate of his works. But his other compositions of the same kind, the *Seasons*, *Stabat Mater*, *The Last Words of Christ*, and *The Return of Tobit*, have not been all equally successful; partly, it is supposed, from the want of coincidence between the music and the words. The last, however, which was written in 1775, is performed annually at Berlin, for the benefit of the widows of musicians.

While Haydn approached that period of life when the faculties usually decline, he was loaded with honours, and his vigorous invention continued to be unimpaired. He received honorary degrees from the academies of Stockholm and Amsterdam in 1798 and 1801; and in the following year, on a vacancy occurring in the National Institute of France, he was elected a member, at which time our countryman Mr Sheridan was one of the candidates. He was also chosen a member of the Phil-Harmonic Societies of Laybach and St Petersburgh, and of the Children of Apollo at Paris, in 1805, 1807, 1808. Nay, the last struck a medal, bearing his portrait, and invited him to the capital, with an offer of a sufficient sum to defray his expences. But this was not all; for Prince Kurakin, the Austrian ambassador at Vienna, presented him with a letter from the Phil-Harmonic Society of Petersburgh, full of gratitude and admiration of his works, and accompanied by a large gold medal, weighing above half a pound, struck in honour of him, and bearing his portrait, with the most flattering legend. He is also said to be the hero of a Spanish Poem on music.

But Haydn was now little more than sensible of the distinctions he received. He bent under the weight of years, and ceased entirely to compose about 1803. It was not without regret, however, that he witnessed his own decay. He feelingly deplores it in a vocal quartett, beginning, "My strength is enfeebled, death awaits at my gate." Indeed he was so much weakened, that it became necessary to construct a piano for him, remarkably light and easy in the touch. We have even heard those who knew him well declare, that he relapsed into a second childhood.

Haydn dwelt constantly at Vienna, and confined himself to his house and garden after the year 1806. The seventy-third anniversary of his birth had been celebrated by a concert in one of the theatres, conducted by the son of Mozart; and, in 1808, a great musical association of that city resolved to close the performances of the season with the *Creation*. Haydn, though withdrawn from the world, consented to be present. He was received by the Princess Esterhazy, and others of distinguished rank, in the hall of performance, and carried, amidst the sound of trumpets and loud acclamations, to a particular part of the gallery which was appropriated for him. He was overwhelmed by this mark of approbation; and upon retiring, which he did very early, signified that he felt it was for ever. This great composer expired on the 31st May 1808.

Haydn's personal appearance betrayed no indications of genius. His stature was large, and his features coarse. But he was mild and complacent in manners; modest and unassuming, and universally beloved in private life. He was never tainted by jealousy, and, unlike those who proclaim their own merits by undervaluing the works of others, he was always ready to approve where approbation was due. Handel's chorusses he thought sublime, though his music might be defective in melody. He entertained the highest opinion of Mozart, declaring his death a public calamity: and when invited to be present along with him at the coronation of the Emperor Leopold at Prague, he observed, "Where Mozart is present, Haydn ought not to appear." Haydn indeed was too reserved. That innate modesty, and his moderate finances perhaps, prevented him from attaining some distinguished situation in his own country, which his talents merited. The Emperor Joseph is justly reproached with neglecting to place the first musician at the head of his orchestra; but probably it is there, as it is in many other countries, that men of real genius are superseded by those who have none. He enjoyed a competency in his later years, but his total fortune did not exceed £250 at the period of his first visit to Britain. He was married many years, but not happily: and he had long been separated from his wife. Two brothers, Michael and John, survived him. The former, who had considerable merit as a composer, died master of the band to the court of Salzbourg; the latter died in the service of the Prince of Esterhazy.

Haydn's compositions exist in the most astonishing variety. They are calculated to amount to 842, including those of every description: and the following is said to be an abstract of a catalogue furnished by himself in the year 1805. Symphonies, 118; various pieces for the baritons, 163; instrumental pieces of from five to nine parts, 20; marches, 3; trios for two violins and a bass, 21, and 3 for two flutes and a violoncello; 6 solos for violin with tenor accompaniments; 3 concertos for violin and violoncello: 1 for the double bass; 2 for horns; 2 for the trumpet; 1 for the flute; 1 for the organ; and 3 for the harpsichord; 66 sonatas for the piano forte, and 83 quartetts. Another unfinished quartett was found at his death, to which some portion that was wanting has been supplied; and it was performed at a grand concert in commemoration of him at Berlin in October 1809. This assembly was opened by an eloquent eulogium on his merits. He also produced 34 compositions of church-music; 5 oratorios; 19 or 20 operas; 13 airs in three or four parts; 42 simple songs and duetts; 40 canons. Besides these, he wrote preludes and basses for 365 Scotch airs; and composed above 400 minuets, dances, and waltzes. At his death there were found 46 unpublished canons, framed to ornament his apartment; not being rich enough, he said, to purchase pictures, he had himself made tapestry to cover the walls.

Amidst such an infinity of works, the whole of which have probably never been heard by any one individual, it is difficult to determine where the preference is due. But the fertility of imagination is conspicuous throughout, and Haydn's compositions are ever new. Perhaps he has been less successful in the vocal than the instrumental departments. None has ever equalled his distribution of music in the orchestra, or called forth the single and combined powers of instruments in an equal degree. Here he has excelled all his predecessors, his cotemporaries, and successors; and those pieces which he has written for a full band stand unrivalled, whether we attend to the unity of design, the relation of parts, or that sudden burst of grandeur which amazes the auditor. Next to the symphonies, Haydn's quartetts seem to be most admired; they are written with apparent simplicity, but almost all of them present considerable embarrassment, unless to skilful performers. This composer is one of the few who presents perpetual novelty, who never imitates himself, and who adapts intimately and exactly the music to those instruments for which it is designed. None of his music is tedious or languid, unlike some modern compositions, whose authors, ignorant that they are producing nothing more than preludes or voluntaries, suppose they have taken up an inexhaustible theme. His minuets and trios are perhaps devised with more ingenuity, and more calculated to please than any that have appeared, and he is particularly successful in variations on an air, and in modulations. Yet it is vain to affirm that equality pervades his works; and it will not appear surprising if inferiority be sometimes discovered in such a multitude. We should remark, as a very extraordinary fact, that the lapse of years had no effect in diminishing the quality of his compositions. The first quartett of the first opera, and his last which he wrote, are excellent, though there be some difference in their style. Haydn ventured far, and was successful; many have endeavoured to follow the same course with doubtful approbation. Perhaps had Mozart not been prematurely cut off, he might have approached to him in excellence; but as yet Haydn is entitled to be designed the first of modern masters. (c)

HAYLING, Isle of. See Hampshire.

HEAD. See Anatomy, vol. i. p. 776.

HEALTH. See Aliments and Longevity.

HEARING. See Anatomy, vol. i. p. 787.

HEART. See Anatomy, vol. i. p. 807. and vol. ii. p. 28; and Physiology.

HEADLEY, the Rev. Henry, an English poet and critic, whose highly promising talents were unfortunately lost to the world at the early age of 23, was the son of a clergyman in Norfolk, and was born at Irstead in that county in 1766. He was educated at the grammar school of Norwich under Dr Parr, and was admitted a commoner, and elected a scholar of Trinity College, Oxford. At the university, the living example of Thomas Warton, then the Senior Fellow of Trinity College, seems to have communicated to Headley an enthusiasm for the elder school of English poetry. While combining this pursuit with his classical studies, he published his Poems and other Pieces in the year 1786; and, in the following year, at the age of 22, he published Select Beauties of Ancient English Poets, with Remarks. In his poems, though marked by elegance and sensibility, there was no promise of transcendant genius; but his Remarks on the elder Poets, displayed an extent of reading, a comprehensiveness of views, and a perspicuity of taste, which were justly regarded with wonder in so young a writer. He cannot, indeed, be said to be wholly free from partiality and exaggeration, in estimating the elder writers, whose beauties he complains of being neglected; but still as a critic, he deserves to be remembered in English literature. Mrs Cooper, in her neat Biographies and Selections, led the way in preserving the memory of our early poets; Warton contributed immense industry in illustrating our literary history; Percy restored to us our ballad poetry; but in the selections and criticisms of Headley, there is a classical taste and condensation of materials, more elegant than what we meet with in any of his fellow labourers in the same pursuit. His critiques are like the portraits of a master, flattered indeed, but done with general truth and great animation. His life was too short to have many events. Some months after leaving Oxford, he married, and retired to Matlock in Derbyshire, in a spot where the wild scenery accorded with his romantic turn of mind. But the symptoms of a consumptive tendency, which had before appeared in his delicate frame and constitution, began now to make rapid advances; and being warned to try the benefit of a warmer climate, he had the resolution to take a voyage to Lisbon, unaccompanied by any one he knew. On landing at Lisbon, far from feeling any relief from the climate, he found himself oppressed by its heat. A few days would have probably terminated his life, when a Mr De Visme, to whom he had received a letter of introduction from the late Mr Windham, invited him to his healthful villa, near Cintra, allotted spacious apartments for his use, procured for him an able physician, amused him with his elegant books, and gave him every chance of benefiting from the change of climate. But his malady was incurable; and having returned to Norwich in the month of August, he expired there, in Nov. 1788, in the 23d year of his age. (s)

HEAT.

Heat.

Introductory observations.

Heat is a term which was originally employed to express the effects produced by a peculiar condition of bodies, when they communicated the sensation of warmth. It was also perceived that hot bodies, or those that had the power of communicating warmth, possessed other properties, such as that of expanding the substances to which the warmth was imparted, of converting certain solids into liquids, and certain liquids into the state of vapour, and many other operations of great importance in the system of nature. Philosophers soon began to speculate upon the cause of these phenomena, and, with a degree of inaccuracy, to which we are liable in the infancy of our scientific pursuits, they employed the same word to signify both the *cause*, and the *effect* produced. It was commonly said, that *heat* occasioned the warmth and expansion of bodies, and likewise that *heat* was excited in bodies by the addition of some peculiar kind of matter, or by a certain modification of their particles. The more precise nomenclature of the moderns has tended to correct this error, and has led to the invention of a new term, *caloric*, to designate the *cause*, while the word *heat* is, strictly speaking, only applicable to the *effect*. As, however, in all the older authors the former phraseology necessarily exists, as it is still adopted in popular language, and as there is no danger of falling into any error, since the distinction has been so fully pointed out, the word *heat* is frequently employed in its double sense, even by the latest and most correct writers, and it will be used in this way in the following article.

Term *heat* employed both for *cause* and *effect*.

How employed in this article.

Importance of the subject.

We have already given some account of the nature and effects of caloric under the head of Chemistry; but it is an agent of such extensive importance in the operations of nature,—it produces such powerful effects both upon organized and unorganized matter,—it is so intimately connected with the existence of life, both animal and vegetable,—and is so essential to all the processes by which we act upon the bodies around us, when we convert them to our support or utility,—that it well deserves to be farther discussed, and made the subject of a separate article. The importance of the object has produced a consequent share of attention to it from the modern experimentalists; and there is perhaps no one topic on which more curious, and, we may add, more unexpected results have been obtained, than have ensued from the researches into caloric. The names of Black, Crawford, Rumford, Pictet, Gay-Lussac, Prevost, Dalton, and Leslie, among many others which will be afterwards referred to, must suggest the recollection of the many ingenious and elaborate trains of experiments, that have occupied the attention of philosophers, during the last 50 years. It will be to an account of what has been done in this period that we shall principally confine ourselves in the following pages; for the experiments and hypotheses that were published before this time, are rather to be regarded as curious historical records of opinions, than as affording much that is important in the actual advancement of knowledge.

Plan of the article.

We shall arrange our observations on heat under four heads: 1*st*, The properties of heat; 2*d*, The effects of heat; 3*d*, The sources of heat; and, 4*th*, The nature of heat. In the course of the article, we shall take an opportunity of tracing the gradual developement of the leading opinions that have successively prevailed on these topics, as well as the most important experiments by which they have been supported.

Properties of Heat.

SECT. I.

On the Properties of Heat.

It might, at first view, appear more regular to begin by investigating the nature of heat, before we described its properties and effects; but it is so difficult to ascertain its nature, and the knowledge which we possess, or rather the conjectures which we form concerning it, are so entirely derived from the observations that we are able to make of its properties and effects, that the order of treating the subject which we have adopted, will be found, we apprehend, the most convenient. For the present, we may consider heat, or caloric, to be a principle or power existing in bodies, which gives rise to many of their most important actions, and modifies their effects upon other substances.

Arrangement of the properties of heat.

The *properties* of caloric are of three kinds: Those that are strictly mechanical, or such as may be conceived analogous to the laws of gravitation or impulse; chemical, or those that tend directly to effect a chemical change in bodies; and a third class, which may be regarded as specific, and which do not bear an exact resemblance to either of the two former.

1. Mechanical properties.

Radiation.

Among the mechanical properties of caloric are its radiation, reflection, and refraction, which bear a very near resemblance to the same affections of light. Some obscure intimation of the radiation of heat may be met with in the authors of the latter part of the 17th and beginning of the 18th centuries, but the subject was not much attended to until the time of Scheele. This distinguished philosopher, in his investigation of the nature of fire, performed some new and decisive experiments, which completely established the existence of this property, and shewed how it differed from the power which hot bodies possess of communicating warmth by contact. He found, that when glass is interposed between the face and a quantity of burning fuel, although the light passes through without interruption, the heat, at least for a certain space of time, is entirely stopped. Heat, he observed, radiates through air, without communicating any warmth to it, and its passage does not appear to be interrupted by any currents in the atmosphere. He found, that a transparent mirror, which concentrates the rays of light, does not produce any increase of temperature in the focus, until it has absorbed a sufficient portion of heat, but it then becomes a radiating body, and emits heat in certain directions. The conclusion which may be deduced from Scheele's experiments is, that caloric is sent off in rays from all hot bodies, and moves through the air with great velocity, but that in this transmission, it does not necessarily communicate warmth to it, and is not diverted from the straight course by any currents or motion of the air itself: (*On Fire*, p. 70, *et seq.*) His experiments also tended considerably to elucidate another point respecting heat, which had been the subject of much controversy, whether it was not identical with light, or only differing from it in consequence of some slight modification of its properties. Heat and light are so frequently observed in connection with each other, emanating from the same sources, and produced, as it would appear, by the same agents, that the opi-

Scheele's experiment on radiant heat.

On the separation of heat and light.

roperties of Heat.

nion of their identity was generally adopted, at the commencement of the last century. Some distinguished experimentalists had indeed embraced the contrary doctrine, and some facts were brought forwards in its support. Instances perpetually occurred, of high degrees of heat being produced, which were not accompanied by light; and, on the other hand, it was found, that there were some luminous bodies which were not hot, and especially, that the moon's rays might be concentrated by a lens, or mirror, so as to produce a very brilliant light, yet that no sensation of heat was excited. These, however, and some other analogous facts, were not deemed sufficiently conclusive to establish the point. Some authors regarded heat and light as the same substance in different states; while those, who did not admit their materiality, conceived that they depended upon the same affection of matter, but differing in its degree or intensity. Scheele's experiments seemed to prove, that heat and light, when closely united together, as in the rays of the sun, or of a burning body, may be completely separated, so that the specific effects of each may be obtained distinct from the other. We have already referred to his observation of the manner in which a sheet of glass permits the light to pass through it, while it intercepts the transmission of the heat; and he also found, that if rays composed both of heat and light, as they were sent off in combustion, be received upon a glass mirror, the heat is absorbed, while the light alone is reflected.

lerschel's xperiments,

The distinct nature of light and heat is rendered still more probable, by some late experiments of Dr Herschel's, in which he separated them from the state of combination in which they exist in the sun's rays. He was led to observe, that the differently coloured rays possess different powers of producing heat; the least refrangible rays, those which excite the sensation of red, possess the greatest heating power; and the power diminishes, until we arrive at the violet, or most refrangible rays, which excite the least heat, the intermediate colours possessing an intermediate power in this respect. But he not only discovered that the rays of heat and of light were thus very differently affected by the prism; he farther found, that the effect upon the thermometer was most considerable in a point beyond the red-making rays, entirely out of the limits of the spectrum, and, of course, in a spot on which no part of the luminous ray was received. Beyond this point, where the temperature was at its maximum, the heat gradually diminished, until it was no longer perceptible: (*Phil. Trans.* 1806, p. 286. *et seq.*) From these experiments, the results of which were verified by Sir H. Englefield, who employed an apparatus of rather a different kind, we learn, not only that heat is emitted in rays from the sun, but that solar heat may be obtained separate from light; and although, like light, it is possessed of the power of being refracted, yet it possesses this power in a different degree. In Sir H. Englefield's experiments, where the blue rays raised the thermometer to 56°, the green to 58°, the yellow to 62°, and the red to 72°, the space beyond the prismatic spectrum elevated it to 79°, and it sunk to 72° when returned into the red rays: (*Journ. of Royal Inst.* i. p. 203.) Similar results were obtained by M. Berard; but he observed, that the maximum of heat was at the very extremity of the red rays, when the bulb of the thermometer was completely covered with them; and that beyond the red extremity, where Herschel found the heat to be a maximum, it was only 1-5th above that of the ambient air. See APPENDIX to this article.

Englefield's experiments.

Berard's experiments.

The radiation of heat was exhibited in a still more decisive manner by Pictet, who seems to have undertaken his experiments on the subject at the suggestion of Saussure. This distinguished naturalist was led to form some speculations concerning caloric, from certain atmospherical phenomena which he noticed, during his travels among the Alps, where he conceived that the communication of heat could not be accomplished by the contact of the heated body. He refers to an experiment of Mariotte's, which was published in the Memoirs of the Academy of Sciences for the year 1682, in which he states, that "the warmth of a fire reflected by a burning mirror is sensible at its focus." Lambert also informs us, in his *Pyrometrie*, that he placed a burning body in the focus of a concave mirror, and that he was able, by means of it, to inflame another body, placed in the focus of an opposite mirror, at the distance of above 20 feet. In this experiment, Lambert distinctly marks the difference between what he calls "luminous heat" and "obscure heat," and attributes the effect to the latter principle, *i. e.* to heat properly so called, in opposition to light.

Properties of Heat.

Experiments of Pictet and Saussure.

Reflection of heat by metallic mirrors.

Saussure repeated the experiment in conjunction with Pictet; and, in order to prevent the interference of the action of light, they employed a ball of iron, heated to a degree short of what would render it luminous in the dark. They used tin mirrors, that were placed more than 12 feet from each other: and, when the iron ball was put into one focus, they suspended a thermometer in the other, and observed the instrument to be very perceptibly affected, more than another thermometer, equally near the ball, but out of the focus. The former was raised from 4° to 14½° of Reaumur; the latter from 4° to 6½° only: (*Voyages dans les Alpes*, § 926.) The result of this experiment is easily explicable, upon the supposition that heat, whatever be its nature, radiates in straight lines; that it impinges against solids that are opposed to its course; and that, according to circumstances, it either raises the temperature of this body, by being united to it, or is reflected from its surface. The heated ball, in this case, emitted rays of heat in every direction: those that were contiguous to the mirror fell upon it; but, owing to its polished surface, were reflected in straight lines to the other mirror, and were again reflected from this, according to the laws of mechanical impulse, into the focus in which the thermometer was suspended. This thermometer received the effect, both of the rays that were sent off by the iron ball, on the side contiguous to it, and of those which were on the contrary side of the ball, next to the mirror; whereas the thermometer not in the focus, only received heat from the side of the ball opposed to it. Pictet's apparatus is shewn in Plate CCLXXXVIII. Fig. 9. See Description of Plates.

Remarks upon the experiments.

Farther experiments of Pictet.

M. Pictet still further prosecuted these experiments, and varied them in different ways, so as to repel the objections that might be urged against the conclusions which he derived from them. In order to separate the light from the heat, and to shew the distinct operations of each, he placed a lighted candle in one of the foci, and noticed its effects upon a thermometer placed in the other focus. He then interposed a plate of glass between the candle and the thermometer; and he found, as he had expected, that although the light passed as before, a considerable portion of the heat was intercepted in its passage from one mirror to the other; in this way confirming the results that had been formerly obtained by Scheele. But, in order to remove more effectually all suspicion that the effect in this case depended upon the rays of light, he placed a small flask of boiling water in the focus, from which we may

Properties of Heat.

be confident that no light could be emitted: and this he found to radiate heat, and to raise the thermometer very perceptibly. The experiments of Pictet may therefore be considered as completely establishing the point, that heat is sent off in right lines from bodies, where light cannot be supposed to be present. He also rendered the radiating power of caloric still more obvious, by shewing, that when rays of heat impinge against a body, if it have a polished surface, they are reflected from it; but, if the surface be such as not to admit of reflection, they enter into it, and raise its temperature. In pursuance of this idea, he found, that when the bulb of the thermometer which he employed was blackened, it rose more rapidly, or absorbed more heat, than when its surface was clean and bright; thus proving, that the heat from boiling water was, in this respect, similar to the heat in the sun's rays, or that emitted during combustion: (*Essay on Fire*, § 51, *et seq.*) We have already referred to the experiments of Dr Herschel, in which he analysed the sun's rays, and separated the part which produces heat, from that which excites the sensation of colour. These experiments proved, in a very decisive manner, the radiating power of the calorific part of the solar beam; and he afterwards made experiments of a similar kind, upon different species of heat, extricated from bodies on the surface of the earth, such as burning fuel and red hot iron. *Phil. Trans.* 1800, p. 316.

Rumford's experiments on radiation.

An interesting train of experiments, on the manner in which heat radiates, or escapes from the surfaces of bodies, was performed by Rumford, in which he shewed, with his usual address and dexterity, the different effects which are produced by a difference in the nature of the radiating surface: (*Phil. Trans.* 1804, p. 89 *et seq.*) By a singular coincidence, nearly about the same time that this essay was published in the *Phil. Trans.* a still more complete view of the subject was taken by Professor Leslie. They both supported their peculiar opinions by a number of well contrived and well executed experiments, which led to many curious and unexpected results, and which have, in some measure, altered our previous notions respecting the nature of heat, or at least respecting some of its most remarkable properties. It had been before known, that the nature of the surface of a body materially affects its power of admitting caloric to enter into it; and this power was now extended to the emission or radiation of heat.

There is so much similarity between the experiments of Rumford and Leslie, that it will not be necessary to refer to both of them, considering the narrow limits to which we are confined in this article; and as those of the at ter are generally the most decisive, and, for the most ar t, performed with the most accurate instruments, we shall principally employ them in our examination of the subject.

Leslie's experiments on radiation.

Professor Leslie's researches illustrate, in a striking manner, the effect of the peculiar nature of the surfaces of bodies, both upon the emission and reception of radiant heat, bodies of equal temperatures discharging and absorbing it in very different degrees. When a body sends off rays of heat, we may conceive that it parts with a portion of caloric that was previously united to it; and that when it receives the rays of heat, a quantity of caloric becomes combined with it, which was before in a free state. These two operations, although the reverse of each other, seem to exist in the same proportion, and in all respects to bear an exact ratio to each other.

Differential thermometer.

Professor Leslie employed in his experiments a species of air thermometer of a new construction, which, besides possessing the advantage of being an instrument of great delicacy, and being sensible to very minute variations of heat, has also the useful property of indicating, at all times, any variation that occurs in the temperature of the portion of air in which it is immersed, and of adapting, as it were, its own scale to this new temperature, so that the apparent effect is the same, whatever be the actual temperature at which the experiment is performed. It was from this property that he gave to his instrument the name of *differential thermometer*, as not indicating the actual degree of heat, but only the degree in which it differs from that of the atmosphere. (It is shewn in Plate CXLI. Fig. 1.) Rumford employed an instrument very similar in its nature, which he called a *thermoscope*.

Experiments with mirrors and a canister of water.

In ascertaining the quantity of heat emitted from the surfaces of bodies, Professor Leslie generally examined the rays after they had been reflected by concave mirrors. Those which he used were composed of polished block tin; and by means of a mould, upon which they were formed, they were made to constitute portions of the parabolic curve. The substance from which the heat was emitted was boiling water, contained in a cubical canister of block tin. This was provided with a thermometer to ascertain its temperature; and the apparatus being placed in the focus of an elliptical tin reflector, the effect was noticed upon the differential thermometer, situated in the opposite focus. The canister had four sides of equal dimensions; and these being prepared in different ways, either polished, or left rough, varnished, or covered with paper, or some other substance, afforded an opportunity of accurately examining and comparing the effect of different kinds of surfaces on the radiation of heat: (*Inquiry*, p. 17.) The apparatus is shewn in Plate CCLXXXIX. Fig. 11. Professor Leslie begins by ascertaining what was the effect of the canister of boiling water, when simply placed in the focus of the reflector, in what length of time the maximum of heat was produced, and how long the process of cooling occupied. He likewise observed the effect produced on the thermometer, by employing water of different temperatures, and also by the degree in which the temperature of the water exceeds that of the temperature of the air of the chamber in which the apparatus is situated. The vessel that contained the water was a cube of 6 inches; and when it was at the boiling heat, and was placed at the distance of about 3 feet from the mirror, the rise of the differential thermometer was equivalent to what would have been 14.5° of Fahrenheit's scale. He also found that the greater was the excess of the heat of the water above the temperature of the room, exactly in the same proportion was its action on the thermometer.

Experiments on the radiating power of different surfaces.

Hitherto the vessel had been employed with its uncovered side turned towards the reflector; and he next proceeded to contrast with this the effect of the other three sides of the canister, one of which had a plate of glass cemented to it, another had writing paper pasted on it, and the fourth was covered with a varnish of lamp black. The effect produced by these different surfaces was very singular, and was, to the experimentalist himself, very unexpected. The uncovered side, which had the usual polish of a metallic surface, produced an effect upon the thermometer equal to 12°, the side to which the glass had been applied to 90°, that covered with paper to 98°, while the varnished side was equal to 100°. From these experiments we arrive at the important conclusion, that heat radiates from a polished metallic surface with not quite $\frac{1}{8}$th part of the energy that it does from a surface that is covered with some substance, which takes away the effect of the polish. *Inquiry*, p. 18.

An experiment, which may be regarded as the re-

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verse of the above, was afterwards tried. Here the thermometer was made to receive heat from the canister, its bulb being first left in its usual state, and afterwards covered with tin-foil carefully applied, so as to admit of a degree of polish. It was then found, that the coated thermometer, analogous to the polished side of the canister, received only about ⅕th as much heat as when the instrument was without the metallic covering. The power of surfaces in absorbing heat, seems therefore to be intimately connected with that of radiating it, materially influenced by the nature of the surface, much less when consisting of polished metal, and greatly augmented when covered with paper, varnish, or any other not-metallic substance. These experiments seemed to indicate, that the power of radiating and of absorbing heat was in an inverse ratio to that by which heat is reflected from surfaces; and this point was afterwards made the subject of direct experiment by Professor Leslie. He had already found, that the polished surface of the canister was a bad radiator, and that the coated thermometer, in consequence of its polish, was equally unfitted for absorbing heat. The next object was to examine, whether these surfaces, which were the least fitted to radiate and absorb it, were not as much superior in their reflecting, as they were defective in their radiating power. The tin reflector was removed, and in its place was substituted one of glass, while the canister of boiling water, and the differential thermometer, were placed as before in the respective foci. In order to produce the greatest action upon the mirror, the varnished side of the vessel was opposed to it; but the effect produced by reflection in this case was not considerable. No important alteration was produced, by removing the metallic coating from the back part of the mirror, or by roughening it with emery; but when the anterior surface of the glass was covered with Indian ink, no heat was sent off from it. On the contrary, when the front of the mirror was coated with tin-foil, the thermometer rose ten times as much as it did from the effect of the naked glass. These experiments, when compared with each other, lead to the following conclusions: That when the rays of heat strike against polished glass, a large portion of them is absorbed, and tends to raise the temperature of the glass itself; but when they impinge against polished metal, few of them enter the metal, and nearly the whole are reflected. *Inquiry*, p. 21.

Professor Leslie having now fully established the connection between the radiating and the absorbing power of different kinds of surfaces, afterwards proceeded to vary the effects in different ways, and to compare them with each other under different modifications. We have mentioned above, that the polished side of the canister, when opposed to the mirror, produced in the differential thermometer a certain rise, which we have called equal to 12, that of the varnished surface being estimated, as a standard of comparison, at 100. When the tin was rubbed with a small quantity of mercury, an effect was produced equal to 14, and when completely coated with it equal to 20. As the brilliancy in this case appears not to have been less than from the pure tin, we must conclude that there is either a different radiating power attached to different metals, independently of their mechanical properties, or that an amalgam of tin and mercury was formed of a soft consistence. It was afterwards found, that when a metal loses its brilliancy by oxidation, the radiating power is increased in the same proportion: a fresh surface of lead raised the thermometer only ¼th as much as the lead when covered with a layer of minium. This effect of oxidation might perhaps have been predicted from the preceding experiments; but the alteration caused by simply scratching or roughening the metal, seems more remarkable. If the perfectly smooth surface produced on the thermometer an effect equal to 12, by rubbing it with a file or with sand, so as quite to destroy its polish, an elevation took place equal to 26, or rather more than twice as much as the former. It was afterwards found, that when the tin canister was coated with an animal substance, such as jelly, if it was spread upon it only to the thickness of a fine film, it raised the thermometer to 38; but when laid on so as to form a thick coating, the effect was about twice as great, or near 80. The effect in this case, was not found, however, to bear an exact ratio to the thickness of the coating; nor was a difference in the thickness of the coating observed to have any effect, except when an animal substance was used, or something of a similar nature, for metallic coatings seemed to act merely from their surface. Some experiments were made upon the effect of colour, in modifying the radiating power of surfaces; but the results are not sufficiently uniform, to prove any thing very decisive on this point. Although the most considerable effects were produced by lamp-black, yet, as has been mentioned above, writing paper was found to be nearly as powerful. We have already had occasion, more than once, to refer to the relation which exists between the radiating and the reflecting power of bodies, a fact which, although contrary to what might have been expected upon a transient view of the subject, is yet established by numerous and decisive experiments. Thus scratching the surface of the mirror, diminishes its reflecting power as remarkably as its augments its radiation; and also a layer of animal matter spread over the face of the canister, diminished its reflecting power to about 1-3d, as was determined by the thermometer. *Inquiry*, p. 76. *et seq.*

Experiments with screens of different kinds.

Professor Leslie was afterwards led to confirm, and very much extend the views which Scheele originally suggested respecting the power of certain substances to retain the caloric which falls upon them by radiation, when they are such as not to send it off again by reflection. In this case, the body receiving the heat, experiences an elevation of temperature, until after some time it becomes itself a source or centre of heat, which emits it to other bodies. It was in this way that heat was separated from light, as we have already related, the light passing without interruption through a plate of glass, by which the transmission of heat is, for a certain time at least, entirely obstructed. When the heat is emitted or radiates from its new source, its progress is then found to be varied from that which it originally possessed, and to be entirely directed by the condition of the surface from which it last escapes. This property of heat was illustrated by a series of experiments, in which screens of different kinds were interposed between the mirror and the canister, to which we have so often referred: (*Inquiry*, p. 26, and 17.) A sheet of tin was found entirely to intercept the heat, and a plate of glass a considerable portion of it; but what constitutes a curious difference between the effect of heat and light is, that the quantity of heat intercepted varies greatly, according to the vicinity of the glass to the radiating body; more heat being transmitted when the glass is near the canister, than when it is more distant from it. But, perhaps, some of the most curious of all Professor Leslie's experiments were those in which he employed two screens of tin, one side of each of which was covered with the black varnish, the other being left uncovered. When these tin plates were laid toge-

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ther, with both their painted sides in contact, and of course the bright sides both external, little heat passed through them, because the side nearest the canister was not adapted to receive caloric, nor the other to radiate the little which might have been received; but when the varnished sides were placed externally, the quantity of heat that passed through them was considerable, because here the varnish enabled the one plate to absorb, and the other to radiate caloric with facility. When only one plate was used, intermediate effects were produced. Several circumstances that were noticed by Professor Leslie, led him to conclude that the rays of heat, like those of light, where they proceed from a near object, are sent off in lines that have a sensible divergence. The radiation of heat seemed to be entirely suspended, by having the heated body immersed in water; and it appears probable that it cannot exist in any medium except air. *Inquiry*, p. 92.

Rumford's experiments referred to.

We have already alluded to the experiments of Count Rumford, which were published almost immediately after those of Professor Leslie, and which so generally agree with them, that although they are both numerous and ingenious, it will not be necessary to give any minute description of them. Like Professor Leslie, Count Rumford found, that polished metal radiates heat in a much less degree than a metallic surface, at the same temperature, but covered with paint or varnish; that a covering of linen, flannel, paper, or in short of any animal or vegetable substance, tends to promote the emission of heat; and he farther found, that the radiation and absorption of heat bore a direct ratio to each other, and likewise an inverse ratio to the power of reflection. In one particular indeed, the Count's experiments had a different result from Professor Leslie's; this latter experimentalist compared the radiating effect of various metals, and conceived that they differed from each other in this respect, while Rumford could not perceive any difference between them; upon the whole, however, we are disposed to regard Professor Leslie's results as the most correct. Count Rumford, according to his usual custom, deduces some important practical conclusions from his experiments, which are the more valuable, because some of them are precisely contrary to the previous ideas that were entertained upon the subject. In putting heated bodies into vessels or tubes, our object is sometimes to retain the heat as long as possible; but in others, on the contrary, we are desirous that the heat should be quickly dispersed through the contiguous air. If we wish to confine the heat, we must employ metal, and have its surface highly polished, a fact fully proved by the above experiments, but directly contrary to the conclusion that might seem to follow from the superior conducting power of a metallic body. On the other hand, if the object be to cool the vessels with their contents, or to transfer their heat to the surrounding medium, we must cover them with paint or varnish, or with some kind of soft coating, not of a metallic nature. As an example of the two cases, we shall mention that of tubes conveying steam, which may, in the one instance, be for the purpose of transporting heat from one vessel to another, and where, of course, it is an object that none should be lost in the passage; here we must use bright metallic tubes, which will radiate as little as possible. But if, on the contrary, we introduce steam tubes for the purpose of warming an apartment, here we wish to promote the radiation as much as possible, and we should therefore use the tubes unpolished, and varnished, painted, or even rusted. In the same way bright metallic vessels should be employed, when we wish to preserve the heat in fluids, where they are used for the purposes of cooking or manufactures, while the opposite plan is to be followed, when the object is to promote their cooling. (*Phil. Trans.* 1804, p. 177, *et seq.*) On the cooling of bodies we shall have occasion to speak more at large, in a subsequent part of the article.

Practical deductions.

Radiation of cold.

We must now advert to a train of phenomena, connected with the radiating power of bodies, although perhaps depending upon a different principle, and leading to some new ideas respecting the nature of heat, the radiation of cold. By the radiation of cold we mean simply to express the fact, that when a cold body is placed in the focus of a concave mirror, a thermometer will fall that is suspended in the focus of an opposite mirror. This singular circumstance was first noticed by the members of the Florentine Academy, and was very distinctly described by them, although they were so much surprised at the effect, as almost to doubt the accuracy of their own experiment. (*Saggi di nat. Esper.* p. 176.) They do not seem to have made any attempt to explain it; no farther notice was taken of it at the time, and it appears to have been almost forgotten, when Pictet, in the course of his experiments, to which we have referred above, after having ascertained the radiation of heat and its reflection by his apparatus, placed a vessel filled with ice in one of the foci, and observed the thermometer in the other focus instantly to sink several degrees; when the ice was removed, the thermometer rose again to its former elevation. By adding nitric acid to the snow, and thus producing a more intense cold, he found that the effect on the thermometer was augmented. *Essay on Fire*, § 69. See our article Cold.

Experiments of Florentine Academy.

Of Pictet.

Of Leslie.

The apparent radiation of cold has been since confirmed by Professor Leslie, and what may, at first view, appear still more remarkable, it seems to be acted upon by bodies in the same manner with radiant heat. It is promoted and retarded by the same kind of surfaces which promote and retard the radiation of caloric, and also in the same proportion. The canister, which had been employed in the former experiments, was now filled with ice or snow, and its different sides in turn exposed to the mirror, the differential thermometer being, as before, suspended in the opposite focus. The cold produced by the varnished side was the greatest, while that from the uncovered side was the least, the glass and the paper being intermediate between the two, exactly in the same manner, as when the vessel had been filled with boiling water. The results also were similar when the thermometer was covered with different substances, so as to affect its power of absorbing heat, and also when the surface of the mirror was changed, so as to change its power of producing reflection. For example, when the thermometer was coated with a leaf of metal it fell less, and when coated with varnish, more than in its ordinary state. And with respect to the mirror, the reflection of cold was most considerable from the bright metallic surface, less when a mirror of glass was employed, and still less when it was varnished. Here the power of the mirror in radiating cold, was exactly in the inverse ratio of its reflecting power, just as is the case with the radiation of heat. Lastly the interposition of screens of different kinds, and with different surfaces, between the ice and the mirror, had effects which were precisely analogous to those mentioned above; so that under all circumstances, Professor Leslie found the strictest coincidence between the two kinds of radiation: (*Inquiry*, p. 23.) It may be proper to mention, that experiments of a similar nature, and with similar results, were performed on the radiation of cold by Count Rumford. They are such as sufficiently establish the facts, and might be esteemed valuable, were they not, for the most part, superseded by those of Professor Leslie. *Phil. Trans.* 1801, p. 170.

The general conclusions that may be deduced from the experiments of Pictet, Rumford, and Leslie, are, that bodies possess a power which generates cold, or reduces actual temperature; and that this power is emitted in right lines, and may be reflected, condensed, or intercepted in its passage from one body to another, like the rays of radiant heat. It also follows the same laws with respect to the action of surfaces upon it, and bears the same relation to their reflecting property. Certainly the most obvious inference would be, that cold, like heat, depends upon the presence of a real material agent, capable of being transferred from one body to another, and subject to similar laws of radiation and reflection; but this supposition is so strongly opposed by many other considerations, which seem to prove, in the most decisive manner, that cold is merely a negative property, and signifies nothing more than the abstraction of heat, that we are compelled to look out for the explanation of the phenomena upon other principles: these we shall afterwards endeavour to elucidate.

We have very few remarks to make respecting the two other mechanical properties of heat, its reflexibility and its refrangibility. The reflection of heat has been abundantly proved by the numerous facts that we have stated, in which the concave mirrors were employed, as well as in all those where the nature of the surface absorbing the rays of heat affected this property; for it has been shewn, that in as much as the surfaces were unfavourable for absorption, they were, in the same proportion, favourable for the reflection of heat. The refraction of heat, as distinct from light, was clearly exhibited in Herschel's experiments; by its passage through the prism, it was diverted from its straight course like light, only in a greater degree, as the calorific rays are found to be dispersed over a larger space than the spectrum formed by the visible rays. The rays proceeding from a candle, or from burning fuel, were also found to be capable of refraction, like those of solar heat. We may conclude that the solar heat consists of rays of different degrees of refrangibility, although no other difference has been detected in their nature, as is the case with the differently coloured rays of light. This conclusion follows from the fact, that the space occupied by the rays after they have passed through the prism is greater than before they entered it. See Appendix to this article.

Before we conclude our account of what we have styled the mechanical properties of heat, we shall offer a very few remarks upon the velocity with which it moves. That the velocity must be very great, is a point of which there can be no reasonable doubt; yet it will be found very difficult to assign the actual velocity. It is perhaps the most probable conjecture, that heat, when radiating from a body, moves at the same rate with light; yet we know of no decisive arguments from which this can be inferred, as more than a conjecture. Pictet made some experiments upon this subject; but they only prove that no perceptible interval elapses in the passage of heat through about 70 feet, a space much too small to prove any thing important.

The second class of properties, which we announced as belonging to heat, are its chemical properties, or those that tend directly to produce a chemical change in bodies. We shall, however, postpone the consideration of these to a future part of the article, because we shall then be better prepared to determine, what properties ought to be regarded as chemical, after we have made ourselves acquainted with the effects of heat, as well as with the other properties that have not yet been considered, which we have styled *specific*. These we shall now proceed to examine.

The specific properties of heat may be classed under two heads: its tendency to diffuse itself equally among bodies, or its mode of communication from one body to another; and the peculiar manner in which it passes through bodies. Whatever be our opinion respecting the real nature of heat, it is almost impossible to enter into any investigation concerning it, without using language that would seem to imply, that it proceeds from the operation of a material cause. If, therefore, we fall into these forms of expression, it must be ascribed, not to our decidedly adopting this hypothesis of the nature of caloric, but to the extreme difficulty of avoiding them, although they must be admitted to be incorrect. With this preliminary caution, we may be allowed to say, that heat differs from other bodies, in its tendency to diffuse or distribute itself uniformly through all kinds of matter. When any substance possesses a different portion of free caloric from the substances in its vicinity, either in immediate contact, or connected with it by the intervention of a third substance, the superabundant portion of heat will have a tendency to pass from the first to the second, and the one will give and the other receive heat, until they arrive at a common temperature. This is one of the most familiar occurrences, and one of which we perpetually avail ourselves in the arts of life. If we wish to impart heat to a body, we bring it near a substance that is hotter than itself, when it immediately begins to receive heat, and continues to acquire it, as long as it remains in its new situation, or until it shall have experienced some change, which renders it incapable of the farther reception of heat. When, on the contrary, we wish to cool a body, we remove it into the neighbourhood of one which is cooler than itself, when an operation the reverse of the former will ensue; the cold body will abstract heat from the warmer, until the common temperature be gained.

The cause of this tendency in heat to fly off from bodies, or to pass from one to the other, and thus to diffuse itself among them, is attributed to its possessing an inherent repulsive power. The particles of all kinds of ponderable matter are necessarily attracted to each other, and consequently, under all circumstances, they have a tendency to be drawn and held together, unless some counteracting cause prevents their union. This is equally exemplified in the attraction which prevails between large masses of matter, by which the planets are kept in their orbits, called the attraction of gravitation, and the attraction which exists between the individual particles of matter, and influences many of the minute operations of nature, under the denomination of chemical attraction. The repulsive power, which appears to be an inherent quality of heat, may be regarded in general as the cause of its diffusion among bodies; but the manner in which it is distributed, or the particular law which it follows in passing off from one body, and attaching itself to others, seems to depend upon a different principle, or at least to be modified in a way that cannot be referred to repulsion. It has been conceived, that the phenomena might be explained upon the idea, that there is a combination of

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the two powers of repulsion and attraction, the heat escaping from a body, in consequence of the repulsive power that exists between its particles, while, at the same time, it is attracted by the particles of the body into which it enters. And perhaps this kind of double operation will serve to explain most of the facts, or at least will enable us to announce them in language which implies no contradiction, and gives an idea of their relation to each other. The equal distribution of heat, as it has been called by some writers, or the equilibrium of caloric, as it has been styled by others, constituting one of the specific properties which we enumerated above, has been the subject of much observation and experiment, and has also given rise to much hypothetical discussion.

Explanation of the equilibrium of heat.

The law by which bodies of different temperatures become the one hotter and the other colder, or by which the equilibrium of heat is produced, was first laid down by Newton, and may be thus expressed in general terms; that the heat lost by the one body, and gained by the other, is in proportion to the excess of the temperature of one above the other; or, stating it in a more scientific manner, that the difference between the temperatures diminishes in a geometrical ratio, while the times increase in an arithmetical ratio. The external circumstances which influence the rapidity of the equalizing process, are the radiating power of the bodies themselves, their conducting power, and, provided they are not in contact, the nature of the medium which is interposed between them, and the mechanical changes which take place in the medium, relative to its position with respect to the heating and cooling bodies, constituting currents. These principally operate in what are styled the elastic fluids; but they have also considerable effect in the action of liquids. The hypothesis which is commonly adopted, and which appears satisfactorily to account for this peculiar property of bodies, was proposed by M. Prevost. It is founded upon the following data. Heat is conceived to be a fluid, composed of distinct particles, which pass through space in right lines, and are projected in all directions, with very great velocity. The particles are so far removed from each other, that, analogous to what takes place with respect to light, a number of currents may flow in different directions, without interfering with each other. All bodies, except such as we suppose to be absolutely deprived of heat, send out rays to each other, although generally in very different degrees. Two bodies, exactly of the same temperature, will mutually give and receive heat, and even a cold body will radiate heat to a hot one; but, in the former case, the quantities given and received by each will be exactly the same, so that the temperature will not be changed; and, in the latter case, the one will give much more than the other, until the temperature of the two is equalized. *Phil. Trans.* 1802, p. 443.

Prevost's hypothesis.

Explains the radiation of cold.

This hypothesis appears to have been originally formed, in order to account for the experiment, of which we gave an account above, the radiation of cold. When a heated body parts with its caloric to the neighbouring bodies, and raises their temperature, the idea that presents itself, as the most natural explanation of the fact is, that the hotter body has merely given off its superabundant heat to the colder, in consequence of the tendency which heat has to distribute itself uniformly through all bodies subjected to its influence. It may be conceived in this case to pass off, in a greater or less degree, according to the excess of the temperature of the one body over the other, modified by the nature of the surface, and the other circumstances to which we have already alluded. But this simple view of the operation will not explain the radiation of cold, or at least will not explain the apparent reflection of it from a concave mirror. If the cold body acted only by attracting heat from the neighbouring bodies, it would take it from the thermometer, the mirror, and all other contiguous substances; and there seems to be no reason why the focus should be colder than any other part of the atmosphere, equally near the source whence the cold proceeds. According, however, to Prevost's notion, when ice is placed in one of the foci, it sends out radiant heat, which strikes against the mirror, and is reflected into the opposite focus; but these rays being comparatively colder than those which proceed from other bodies in the vicinity, have the effect of generating absolute cold in the second focus, and thus tend to depress the thermometer which is suspended there. A mutual exchange of heat thus takes place between the ice and the thermometer, and the equilibrium is established, by the ice acquiring, and the thermometer losing, each a portion of caloric. (*Journ. Phys.* t. xxxviii. p. 3.) The facility with which this hypothesis explains the radiation of cold, is itself an argument in favour of its validity; and it must be admitted, that it applies equally well to all the other phenomena in which caloric is concerned. An objection has indeed been urged against it, that it does not take into account the effect of the conducting power of bodies, which must have an important effect in the equalization of their temperature. This is not, however, properly an objection against the general doctrine of the reciprocal interchange of radiant heat, but an omission in Prevost's manner of applying it; and it seems that the two operations are not in any degree incompatible with each other. Still, however, M. Prevost's opinion must be regarded rather as a plausible conjecture, which has the merit of satisfactorily explaining the phenomena, than as a theory founded upon any direct experimental proofs. It has indeed been conceived, that Professor Leslie's researches afford considerable support to it, as they tend to establish the existence of a radiating energy in bodies, quite independent of their conducting power; an energy, by which even the worst conductors of heat, under certain circumstances, become the most active radiators of it. Yet this radiation can never be proved to exist, except there be a previous difference of temperature between the bodies; because the thermometer, which is our only measure of heat, and the only index which we possess of its presence, is never affected except by an unequal distribution of it.

Supported by Leslie's experiments.

Conducting powers of bodies.

Having now described the manner in which heat tends to pass from one body to another, we shall next proceed to the second of its specific properties, the power by which it moves among the particles of the same body; or is conducted, as it is styled, through their substance. As bodies appear under the three states of solids, fluids, and gases, we should consider the power which heat exercises in its transmission through each of these different forms of matter. Our remarks will, however, be chiefly confined to the action of solids and liquids upon heat; for in consequence of the tenuity of gases, or the distance at which their particles are situated from each other, it does not appear that any very notable effects can be attributed to them upon the passage of free caloric, at least in comparison with what we observe in the two other classes of bodies.

Passage of heat through solids.

When heat, in its uncombined state, radiates through air, or through a vacuum, it moves with a velocity which has not been accurately measured, but which, there is reason to suppose, is immensely great; so that, with respect to any distances near the earth, it may be said to be infinite. Heat also passes through the most dense and solid bodies, as, for example, through metals; but in this case its progress is prodigiously retarded. It is also found to move through these bodies with various degrees of velocity, which do not seem to bear an exact ratio to any other of their properties, and which can only be ascertained by direct experiment. This, in opposition to the rapid transmission of heat through the air, or through a vacuum, has been styled its slow communication; and the power which solids possess of enabling heat to pass along them, has been called their conducting power. When solids are in contact, and are possessed of different degrees of heat, they immediately tend to produce an equilibrium of temperature; which is not brought about, as in the former case, by radiation, but by the one directly abstracting a portion of heat from the other, conducting this portion through its own substance, and diffusing it equally among its particles. This faculty exists in bodies in very different degrees; but it is found that each individual body always preserves the same degree of this power, unless some change takes place in its chemical or physical condition, when a change is at the same time produced in its conducting power. A familiar but a correct example of the different degrees of this conducting power in bodies, may be noticed in the different effects that are produced upon metal and upon glass. If a rod of each of these substances have one of its ends plunged into hot water, the metallic rod will soon become so thoroughly heated, through all its extent, that it will be impossible to apply the hand to the other extremity, while the glass rod will remain a long time in the water, before the upper end is sensibly affected. Hence we say, that metals are good conductors of heat, and that glass is a worse conductor of heat than metals. As a general principle, it may be stated, that the densest bodies are the best conductors; but to this rule there are many exceptions. Upon the whole, however, the principle seems to hold good in so many instances, that we may infer the existence of a necessary connexion between the density and the conducting power of bodies, and that when the ratio is not correctly maintained, it should be attributed to the interference of some other principle. Thus it is remarked, that the same body, without having experienced any chemical, or any other physical change, except a difference in its state of aggregation, has its conducting power increased or diminished, in proportion to its density, or to the contiguity of its particles. Rumford found that a solid piece of iron is a better conductor than the filings of the same metal; and that wood is a better conductor than saw-dust.

Many experiments have been performed on the conducting power of solids, the object of which was to ascertain the amount of this power, and to learn whether it bore an exact ratio to any other physical or chemical property. Metals, as was remarked above, are some of the best conductors of heat, but they differ considerably among themselves in this respect. Ingenhousz instituted a simple, but ingenious process, for discovering their relative power, which consisted in providing himself with rods of different metals, all of the same diameter, and having a certain length covered with a coating of wax of the same thickness. The other ends of the rods were then plunged to the same depth in a heated fluid; and according to the quantity of wax that was melted, their conducting power was estimated. The best conductors were found to be silver, gold, tin, and copper, while platina, iron, and lead seemed to be the worst: (*Journ. Phys.* tom. xxxiv. p. 68.) These experiments prove that the conducting power of the metals is not precisely in the same ratio with their density. Richmann of Petersburg endeavoured to ascertain the same point by a different process. He procured hollow balls of the several metals; into these he inserted the bulb of a thermometer, immersed the balls in boiling water, and observed the effect upon the mercury: (*Comment. Petrop.* vol. iv. p. 241.) The results do not precisely agree with those of Ingenhousz; but although more elaborate, we think them less direct; because in Richmann's, other causes besides the mere effect of the conducting power might act upon the thermometer, an objection which does not seem to apply to Ingenhousz's.

A set of interesting experiments was performed by Rumford on the conducting power of various animal and vegetable substances. The plan which he pursued was to provide himself with a glass cylinder, which terminated in a globe of somewhat more than an inch in diameter. The bulb of a thermometer was suspended in the centre of this globe, and was surrounded by the substance to be examined; and the whole apparatus was then plunged into boiling water, and when raised to a certain elevation of temperature, it was immersed in a mixture of ice and water, and the time noticed which was required to bring it down to this degree of heat. The heat from the water must obviously pass through the substance upon which the trial was made, before it could reach the thermometer; therefore its conducting power was estimated by the effect which it produced upon this instrument. He began by observing the length of time necessary for raising the thermometer enclosed in the cylinder, when it was surrounded only with air, and what length of time was also necessary to cool it, by afterwards immersing it in a mixture of ice and water. He then successively introduced into the globe, similar weights of wool, cotton, silk, linen, down, and fur, and compared their effects with air, taken as a standard; the two last bodies were found to be the worst conductors, and linen the best, a fact which agrees with our experience of their effect when used as clothing; for we know that their only operation, as producing warmth to the body, must depend upon their retaining the heat which is generated in it, and preventing its escape. The Count concludes, that the relative conducting power of these substances was in the inverse ratio of the quantity of air interposed between the particles or fibres of which they are composed. He found that their non-conducting power was not in proportion to the quantity of solid matter which they contain, and therefore could not be from any mutual attraction between the solid matter and the air; for the power bore no ratio to the actual quantity of the substance, but obviously depended upon the manner in which it was arranged.

He performed a direct experiment on silk, which establishes this point. Equal quantities of raw silk, the ravellings of spun silk, and twisted silk thread, were respectively placed in the apparatus; and their conducting powers were found to be in the proportion of 9, 11½, and 13. He afterwards examined how far the air itself in the globe and cylinder might be conceived to be the sole agent, when it appeared, by calculating the space which the different substances occupied, and comparing the effect of the bulk of air which would be left, with the effect of the instrument when entirely

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filled with air, that the process of cooling was retarded by the mixture of the body with the air; and hence he deduced the conclusion, that the presence of the solid matter impedes the motion of the air, and prevents those currents from being formed in it, which we shall afterwards find to act so important a part in the heating and cooling of fluids: (*Phil. Trans.* 1792, and *Essays*, vol. ii. p. 428.) At the time when Rumford published his Essay, the effect of the radiation of surfaces was not thoroughly understood, and it is entirely neglected in the view which he takes of the subject. It must, however, have had a considerable share in the production of the phenomena; and we may imagine, that the more the particles or fibres of the solid matter are dispersed through the mass of air, the greater number of rays will be interrupted by them. It is also probable there is a real attraction between air and the different substances that were examined, which must have had its share in affecting the nature of the results; but whether the attraction differs in different substances, or whether the attractive power of the air is precisely equal upon all of them, does not appear to be exactly ascertained.

Remarks on Rumford's experiments.

Meyer's experiments on woods.

Some experiments were made by Meyer of Erlangen, on the conducting power of the different kinds of wood. He procured balls of them, in which he formed a cavity to receive the bulb of a thermometer; the balls were then exposed to the same temperature, and the effects upon the mercury were noticed. The experiments, although performed with apparent accuracy, are defective in not making any allowance of the action of radiation. Lime, fir, alder, and oak, were the worst, while ash, apple, and ebony, were found to be the best conductors of heat. *Ann. Chim.* t. xxx. p. 32.

Effect of different conductors on the sensations.

The different conducting power of bodies produces a great difference in their action upon the nerves in exciting the sensations of heat and cold, although the bodies indicate the same temperature to the thermometer. Thus it is well known, that in the same apartment, when it contains no source of local heat, the different articles of furniture will convey to the hand very different degrees of warmth. Metals feel the coldest, stone or marble is the next in degree, while wood, and still more woollen stuffs, produce little or no feeling of any change of temperature. The effect in this case depends upon the different conducting power of these substances; the human body being almost always warmer than the objects that are contiguous to it, its heat is abstracted by them; but this operation goes on in proportion to their conducting power, *i. e.* to the respective velocity with which they are enabled to remove the heat from our body. It obviously follows, that when we wish to retain the heat in any substance that is warmer than the surrounding medium, we must enclose it in bad conductors of heat; and that exactly the same method must be pursued, if we wish to keep any substance at a lower temperature than the atmosphere, or other contiguous bodies. Thus we envelope ourselves in woollen cloth or furs when we wish to retain our natural warmth; and we should employ the same method to prevent the melting of ice or snow.

Cause of the different conducting powers.

We have already observed, that one cause which obviously tends to affect the conducting power of bodies, is their possessing a spongy texture, by which portions of air become, as it were, entangled in its pores, and thus seem to prevent the communication of heat. But we observe a very marked difference in the conducting power of bodies that are perfectly solid, and where no air, or at least no quantity that can be supposed capable of producing any effect of this kind, is present. What is it, in this case, that causes the difference in the conducting power of bodies? Is it an attraction which the heat possesses for the particles of the solid, or do the experiments of Rumford and others lead us to regard the operation as of a more mechanical nature, as if there was something in the arrangement or shape of the particles, which retards the passage of the heat along them? These are questions which at present it appears to be beyond our power to answer. Those cases in which a greater or less degree of density, or of aggregation of the parts of bodies, produces a considerable effect upon their conducting power, would induce us to suppose, that the worst conductors should be regarded as merely the most effectual retarders of heat, and the best conductors as simply those that have the least power in retaining the heat that has been imparted to them. But this view of the subject seems scarcely to apply to metals and other solids of a similar kind. The radiation of the surface may be supposed to have some influence in these cases; and M. Poisson goes so far as to conjecture, that the conducting power of solids, generally, is to be regarded as a kind of radiation from particle to particle, operating at very small distances: (*Journ. Phys.* t. lxxx. p. 434. *et seq.*) Upon this point, however, it does not appear that we have any data which can enable us to form a decided judgment.

Opinion of Poisson.

Circumstances which affect the conducting power.

Without, however, entering upon any abstruse theory on the subject, for which the present state of our information does not seem to afford a sufficient foundation, we may assume, as the most natural deduction from the facts, that the conducting power of bodies depends principally upon three circumstances. It is affected partly by the mechanical relation of their particles to each other, partly by an attraction between the heat and the particles of which the body is composed, and partly by the radiating power of the heat. The heat which escapes from the surface will tend to draw from the interior a portion of its remaining heat, in order to supply what has been lost from the external parts. There are also other causes, which, although perhaps less efficacious, are not to be neglected. The consequence of adding heat to a body, is to expand it in all its dimensions; but, by this expansion, it appears to acquire a greater capacity for retaining heat, so that it will become more disposed to carry it from other bodies, and to diffuse it over its own substance, and thus to have its conducting power increased. The effect which caloric has in altering the state of bodies, may likewise materially affect their conducting power, according to the nature of this change. Thus, if we throw a certain quantity of heat into a metal, it is reduced to the fluid state, by which its relation to heat, and the manner of conducting it, will be much affected. There is some reason to suppose, from an experiment of Pictet's, that heat passes more readily upwards than in the contrary direction. He enclosed a metallic bar vertically in a vacuum, and, heating it exactly in the centre, observed the effect produced upon thermometers attached to each end; when it appeared, that the one at the upper end was affected sooner than the one at the bottom: (*Essay on Fire*, § 33.) The experiment is ingenious: but there are some points connected with it, which render the result rather dubious.

Conducting power of fluids.

We now proceed to consider the manner in which heat passes through fluids. Fluids differ essentially from solids in their particles being moveable among each other; and this circumstance, as we shall find, acts a very important part in the transmission of heat. Fluids, like solids, are expanded by caloric, and of course become specifically lighter; and therefore when heat is partially applied to them, in consequence of this

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alteration of gravity, the parts change places with respect to each other, the lighter or heated part rises to the surface, while the colder part sinks to the bottom. It is obvious, then, that heat may be supposed to pass through fluids in two ways; it may either be transmitted from particle to particle, as is the case with solids, or it may be conveyed by a change of gravity in the substance itself, producing a species of circulation among its parts. Many facts that fall under common observation, shew that this circulation takes place in partially heated fluids, and prove that it is much easier to cause heat to pass upwards through them, than in the contrary direction; but the impossibility of heat being propagated downwards through fluids, was not admitted until after the experiments of Rumford. These experiments, which are perhaps the most ingenious of any which he ever performed, have been generally regarded as sufficient to prove the general principle, to which we have already alluded, that when any portion of a fluid is heated beyond the temperature of the remaining part, it rises to the surface, in consequence of its comparative levity; and if the heat be applied to the bottom of the vessel, which is usually the case, the successive portions of the fluid, as they receive the heat, rise in their turn to the upper part, until the whole acquires one uniform temperature. On the contrary, if the heat be applied to the top of the fluid, it is only the upper stratum which becomes heated, the remainder retaining its former temperature. Rumford placed a portion of ice on a certain quantity of boiling water, and found that it was melted in about 3 minutes; but when the same substances and apparatus were used, except that the ice was fixed at the bottom of the water, several hours elapsed, and yet the ice was not completely thawed. To render the operation still more striking, it was so managed that water was made to boil in the upper part of a cylindrical vessel, while the lower part remained full of ice. *Essays*, vol. ii. p. 241, *et seq.*

Rumford's experiments.

We have already mentioned the experiments in which it was found that heat passed less readily through solids, when they were of a spongy or porous texture, than through those that were more dense and compact. The same kind of effect was found by Rumford to take place in fluids when substances were mixed with them, which, by their viscidity, or other analogous property, would prevent the motion of their particles, and thus put a stop to the circulation, which we have described as conveying the heat through their different portions. He compared the time which was necessary for a quantity of pure water to change its temperature, by a certain number of degrees, with the same bulk of water when mixed with down or with starch; and he found the times to be as the numbers 6, $9\frac{1}{2}$, and 11. He afterwards went on to shew, that by increasing the quantity of matter in the fluid, the difficulty of the passage of heat through it was proportionally increased. $\frac{1}{10}$th part of its weight of down added to water, produced a retardation equal to 75, while $\frac{1}{11}$th of the same substance produced an effect equal to 95: (*Essays*, vol. ii. p. 221, *et seq.*) The general principle, therefore, appears to be fully established, that fluids transmit heat, or suffer it to pass among their parts, in a different way from that in which heat is transmitted through solids, not by its being given off from one particle and received by another, but by all the particles coming successively to the source of caloric, and individually receiving it from the heating body. Whatever impedes the intestine motions of the fluid, and prevents this circulation of its particles from taking place, stops the passage of heat through it, and confines its effect to the portion which first received it.

Fluids non-conductors of heat,

The facts brought forward by Rumford may be considered as very decisively proving the general principle; but it has still been questioned, whether there is in fluids that absolute and complete non-conducting power which he attributes to them. Some experiments to prove that they really possess a small degree of a proper conducting power, have been performed by Dr Hope, Mr Nicholson, Mr Murray, Dr Thomson, and Mr Dalton. Their plan was to communicate heat to fluids in a direction different from that in which the supposed currents would act, as by applying it to the upper surface, and by their using every precaution to prevent its being carried downwards by the sides of the vessel containing the fluid, or by any other counteracting cause. The experiments appear, upon the whole, to prove their position, and thus to modify the conclusions of Rumford; but perhaps in all of them there may still be some sources of inaccuracy, which it is very difficult to guard against. The process of Mr Murray appears, upon the whole, to be the most unexceptionable. He formed a hollow cylinder of ice, which served as a vessel in which to contain the subject of his experiment; for ice, as long as it remains unmelted, being a perfect non-conductor of heat, the objection must be removed, which depends upon the conducting power of the vessel itself. The other arrangements made by Mr Murray were very ingenious, and appear to be well adapted for preventing the passage of heat in any manner except through the actual fluid; yet heat seemed to be certainly transmitted from the upper surface to the lower part, so as to affect a thermometer fixed near the bottom: (Nicholson's *Journal*, vol. i. p. 421.) If, then, we are brought to conclude, that fluids possess some degree of conducting power, it next remains for us to inquire, what is the relative degree in which it exists in different kinds of fluids? This, however, is a question which it is impossible for us to answer with any accuracy; because we have no correct means of learning how far the communication of heat to them depends upon their proper conducting power, and how far upon the motion between their particles. It may be inferred, from some experiments of Rumford's, that mercury is a better conductor of heat than oil or water; and this might be expected to be the case. It is natural to suppose, that mercury, so far as it is a fluid substance, conveys caloric, by internal motions among its particles, like other fluids, yet that it still retains its metallic property, and may conduct it from particle to particle.

or only in a small degree.

Murray's experiments.

The subject of the conducting power of liquids has very recently been investigated by Dr Brewster, who has removed every doubt that could remain respecting the existence of this property in fluid bodies, and has pointed out a simple method by which the conducting power of all transparent fluids may be rendered visible to the eye, and easily measured, without the aid even of a thermometer. The apparatus by which these experiments were made, is shewn in Plate CCLXXXIX. Fig. 8. where ABCD is a tin vessel about a foot long, having two openings E, F, in which two pieces of parallel glass are firmly cemented. A heated iron GH is suspended by a wire LM, and a stand RT, having a small circular aperture P, about one-eighth of an inch in diameter, is placed very near the plate of glass F, so as to be seen distinctly by an eye at E. This aperture is capable of being raised and depressed by a finger screw S. The vessel is now filled with water, or any other fluid, nearly to the top, and the eye being placed

Brewster's experiments on the conducting power of fluids.

PLATE CCLXXXIX. Fig. 8.

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at E, and the aperture P raised so as to be seen through the upper stratum of fluid, it will appear of a perfectly circular form. Let the heated iron be now suspended, as in the Figure. In a few seconds the upper stratum of fluid will expand, as the heat penetrates the mass, and the circular aperture will have an elliptical form, as shewn at *a*, Fig. 9. By depressing the aperture P, so as to allow the rays which diverge from it to traverse the fluid strata at different depths, the aperture will have the appearance shewn at *b*, *c*, becoming perfectly circular at the point *c* to which the heat has advanced. These appearances are the necessary consequence of the propagation of the heat downwards, which diminishes the density, and consequently the refracting power of the upper strata. A very curious phenomenon now takes place upon removing the hot iron GH. The uppermost stratum *m n*, Fig. 9. which was formerly the hottest and the least dense, now gives out its heat to the superincumbent air, and to a certain depth *c*, Fig. 10. the fluid diminishes in density, while from *c* to *f* its density increases. If, in this situation, we again examine the circular aperture, it will be found to be extremely elliptical at *a*, Fig. 10. having its larger axis horizontal. The ellipticity will gradually diminish towards *c*, where its form will be circular, and below *c* it will again become elliptical, the larger axis of the ellipse being now in a vertical direction. In these experiments the heat propagated down the sides of the vessel produced no effect, and if it had produced any, it could have been easily distinguished from that which was occasioned immediately below the hot iron.

Plate CCLXXXIX. Fig. 9.

Fig. 10.

Now as all these changes are capable of being accurately measured by a micrometer, we are furnished with the means not only of ascertaining the relative conducting powers of all transparent bodies, but also of determining the curve of density, whether the variation of refractive power is produced by heat, by pressure, or by the mutual penetration of two different fluids. The optical properties which were developed during these experiments, will be explained in our article Optics. Similar results may be obtained in a manner very different, but equally satisfactory. Let AB, Fig. 10. No. 2. be a vessel having a plate of annealed glass, whose section is MN, placed horizontally near the surface *m n* of the fluid, and supported by a glass pillar P. When this vessel is properly exposed to polarised light, no appearance will be seen through the edges MN of the glass; but if a heated iron is suspended, as in Fig. 8. the descent of the heat towards the surface MN, and its propagation through the glass plate, will be marked by beautiful fringes of light parallel to MN. Hence we have another method, and a very direct one, of *measuring the conducting powers either of transparent or opaque bodies*, by the Chromatic thermometer. See Glass, vol. x. p. 321; Thermometer; and the *Phil. Trans.* 1816, p. 108.

Fig. 10. No. 2.

Transmission of heat through gases.

We have but few remarks to make on the manner in which heat is transmitted through gases. From their physical constitution, especially from the facility with which their particles move among each other, we might infer that heat would be conveyed through them, more in the way that it is through fluids, by the action of currents, than from particle to particle, as in solids. We know also that air, like liquids, is expanded by heat, and that this expansion causes it to become specifically lighter, and thus forms ascending currents of warm, and descending currents of cold air. Rumford endeavoured to prove by experiment, that the passage of heat through air was entirely brought about by these currents, and that it was in itself a perfect non-conductor. (*Essays*, vol. ii. p. 410. *et seq.*) But his experiments, and the reasoning founded upon them, although ingenious, do not decisively prove the point; they only go so far as to show, that whatever impedes the motion of the air, retards its heating and cooling, and that the communication of heat to air is, in part at least, effected by the same means as it is in fluids. Berthollet has indeed advanced some considerations in favour of an opinion the very opposite to that of Rumford's, that air is a good conductor of heat, (*Stat. Chim.* tom. i. p. 467,) but they cannot be considered very decisive, and, in short, the question must be regarded as one which is still open to further discussion.

Rumford's experiments.

Berthollet opinion.

Cooling of bodies.

Before we conclude the subject of the properties of heat, we must make a few remarks upon the cooling of bodies. This process depends upon the combination of a variety of circumstances; partly upon the tendency to radiation, partly upon the conducting power of the substances in contact with the body to be cooled, and partly upon the presence of those currents, which we have described as existing in fluids and gases. Professor Leslie, in the course of his researches, to which we have so often alluded, made some experiments on the cooling of water contained in vessels that had differently radiating surfaces. He found that a globe of polished metal, when filled with boiling water, cooled to a certain degree in 156 minutes, while under the same circumstances, except that the globe was coated with lamp black, the water required only half that time for cooling. In this experiment, however, the cooling depends partly upon radiation, and partly upon the conducting power of the substance of which the vessel is formed; and Professor Leslie attempted to estimate the relative effect of these two operations. From previous trials, he knew what quantity of heat would have been abstracted by radiation alone; and thus it was easy to calculate what portion of the heat was removed by radiation, and what by the conducting power of the vessel. The general result is, that the effect of radiation is more powerful than that arising from the conducting power; for the lamp black, which is known to be a bad conductor, increases the cooling of the water by augmenting the radiation. As might be predicted, from what has been already related, when the globe was immersed in water, the cooling went on at the same rate, whether the surface was clean, or was covered with the black paint. In this case the process depended entirely on the internal currents that were formed in the water, while the surface of the vessel has no effect upon it. *Inquiry*, p. 268. 316.

Leslie's experiments.

Both Professor Leslie and Count Rumford performed a number of experiments, similar to the one mentioned above, on the action of the surfaces of vessels in promoting or retarding the escape of heat from bodies contained in them. We arrive at many conclusions which are singular and important; but they so obviously follow from the facts which have been already noticed respecting the radiation of heat, that it will not be necessary to dwell very long upon them. In Professor Leslie's experiments, it was always found that the cooling of water in metallic vessels was accelerated by coating the vessel with paper, paint, isinglass, or other similar substance; and while the coating was comparatively thin, this acceleration appeared to be in proportion to its thickness. So that although in these cases the conducting power must have been injured, yet this defect was more than counteracted by an increase of radiation. It can, however, scarcely be doubted, that, were we to go beyond a certain limit, we should find, that, by augmenting the thickness of the coating, the diminution of

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the conducting faculty would prevail over any advantage which might be derived from the increase of the radiating power. There are several reasons which induce us to suppose that this latter quality is affected principally by the nature of the surface, while the conducting power must depend equally upon the nature of the substance through its whole thickness. It does not appear that any experiments have yet been performed, by which we can learn in what point this balance of power exists. Rumford's general conclusions entirely coincide with Professor Leslie's. He found that the same metallic cylinder, which, when filled with water, required 55 minutes to cool through a certain number of degrees, required only 43 minutes when covered with a layer of glue, 36 when covered with linen, and 34 when coated with a varnish of lamp black. *Phil. Trans.* 1804, p. 90.

Rumford's experiments.

Effect of currents of air.

When bodies are surrounded either by a fluid or by air during their cooling, the rate of the process will be considerably affected by the motions that take place among the particles of the investing medium. The action of a current of air in promoting refrigeration is too well known to require illustration; and this must evidently be an effect entirely independent of radiation, and in a great degree at least of the conducting power of the air. Without deciding the question, whether air be an absolute non-conductor, it is rendered probable, both from circumstances that fall under daily observation, as well as from the direct experiments of Rumford and others, that air is not a good conductor of heat, and that one of the most effectual methods of retaining the temperature of a body, is to surround it with a stratum of air, so confined, that no internal motion can take place among its particles.

New properties of heat discovered by Dr Brewster.

Hitherto heat has appeared only as a simple substance, capable of being communicated through the parts of solid bodies with different degrees of velocity, according to their conducting power; the presence of the heat being in every case marked by an expansion of the solid body corresponding with the temperature. These views, however, though universally received both among chemists and natural philosophers, have been completely disproved by some recent experiments made by Dr Brewster on the propagation of heat along glass, obsidian, semiopal, muriate of soda, fluor spar, alum, gum copal, rosin, horn, amber, tortoise shell, and other substances. We shall endeavour to lay before our readers as brief and perspicuous an account as we can of the new properties of heat which were discovered in the course of these experiments, without anticipating any of the phenomena, which more properly belong to the subject of optics.

Plate CCLXXXIX. Fig. 1, 2.

Let a plate of glass, ABDC, (Fig. 1.) having MN (Fig. 2.) for its section, be placed with its edge CHD upon a hot iron, or be in any way exposed to a source of heat. The heat will be slowly communicated through the substance of the glass in the direction HGFE, and when the heat has reached E, the temperature will be greatest at H, diminishing gradually towards E. The glass will, therefore, according to the common doctrine, be in a state of expansion, as shewn in Fig. 3. being most dilated at H, and least dilated at E. The case, however, is very different. When the heat has entered the glass at the edge CD, the parts of the glass between the edge and the dark line at G are in a state of expansion, diminishing towards G, and at the same instant the parts of the glass between E and F are thrown into a similar state of expansion, while the intermediate portions between F and G are thrown into a state of contraction, the lines AFB and CGD being the limits between the contracted and expanded portions, where the glass has suffered no mechanical change. These opposite effects, which are shewn in Fig. 4. are distinctly produced before the heat has reached the point F. When the height of the glass plate HE is very small, EF is equal to HG, and the contractions and expansions are almost simultaneously produced; but when HE is two or more inches, EF is always much greater than HG, and the expansion between E and F is less distinctly seen, being spread over a greater space. From these results it follows,

Fig. 3.

Fig. 4.

1. That heat, in passing along a plate of glass, *expands a part of the glass, where the heat does not exist in a sensible state.*

2. That the heat also *contracts an adjacent portion of the glass, where it does not exist in a sensible state.*

3. That the heat *contracts a part of the glass where it does exist in a sensible state.*

4. That the heat *expands an adjacent portion of the glass where it does exist in a sensible state.*

Plate CCLXXXIX. Fig. 5.

If the plate of glass ABDC, instead of being heated, is brought to an uniform temperature by immersion in boiling water, and is then allowed to cool in the air, all the effects, which we have described, are exactly reversed during cooling, as shewn in Fig. 5. the parts of the glass which were formerly contracted being now expanded, and *vice versa.*

If the expansion between H and G is either increased or diminished by a variation in the source of heat, the other expanded and contracted portions suffer a similar change; so that there must always be an equilibrium among the forces, by which these opposite mechanical states are produced.

Fig. 6.

Let the plate of glass ABDC, Fig. 6. be cut with a diamond through its centre O, by a line MN, but not separated into two parts, and in this state let it be placed with its edge CHD on a hot iron as before. It will now exhibit the very same phenomena as those which we have already described, just as if it had never been touched with the diamond. When it is in this state of contraction in the middle, and of expansion at the edges, let it be suddenly broken through at the line MON, and it will be found that each of its halves ABNM, MNDC, Fig. 6. are thrown into the same state of contraction and expansion, as when the plate was unbroken. Between E and f, g and O, O and f', g' and H, the glass will be expanded, while between f and g, and f' and g' it will be contracted, as shewn in Fig. 7.

Fig. 7.

Hence, it is obvious, that the contraction and expansion, or rather the phenomena by which they are indicated, are produced by some fluid, which is decomposed by heat into two fluids possessed of opposite polarity, in the same manner as the electric fluid of the tourmaline is decomposed by the action of heat, or the magnetic fluid of a piece of iron by the action of a loadstone. All the phenomena, indeed, which are exhibited during the passage of heat through a plate of glass, are *precisely the same* as the phenomena which take place in the communication of magnetical and electrical polarity; and if we admit the existence of two fluids as the agents by which the phenomena of electricity and magnetism are produced, we are compelled to make the same admission in the case of the propagation of heat along glass. It is not unlikely that the phenomena may be produced by the mutual action of free and latent heat. In our article Optics we shall have occasion to resume this subject at great length, and to give drawings and descriptions of the various optical phenomena which are produced by the singular state into which glass and other bodies are thrown during the propagation of heat through their substance. Those

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who wish for full information on this subject may consult the *Philosophical Transactions* for 1816, part i. p. 46—114, and 156—179.

SECT. II.

The Effects of Heat.

Effects of heat.

We now arrive at the second of the great divisions into which we proposed to arrange our materials, the effects of heat. The principal of these are four. 1. Temperature, or the production of the sensation of heat; 2. Expansion, or the simple augmentation of the bulk of a body, without altering its condition; 3. A change in the physical state of a body, by which a solid is converted into a fluid, and a fluid into a gas; and, 4. Ignition, or the operation of heat by which a body is rendered luminous.

1. Temperature.

1. Temperature is often used rather as a generic term, applicable to all the phenomena that bear a relation to heat, than as a specific term, proper to designate any one of them in particular. It is, however, not unfrequently used to express the power of exciting the sensation of heat, or the effect which it produces on the animal body; and there seems to be some propriety in establishing this restriction, because the word heat, which might otherwise be employed, as we have already remarked, is liable to the objection of being sometimes used to express the *cause*, and at other times the *effect*. The temperature of a body varies according to the quantity of heat which it contains, and may be said to be in the direct ratio of this quantity, although the indication of temperature, which we derive from the sensations, is much too vague to enable us to lay down an exact scale of admeasurement. This proportion of effect, however, only applies to the same body, or to those of a similar kind; for it has been found that the same quantity of heat affects the temperature of different bodies in very different degrees. These different effects depend partly upon the capacity of bodies for heat, and partly upon their conducting power; a point to which we have already referred in a former part of the article. The sensation of temperature is also very much influenced by the state of the nervous system, independent of the quantity of heat in the substance exciting it. It is well known that when the hand is cold, a body that is applied to it will appear hot, when the same body would excite the sensation of cold, had the hand been previously exposed to a higher temperature. This subject belongs more to physiology than to natural philosophy in general; we shall therefore only remark, that we seem always to compare our present feelings with our former ones, and to refer our sensations, not to any invariable standard, but to what we have felt just previous to the present impression.

Effect upon the sensations.

2. Expansion.

2. The effect of heat upon the sensations, although the one which must have been first attended to, and that which constantly offers itself to our observation, is found to be so inaccurate as a measure of its quantity, that we always have recourse, for this purpose, to the second of its effects, which we enumerated above, expansion. According to one of the characters of heat, which we have already described, that of distributing itself equally among bodies whenever two substances are brought together, which differ in their temperature, the one gives off a portion of its heat to the other, and that which receives it becomes expanded, or has its bulk increased in all its dimensions. This expansion continues as long as the body in question maintains its elevated temperature; but when the heat is withdrawn, it begins to contract, and by degrees it acquires its former bulk. This expansion occurs, with very few exceptions, in all bodies; but it differs extremely in degree. It is by much the greatest in aeriform fluids of all kinds. It is less in quantity, although still considerable, in liquids; while in solids, it is so small as not to be perceived, except by the intervention of an apparatus expressly contrived to render it visible. Not only these general classes of bodies, but many of the individual substances comprized under each of them, have very different degrees of expansive power, which has been frequently made the subject of experiment.

Expansion of gases.

The different gases have been submitted to numerous trials, for the purpose of ascertaining their relative expansion. Priestley paid a good deal of attention to the subject. It was farther investigated by Roy, Monge, and Saussure; and lastly, with much apparent accuracy, by Guyton. (*Ann. Chim.* t. i. p. 256. *et seq.*) Their results, although various, agreed in the main conclusion, that each of the gases had a specific power of expansion peculiar to itself, and which is uniform for each of the gases at the same temperature. But, notwithstanding the weight of these authorities, a farther examination of the subject by Mr Dalton and M. Gay-Lussac has led to an opposite conclusion, that all the aeriform fluids suffer the same expansion from the same addition of heat. Mr Dalton's experiments indicate, that 100 parts of any gas, in passing from the freezing to the boiling point, increase to 137 parts, which is nearly $\frac{1}{480}$ for each degree: (*Manch. Mem.* vol. v. p. 598.) M. Gay-Lussac's experiments were published a short time subsequent to those of Mr Dalton; but being made without concert or co-operation, they are to be regarded as equally original, and they lead to conclusions so nearly similar, as to afford the strongest evidence of their correctness. (*Ann. Chim.* t. xliii. p. 137. *et seq.*) The source of error in the experiments that had been performed previous to those of Dalton and Gay-Lussac, appears to have arisen from a quantity of aqueous vapour that had been mixed with the gases. See Expansion.

Experiments of Dalton and Gay-Lussac.

The expansion of liquids.

The expansion of liquids by heat differs, in many respects, from that of gases; it is less in amount, it varies much in different fluids, and it is found not to be in proportion to the quantity of caloric that is added to the heated body. If we observe the effects produced upon mercury, water, and alcohol, by the same addition of heat, and when they are all at the temperature of 50°, we shall find it to be, in the first of these fluids, equal to $\frac{1}{190}$ of its volume, in the second $\frac{1}{113}$, and in the last $\frac{1}{33}$. The comparative changes in bulk are also found to vary for the same fluid at different temperatures, contrary to what has been observed with respect to aeriform bodies, the expansion proceeding, in a gradually increasing ratio, as the temperature advances. Thus at the temperature of 50°, the expansion produced by a single degree of heat, is less than what would be produced by a single degree of heat at the temperature of 100°. Many accurate experiments, of which we have given an account in our article Expansion, were performed on this subject by Deluc. He found, that in fluids the rate of expansion is frequently irregular near the two extremes of freezing and boiling, and more equable in the middle of the scale; and hence he deduced a practical rule, that those fluids are the best adapted for measuring the degrees of heat, which have the largest interval between the limits of freezing and boiling. The general result of our examination of the expansive power of different fluids, leads us to conclude that it has no connexion with their density, but it seems rather to be related to the quantity of heat necessary to convert them into the gaseous state. Thus ether is probably the most expan-

Deluc's experiments.

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sible, and mercury the least so, of any fluids, because they possess respectively the lowest and the highest boiling points. *Recherches*, t. i. p. 271, 311.

Expansion of water.

We have hitherto spoken of the expansion of fluids by heat, and their consequent contraction by cold, as of a property possessed by all bodies of this description; but there is one very remarkable exception to the general law, that of water. Water, through a certain range of temperature, like other fluids, experiences the usual augmentation of bulk by an addition of heat; but when it is cooled down to about 40°, it seems to arrive at its maximum of density; and if the cooling process be farther continued, it begins to expand, and continues its expansion until it arrives at its freezing point, when it becomes solid. By employing certain precautions, particularly by avoiding every degree of agitation, it will continue fluid for several degrees below the usual point of congelation, and it still goes on increasing in volume, until its actual solidification takes place. When a water thermometer, therefore, stands at 50°, it is impossible to know whether it be really at the temperature of 50°, or at that of 30°, 18° above, or two degrees below, its freezing point.

Experiments of Deluc.

This anomaly, with respect to the expansion of water by the abstraction of heat, was one of the discoveries of the Florentine academicians, about the middle of the 17th century; but it was not much attended to, until it was again brought into view by Deluc. He repeated the experiment with more accuracy, and he attempted to ascertain the exact degree at which the expansion commences. This he fixed at 41°; and he farther discovered, that the expansion is nearly equal when water is either heated or cooled, the same number of degrees above or below 41°: (*Recherches*, t. i. p. 225.) Some circumstances which were not sufficiently attended to by Deluc, particularly the expansion of the glass in which the water is contained, were afterwards carefully noticed by Sir C. Blagden, and in consequence of these corrections, he fixed the point of greatest density at 39°. (*Phil. Trans.* 1788, p. 125, *et seq*.) Le Fevre-Gineau came to the same conclusion respecting this anomaly in the expansive power of water, by a very different process. He weighed a cylinder of copper in water at various temperatures, and thus obtained the weight of a cylinder of water exactly equal to that of the metal which he employed. The result of this process was to fix the maximum of the density of water at the 40th degree. Dr Hope adopted another method of arriving at the same conclusion, which we have fully explained in our article Expansion. Rumford has since performed a set of experiments upon the same principle, and with nearly the same results. There have been some objections made against these experiments, although they appear so correct, and were so much varied; but upon the whole, we conceive the conclusion to be thoroughly established, that the greatest density of water is at about 8 or 9 degrees above its freezing point. The cause of this peculiarity with respect to water is involved in considerable obscurity. It appears to be connected with the increased space which water, as well as many other substances, occupy, when they assume the crystalline form; and we may conjecture, that some tendency to this state takes place in water before its actual occurrence. See Expansion, p. 257, 258.

Blagden. Le Fevre-Gineau. Hope. Rumford.

Expansion of ice.

The greater space which water occupies, when in the state of ice, has been long observed, and has been made the subject of some curious experiments, particularly by Major Williams, who, during an intense frost at Quebec, actually burst a cannon, by the freezing of only a comparatively small quantity of water: (*Edin. Trans.* vol. ii. p. 23, *et seq.*) When water is converted into the solid state, it forms spicular crystals, which cross each other at a determinate angle; and thus interstices are left, which cause it to occupy more space. Dr Thomson found, that the specific gravity of ice is to water at 60°, as 92 to 100; and hence we may conceive the great force that will be exerted, when water suddenly expands itself, so as to have its gravity diminished in the above ratio.

Expansion of solids.

The expansion of solids, which we are now to consider, is much less than that of liquids. The same elevation of temperature, which increases the volume of a gas from 100 to 137 parts, increases that of a liquid only to about 104 or 105 parts, while it adds to a solid not more than $\frac{1}{1000}$ of its bulk. A set of experiments on the expansion of metals was performed by Smeaton, when he found, that, in passing from the freezing to the boiling points of water, platina was expanded from 100,000 to 100,087, gold from 100,000 to 100,094 parts, steel to 100,112 parts, copper to 100,170 parts, silver to 100,189 parts, tin to 100,288 parts, lead to 100,287 parts, and zinc to 100,296 parts: (*Phil. Trans.* 1754, p. 612.) It appears that the densest metals are generally the least expansible; but this proportion does not universally obtain.

Smeaton's experiments on metals.

Deluc's experiments on glass.

The expansion of glass, which is a point of great importance to ascertain, as affecting the result of many other experiments, was made the subject of careful examination by Deluc. Supposing its bulk at 32° to be 100,000, at 212° it was found equal to 100,083, an expansion nearly the same with that of platina. From this estimate we learn that glass is expanded about $\frac{1}{100000}$ of its bulk by one degree of heat, and the expansion seems to be nearly uniform, for the same degree of heat, through the different parts of the scale. This equal augmentation of bulk, by equal increments of heat, is supposed to prevail generally in solids; but, from the minuteness of the effect, it is less easy to ascertain this point, than with respect to gases and liquids.

Expansion of metals when they become solid.

Several of the metals expand at the time they are converted from the fluid to the solid form; and this, as is the case with water, seems to depend upon the occurrence of a kind of crystallization, or regular arrangement of their particles. This is said to be particularly the case with respect to iron, and is the reason why we are able to take such accurate casts, when the melted metal is poured into moulds. It must, however, be observed, that the increase of bulk, which either water or melted metals acquire when they become solid, is no exception to the general law of expansion; for this applies solely to bodies as long as they retain the same state. The only anomaly, therefore, is the expansion of water while it remains fluid.

Thermometer.

It is upon the expansive power which heat exercises over bodies, that the thermometer is constructed; an instrument, as its name imports, employed for the purpose of measuring the degree of heat, or temperature of substances to which it is applied, and which, considered in all its relations, may perhaps be regarded as the most useful agent in philosophical researches of which we are in possession. It appears to have been invented by Santorio, the celebrated Italian physician, who devoted so much of his attention to what has been called statical medicine. His instrument depended upon the expansive power of the air, and consisted of a tube, with a bulb of considerable size, the lower end of the tube being left open, and being plunged into a fluid, which was suffered to rise to a certain degree into the tube. As the air in the globe was expanded or

Invented by Santorio.

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contracted by the addition or subtraction of heat, it is obvious that the fluid would sink or rise in the tube, and thus mark the degree of heat. The Florentine academicians had the merit of considerably improving the apparatus of Santorio, by substituting alcohol for air, and by confining it in a tube nearly similar to the one now in use. Halley is said to have been the first who employed mercury, and Newton made the very important improvement of forming a regular scale, by which the observations might be recorded and compared together. It is, however, to Hooke that we are indebted for what may be regarded as a still greater improvement, viz. the formation of fixed points in the scale, by which, at all times and in all cases, thermometrical observations might be compared together, and be, as it were, all referred to one invariable standard. He perceived that water became solid always at the same temperature, and that, under the same atmospherical pressure, the fluid always becomes converted into vapour at the same degree of heat. Hence it follows, that if we immerse a tube containing mercury first into freezing, and afterwards into boiling water, we obtain two stationary and invariable degrees or points in the scale, which will bear the same relation to the temperature of other bodies, whatever be the size of the instrument, or under whatever circumstances the experiment is performed. Having ascertained these points, the numbers which are affixed to them, or the number of degrees into which we divide the interval between them, is entirely arbitrary, and comparatively unimportant.

Improved by the Florentine academicians. Halley. Newton. Hooke.

Different thermometric scales.

The thermometric scale in general use in this country was formed by Fahrenheit, in which the cypher or zero is supposed to be indicated by a mixture of common salt and pounded ice. The freezing point of water is fixed at 32°, and the boiling point at 212°, so that the interval between the freezing and boiling of water comprehends 180°. In France, before the Revolution, the thermometer of Reaumur was generally employed. Here the freezing of water is the zero, or the commencement of the scale, and boiling water is assumed as the 80th degree. Since the Revolution, the centigrade scale is employed, which had been previously adopted by Celsius, a Swedish philosopher. Here freezing water is marked 0°, and boiling water 100°. Perhaps none of them are without considerable objections. Fahrenheit and Reaumur's scale are completely arbitrary; while the centigrade has its degrees too large for many purposes, and it has also the defect of beginning too high, so that we have very frequent occasion to employ the terms + and —, which may lead to confusion. Of the three, that of Fahrenheit is certainly the best; both because it is, in a great measure, free from this last objection, and because the degrees are not too large. Nor is it of much consequence that the commencement and termination are so entirely arbitrary; for when we are once accustomed to it, the mind refers to it as a term of comparison, without ever considering the reason for fixing upon the numbers that are employed.

The fluids employed in the formation of thermometers are either mercury or alcohol. Where we wish to ascertain very low temperatures, the latter is preferable, because it cannot be frozen but by the most intense cold, see COLD, vol. vi. p. 735; whereas mercury becomes solid at —39°. But for every other purpose, mercury has a decided advantage. Its expansions from the same additions of heat are more uniform; it is also more sensible to slight variations of temperature; and its boiling point is so elevated, that it possesses a range in the upper part of the scale, which is applicable to most practical purposes. Except, therefore, for measuring very low temperatures, mercury is now always preferred. See THERMOMETER.

Is mercury an exact measure of heat? Deluc's experiments.

A great deal of attention has been paid to the question, whether mercury, or any other fluid used for thermometrical instruments, was an exact measure of the additions of heat? whether the expansion was the same, by adding a certain quantity of heat at the lower as in the higher part of the scale? The experiments of Deluc on this point are regarded as the most correct. He observed the height to which the mercury rose in the tube, by immersing it in two equal portions of water, at temperatures considerably different from each other; then he mixed the two portions of fluid together, and examined whether the thermometer indicated the mean between the two. The result of Deluc's investigation was, that no fluid is an exact measure of temperature; but that, in all cases, the augmentation of bulk is in a greater ratio than the actual addition of heat. Mercury appeared to be the most uniform; but even in this fluid, the temperature of a mixture of two portions, one at the freezing, and the other at the boiling point, was 2½° less than the mean. The real temperature in this case is 122°, but, according to the common graduation, the thermometer stands at 124½°, (*Recherches*, t. i. p. 311.) Hence, in order to obtain a precise measure of the increments of heat, we ought to have a thermometer so graduated as to allow for this deviation; and although we are not aware that any instruments have been constructed upon this principle, yet tables have been calculated by which a proper scale might be very easily formed.

Method of determining high temperatures.

The thermometer, however, in its most improved form, is only applicable to a range of temperature below that at which mercury boils; and although this includes most cases that usually fall under our observation, yet we have not unfrequently occasion to measure much higher degrees of heat. Newton attempted to accomplish this point, without any apparatus directly adapted to the purpose, by a species of computation. He ascertained the rate at which bodies cool, compared to the heat of the surrounding medium, at temperatures within the reach of the thermometer, and he then extended the same ratio to the higher degrees of heat. By this very ingenious method he discovered the temperature of red hot iron, and the melting point of many of the metals, with a considerable degree of precision. Since his time, different instruments, called *pyrometers*, have been invented, of which the most valuable, and that which has come into the most general use, was invented by Wedgewood. In the course of his experiments on the manufacture of earthen ware, he perceived that the different kinds of earths, called *clays*, into the composition of which a large quantity of alumine enters, had the remarkable property of contracting by exposure to a great heat, and likewise that this contraction was in proportion to the degree of heat employed. When the clay has once contracted, its bulk remains permanently diminished, so that by applying it to a guage, previously graduated for the purpose, we can ascertain to what degree of heat the piece of clay in question has been exposed. The guage by which the contraction of the clay is ascertained, consists of two straight pieces of brass, fixed on a brass plate in such a manner that they are nearer together at one end than at the other; and thus the more the clay has been contracted, the farther will it slip between the brass bars. Wedgewood then proceeded to examine the relation between his pyrometer and the common mercurial thermometer, and he determined that the

Newton's theorem.

Wedgewood's pyrometer.

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0° of his scale was equivalent to the 1077° of Fahrenheit's were it so far extended. The degrees, the size of which was arbitrary, were each of them equal to 130° of Fahrenheit's; and the highest temperature which he actually measured was 160° of his pyrometer, corresponding to above 21,800° of Fahrenheit, which was found to be the temperature of a particular air furnace which he employed in his experiments: (*Phil. Trans.* 1782, p. 305, *et seq.*) This pyrometer has generally been regarded as a very valuable addition to our philosophical apparatus; but there is one circumstance which unfortunately much impairs its use—the difficulty of procuring the same kind of clay on which Wedgewood operated for the test pieces, as the mass which he originally employed is exhausted; and it does not appear certain, whether the imitation of it that has been since prepared, is possessed of precisely the same physical properties. See CHEMISTRY, p. 152.

Guyton's pyrometer.

Several other pyrometers have been invented, depending upon different principles, and possessing different degrees of accuracy. Muschenbroek, Ferguson, Ellicot, and Smeaton, have all exercised their ingenuity upon this point; but the only apparatus which we shall farther notice is that of Guyton. In this instrument a long rod of platina is fixed in an horizontal groove, formed in a mass of clay, that had been hardened by exposure to a strong heat; one end of the rod extends beyond the groove, and presses against another rod of platina, which acts as a lever; its longer arm being extended, so as to form an index, which moves upon a graduated arc. As the rod is more or less expanded by the heat, the index is carried along the scale, and serves to point out very minute variations in the bulk of the metal: (*Ann. Chim.* tom. xlvi. p. 276.) We are not certain whether this instrument has ever been employed in England; but it appears to possess many advantages as an accurate measure of high temperatures. See PYROMETER.

Change of state in bodies.

3. We now arrive at the *third* of the effects of heat, the change which it produces in the state of bodies, converting, according to circumstances, a solid into a liquid, or a liquid into an aeriform fluid. The effect of caloric, which we last described, consists in introducing a portion of heat between the particles of bodies, by which they are, to a certain extent, separated from each other, so as to experience an increase of bulk, without having their cohesion materially impaired. If, however, the addition of heat be continued beyond a certain limit, the particles are removed still farther from each other, until at length they are so far separated, as to lose their cohesive power, and to become easily moveable among themselves in all directions. By this change of form, the substance in question undergoes a complete alteration in its physical properties, and not unfrequently in its chemical action upon other bodies. The effect is produced by destroying the balance between the expansive power of heat, and the force of attraction; the former tending to remove the particles of bodies to a distance from each other, the latter to retain them in close contact. But although the attractive force is conceived to be very much weakened in bodies when they assume the fluid state, it is not entirely destroyed, but is still exerted with considerable energy.

Conversion of a solid into a liquid;

of a liquid into a gas.

It is also to be remarked, that after a solid has received an addition of heat, so as to convert it into a fluid, a still farther quantity of heat may be given to it, which has the simple effect of expansion. If, however, we continue to increase the quantity of heat after the expansion has advanced to a certain length, the body again assumes a new form, and becomes a gas; and it now, as before, after this third change, by adding still more heat, suffers merely an expansion in its volume. But the expansion in these three cases, as has been already observed, differs considerably in its degree, being small in the first instance, greater in the second, and much more so in the last. This peculiar quality of assuming the different states of solidity, liquidity, and elastic fluidity, may be considered as a property common to all kinds of matter; for it would appear, that if we had the power of producing, at pleasure, temperatures sufficiently high and sufficiently low, every substance that usually appears under the solid form might be vaporized, and every substance that usually appears as a vapour might be rendered solid. When we speak, therefore, of any body being naturally in the solid, or naturally in the liquid state, we mean no more than that, under the ordinary temperature of the atmosphere, or under the circumstances in which it commonly presents itself to our notice, it is solid or fluid.

Some bodies not capable of these changes.

There is, indeed, another obstacle to altering the state of bodies, besides the difficulty of procuring very high or very low temperatures, that by a great addition or subtraction of heat, their chemical constitution is affected, and they are either decomposed, or are disposed to enter into new combinations. Organised substances in general, both of animal and vegetable origin, when subjected to high temperatures, are converted into their ultimate elements; and, on the contrary, in some cases, a great reduction of temperature causes the constituent parts of certain bodies to separate from each other, before they are brought into the solid form. These, however, are to be regarded rather as incidental circumstances, interfering with particular operations, than as any fundamental exceptions to the general law that has been laid down. It would appear, from the experiments of Sir James Hall, that many of these apparent exceptions may be brought under the general rule, merely by employing strong pressure or other mechanical means. Thus it had been supposed impossible to melt the carbonate of lime, because at an elevated temperature the carbonic acid escaped in the form of gas; but when the substance was subjected to strong compression, so as to prevent this escape of gas, the fusion was easily accomplished.

Sir James Hall's experiments.

The suddenness of the change which occurs when the body receives so much heat as to convert it into the liquid state, shews that some other circumstance takes place besides the mere addition of caloric. And the same remark applies to vaporization; for here again no indication of the change of state can be observed, until the actual change occurs in its full extent. This point we shall soon consider more at length; but, in the mean time, before we quit the subject of the change of bodies from the solid to the liquid form, we must offer a few observations upon some phenomena that occur when we reverse the operation, and convert them from the liquid to the solid state. All bodies that undergo this change, without having their chemical constitution materially altered, have a fixed point at which they are said to freeze, congeal, or become solid; and except under certain circumstances, this point is invariably the same. This is so much the case with respect to water, that the freezing point of this fluid has been employed as one of the fixed degrees which regulate the graduation of the whole scale.

Freezing point of bodies.

Cooling water below the freezing point.

It is, however, possible, by certain management, to cool water several degrees below its freezing point, without rendering it solid; according to the experi-

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Experiments of Dalton,

ments of Mr Dalton, as low as 5° or 27° below the usual point of congelation. In order to succeed in giving water this unusual degree of cold, without converting it into ice, it is necessary that it be kept in a state of the most complete rest; for the least agitation either prevents it from falling lower than 32°, or if it be brought down below this point, it instantly begins to freeze, and the fluid part rises to 32°. Black found that by carefully boiling the water, so as to expel from it all the air which is generally dissolved in it, it was less easy to reduce the temperature below the ordinary degree; and Blagden discovered, that when water is thus artificially cooled, no circumstance had more effect in producing its sudden congelation, than introducing into it a small particle of ice. Hence when the freezing of water has once commenced, it proceeds with so much rapidity in these experiments; and it may perhaps also, in some measure, account for the effect which water confined in close vessels has in bursting the vessel when it freezes. In these cases the fluid may probably descend some degrees below the usual freezing point, before the congelation commences; a slight agitation, or other incidental circumstance, then causes the freezing to commence, and the first spiculæ of ice that are formed, tend to convert the remaining part of the water into the solid state so rapidly, as to produce a greater expansion, than if the particles had arranged themselves more quietly in the crystalline form.

Black,

Blagden.

Vaporization.

The effect of a continued addition of heat to a liquid is, as we have remarked above, to convert the liquid into the state of vapour. This, like the former, is a sudden change, and, like it, is attended with a complete alteration in the physical properties of the substance so changed. A certain portion of caloric added to a body, insinuates itself among the particles, and places them so far from each other, as to diminish the attraction which unites them into the solid form, without, however, entirely destroying their aggregation; while a larger portion removes them to a still greater distance, and seems as if it entirely placed them beyond the reach of their mutual attraction. The most obvious property of the body, when in this vaporized state, is its power of expanding itself in an indefinite degree, until its particles be brought nearer together by an external compressing force. If this external force be removed, it quickly regains its former dimensions; and hence we regard it as a body possessed of a perfect degree of elasticity. It is upon the elastic power which different substances possess, when they are converted by heat into the gaseous or aeriform state, that many of the most important operations, both in art and nature, are brought about. The force which different bodies exercise when they are reduced into the gaseous state, and are at the same time subjected to strong pressure, is almost inconceivable; it is, in short, unlimited in its extent, and may be so managed as to produce any assignable degree of effect. Notwithstanding, however, the expansive power which bodies exercise during their conversion from the fluid to the gaseous form; yet when they are finally brought into this state, they are compressible. Thus, although the conversion of water into an aeriform fluid is capable of generating an almost immense degree of mechanical power, in consequence of the greater space which it then occupies, a power of which we take advantage in the steam engine, yet the vapour, when once produced, may be easily compressed into a less bulk, by the weight of a comparatively small quantity of mercury. Further increments of heat, when added to the gas, only serve to produce a corresponding increase of its bulk; and this increase, as we have already remarked, is equable for the same quantity of heat, and is likewise similar in all the different gaseous bodies.

Elasticity of vapours.

Boiling point of liquids.

The point of vaporization, like that of solidification, differs for almost every kind of liquid. There are some bodies that always appear in the state of gas when not combined with other substances, and no degree of cold which has yet been applied to them has been able to deprive them of their elastic fluidity. Yet from analogy we conclude, that these bodies have nothing in their nature essentially different from those which we observe to assume either the liquid or the gaseous state, according to the temperature in which they are placed; and we conceive, that, had we the power of employing a degree of cold sufficiently intense, they might be rendered liquid, or even solid. Ether has the lowest, and mercury the highest vapour points of any liquids with which we are acquainted. If we were always immersed in a temperature above that at which ether boils, we should never see it in a fluid state; and if we had not been able to produce a temperature above 670°, at which mercury boils, we should have had no conception of this substance being reducible into the state of a vapour. The terms *fixed* and *volatile*, like *solid* and *liquid*, are therefore to be regarded as merely relative, and as not indicating the absolute quality of the bodies, but pointing out the forms under which they usually present themselves to our notice. But although we regard this as the most correct view of the subject, yet many chemists of eminence have supposed that there is some essential or radical difference between the two kinds of aeriform fluids, and have called them by different names; to those that are easily reduced to the liquid state the term *vapour* has been exclusively applied, while the others have been called *gases*, or permanently elastic fluids. The discussion of this question belongs more to chemistry, than to the immediate subject of this article; but we shall farther remark concerning it, that when, by the effect of chemical affinity, these gases are reduced to the liquid or solid form, heat is extricated; thus proving that it entered into their constitution, and was necessary to their existence.

Vapours and gases.

Vaporization influenced by pressure.

An important circumstance connected with the conversion of liquids into the state of elastic fluidity, is, that it is influenced by the degree of pressure to which the liquid is subjected. External pressure thus counteracts the repulsive power of heat, and as it were keeps the particles in a state of forcible approximation. It follows, from this order of things, that if we remove from the surface of a liquid the whole or a part of the weight of the atmosphere, by placing it under the receiver of an air-pump, or by ascending a high mountain, it boils at a lower temperature than under ordinary circumstances. Thus water, which boils at 212°, when the barometer stands at 30 inches, boils at about 70° *in vacuo*; and on the top of Mount Blanc, it was found by Saussure to boil at about 187°. As the temperature at which different species of elastic fluids are formed, depends so much upon the pressure which is applied to them; so, after the gaseous state has been assumed, the elastic force of the vapour varies according to the degree of pressure under which it exists. Mr Dalton has made this the subject of an extensive range of experiments, in which he determines the height of the mercurial column which the vapour of water will support at different temperatures. Thus if the vapour of water be taken at the freezing and boiling points, and at 122°, which is intermediate between them, he found

Difference in the boiling point.

Dalton's experiments.

Effects of Heat.

that the column of mercury supported in these three cases, was equal to 0.2, 3.5, and 30 inches respectively. By making a few experiments, and observing the ratio which the numbers in these cases bore to each other, he constructed a table containing every degree of heat, from 0° on Fahrenheit's scale to 325°: (*Manch. Mem.* vol. v. p. 559.) Experiments of a similar kind have been performed in France by M. Bettancour. As the boiling point of liquids is lowered or raised, according as the atmospherical pressure upon them is diminished or increased, it has been found, that if the pressure be augmented in a very great degree, as is the case when water is inclosed in Papin's digester, it is capable of receiving a much higher temperature, than what it can maintain under other circumstances. Water has, in this way, been heated 200° or 300° beyond its usual boiling point; and it has then acquired the power of dissolving many substances, over which it has no action in its ordinary state.

Evaporation and distillation.

It is upon the property which liquids possess, of being convertible into the gaseous state, that the processes of evaporation and distillation depend. The first of these is performed, when our object is to separate the more volatile parts of a compound, for the purpose of procuring those that are less so; and the second, on the contrary, is done in order to procure the volatile part itself. A minute account of these operations belongs more to chemistry, and to the various branches of chemical manufactures, than to the general view which we are taking of the effects of heat. (See Distillation and Evaporation.) In both cases, the separation is effected by the combination of heat with the liquid; in the one, it is sometimes produced by the heat which naturally exists in the atmosphere, aided by a current of air, continually presenting a new stratum to be acted upon; and at other times a quantity of heat is thrown into the substance by the combustion of some kind of fuel. It is, however, necessary, in either case, that a large surface should be exposed to the atmosphere, for the purpose of carrying off the vapour as rapidly as it is produced; for it appears that it is principally at the surface that it is generated. In the process of distillation, artificial heat is always employed, and commonly in a greater degree than where the object is merely to produce evaporation. Here the liquid is confined in close vessels; and the operation depends upon a portion of it, which is nearest the source of heat, becoming converted into vapour, and passing up through the other parts of the fluid in the form of bubbles, constituting what is styled *ebullition*.

Sudden change in the state of bodies.

We have already remarked, that when a solid is converted into a liquid, or a liquid into an elastic fluid, the conversion is brought about suddenly. The substance in question, before it changes its state, continues to receive heat, is expanded in a certain degree, and has its temperature raised; but if an additional quantity of heat be still given to it, the expansion no longer goes on in the same manner, and the temperature is no longer elevated, but it assumes a new form, becoming, according to circumstances, either a liquid or a vapour. It was formerly supposed, that this change did not depend upon any peculiar or specific action, but that the mere addition of a certain small portion of heat was adequate to effect it. Dr Black, however, perceived the insufficiency of the opinion usually entertained upon the subject, and was induced to investigate it with great assiduity; the result of which was, the establishment of his celebrated theory of latent heat. The fundamental position of this theory is, that when a solid is converted into a liquid, or a liquid into a gas, a much greater quantity of heat is absorbed by it than is perceptible by the sensations, or the thermometer, the effect of which is to unite with the particles of the body, and thus to alter its form. When, on the contrary, the vapour is reduced to the state of a liquid, or a liquid to that of a solid, heat is disengaged from it, without the substance in question indicating any diminution of temperature, either to the sensations, or to the thermometer. This phenomenon is considered to be the reverse of the former; here the heat that escapes is not supposed to have affected the body in the way that free caloric acts, but simply to have maintained it in the state of elastic fluidity, or of liquidity.

Dr Black's theory of latent heat.

Difference between free and latent heat.

We are hence led to regard heat as existing in two states that are essentially different from each other: the one producing temperature and expansion, and of course capable of being measured by the thermometer; the other not manifesting these properties, but uniting itself to bodies, and changing their form. The former we call free or uncombined heat; the latter latent or combined heat. As we are in the habit of conceiving temperature and expansion * to be the most certain indications of the presence of heat, it required a train of minute experiments to establish a position which appeared, at first view, so much at variance with our ordinary conceptions, as that heat could be communicated to bodies without producing these effects. The following facts may be considered as the ground-work of Black's doctrine. Let a mass of pounded ice, cooled several degrees below the freezing point, be exposed to the heat of a furnace, so that it may receive equal quantities of caloric in equal intervals of time. The ice, as it receives the heat, becomes warmer at each successive interval, until the whole acquires the temperature of 32°; but now, although the heat still remains applied as before, the ice acquires no additional warmth; it still indicates 32° to the thermometer, but it is observed gradually to dissolve. No increase of temperature takes place until the whole is rendered fluid, and then it again begins to grow warmer, and as before acquires successive increments of heat, until it arrives at the 212th degree. Here, again, the process ceases; and whatever quantity of heat be sent into the fluid, its temperature remains unchanged; but now the fluid is observed gradually to assume the state of vapour, until the whole of it is converted into the aeriform state. Now there is every reason to conclude, that in this case the ice and water continue to receive equal quantities of heat for the whole period; yet during some part of the process, the thermometer remains stationary. At this very time, however, the change of form occurs; and therefore it is natural to conclude, that it is connected with the absorption of a portion of heat, which, in consequence of its not producing either temperature or expansion, has obtained the name of *latent*. The legitimate inference is, that a certain quantity of caloric, which would otherwise have been employed in producing temperature and expansion, is necessary in the one case for melting the ice, and in the other for vaporizing the water.

Proofs of the theory of latent heat.

Deductions from the theory.

What we have now stated may be regarded as the foundation of the celebrated theory of latent heat; which has been universally received, as affording a satisfactory explanation of some of the most interesting phenomena that occur in the system of nature. A number of very important consequences were immediately deduced from it, of which we may enumerate the

* It will be seen, in another part of this article, that expansions and contractions are produced by heat in glass and other substances where it *does not exist in a sensible state*. See page 677.—Ed.

Effects of Heat.

two following, as those the most deserving our attention:

1. When solids become liquid, and liquids become elastic fluids, a quantity of heat, previously latent, becomes sensible, and may be now measured by the thermometer, although before it was not capable of affecting this instrument. On the contrary, when vapours are converted into liquids, or liquids into solids, a portion of heat, which was previously in the uncombined state, is now absorbed or rendered latent. In the former process, therefore, warmth is produced; in the latter, cold is generated.

Capacity for heat.

Specific heat.

2. Substances which are at the same temperature actually contain different quantities of heat. Ice just before liquefaction, and the water which is formed, are both at the temperature of 32°, and steam is no hotter than the boiling water from which it is produced; so that the water and the steam both contain a large quantity of heat, in the combined or latent state, which they have absorbed in order to cause the fusion of the one, and the vaporization of the other. This property in bodies, of indicating the same temperature when they contain different quantities of heat, is denominated their capacity for heat; while the quantity of heat which they require to bring them to the same temperature is called their specific heat, in opposition to the real quantity, which is stiled their absolute heat.

It would carry us far beyond our prescribed limits, were we to give an account of all the experiments which were performed by Black, for the purpose of establishing his theory, and of repelling the objections against it. They consisted, in the first place, in comparing the effect produced by the same quantity of heat upon bodies which possessed different capacities, as ice and water. When the same weight of ice and water, both at the temperature of 32°, were suspended in an atmosphere of 47°, the water rose to 39° in 30 minutes, while the ice required ten hours to become liquid, and to acquire the same temperature. The ice therefore was 21 times as long as the water in acquiring the same degree of warmth, and we may conclude that it would absorb 21 times as much caloric. While the number of degrees gained by the water was no more than seven, the number that entered the ice would be 147°; but of these only seven were employed in warming the substance, the rest was expended in melting it. Hence we should say, that when ice is converted into water, 140° of caloric are rendered latent. The same general conclusion was obtained by a different process. When two equal portions of water, at unequal temperatures, are mixed together, the mixture indicates the mean temperature of the two portions; thus a pound of water at 32°, and a pound at 172°, produce a mixture which indicates 102°; but if we mix a pound of ice at 32°, with a pound of water at 172°, the ice is melted, but the temperature of the fluid is not raised. Hence the 140° of heat are all employed in thawing the ice, and thus becomes latent.

Cold produced by evaporation.

The absorption of heat that takes place when solids are melted, or liquids evaporated, and the discharge of heat that occurs in the reverse operations, are often employed in different processes, for the purpose of cooling or warming bodies. The effect of evaporation in generating cold is well known, both as it affects the sensations, and as it actually reduces the temperature of substances. In hot climates, fluids and various articles of diet are preserved at a temperature considerably below that of the atmosphere, by placing them in vessels, from the surface of which evaporation is continually going forwards; and by the proper management of this process, even ice is formed in considerable quantity, for the purposes of domestic economy, at a temperature some degrees above the freezing point. By means of the evaporation of ether, water is easily frozen at the medium temperature of our climate, and indeed a degree of cold may be generated far below that of the freezing point. A still greater diminution of temperature is produced by a solution of certain salts;* a circumstance which depends partly upon the heat that is rendered latent by the conversion of a solid into a liquid, and partly by the mixture possessing a greater capacity for heat than the ingredients in their separate state. To these two circumstances, the change of state which bodies experience, and the change in their capacity, as depending either upon this alteration in their state, or upon the new combinations into which they enter, we ascribe the increase of temperature which occurs in a variety of chemical operations, where caloric is not introduced from any external source. The heat, which is excited by combustion, is to be attributed to the latter cause, the change of capacity in the substances; the products of combustion, particularly the carbonic acid, being supposed to possess a less capacity than the carbon and oxygen before their combination.

Heat produced by solidification.

The cases in which the conversion of a body from the liquid to the solid form actually produces an increase of temperature, are not very numerous; but there are not unfrequent instances in which the rate of cooling is obviously retarded by this process. And in no operation is this more remarkable than in the natural freezing of water. When water is exposed to the influence of external cold, its temperature sinks in proportion as the heat is removed from it, until it arrives at 32°; the refrigeration is then suspended, but the water begins to become solid, and the temperature remains stationary, until the freezing is completed; then the cooling recommences, and is continued until the ice arrives at the temperature of the surrounding medium. The freezing of water, however, under particular circumstances, affords an example of the actual evolution of heat. This takes place in that case which has been described above, where water has been cooled below 32° without becoming solid; if it be then agitated, or a small spicula of ice be introduced into it, the congelation takes place with great rapidity, and the portion of water which still remains fluid instantly rises to 32°. An experiment of an analogous kind may be performed on the crystallization of salts. By proper management, a warm saturated solution of the sulphate of soda may be cooled for several degrees, without any of it beginning to crystallize; if the vessel be then slightly shaken, the process suddenly commences, and a large part of the salt immediately becomes solid, in consequence of which the temperature will be very sensibly raised. The general law, both in this and the reverse operation, is, that the most powerful effect, either of heating or cooling, takes place when the process is performed with the most rapidity, when the substance that has its state or its capacity changed, has its equilibrium with the neighbouring bodies restored in a short space of time, and therefore most perceptibly affects their temperature.

The same kind of experiments which Black performed to establish the absorption of heat, when a solid is

* See Walker's experiments on freezing mixtures, *Phil. Trans.* 1801, p. 120; and our article COLD, vol. vi. p. 733, 734.

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Heat rendered latent in vapour.

converted into a liquid, he afterwards made on the conversion of a liquid into an elastic fluid. He also attempted to ascertain the exact quantity of heat which is rendered latent in this operation, in which he was essentially aided by Mr Watt; and the result of their inquiry was, that when water assumes the state of vapour, it absorbs 950° of caloric.* This number he obtained in two ways: 1st, By comparing the heat necessary to raise the temperature of a certain portion of water to the boiling point, with the effect produced by an equal addition of heat in afterwards evaporating the water; and, 2dly, By finding what quantity of caloric was extricated, when steam is reconverted into water by condensation. We have already mentioned, that when water is strongly compressed, as by being inclosed in Papin's digester, its temperature may be raised far above the boiling point, without its assuming the aeriform state. In this case its tendency to evaporation is mechanically prevented, by the particles not being allowed to separate from each other; and therefore as it cannot alter its form, its capacity remains the same, and its caloric all continues to be in the uncombined state. But if the pressure be suddenly removed from the water, its particles now being at liberty to expand themselves, they unite to a portion of the heat, instantly assume the elastic state, and the remainder of the fluid sinks to 212°.

Capacity for heat illustrated.

We have already explained, in a general way, the meaning of the term *capacity for heat*, and the difference between the absolute and the specific heat of bodies; but we must illustrate the subject with a little more minuteness. As a foundation for our reasoning, it may be assumed, that when equal quantities of the same substance, but at different temperatures, are mixed together, the temperature of the mixture indicates that of the arithmetical mean of the two ingredients. This, however, only applies to bodies of the same kind; for when different substances are employed, it is impossible to predict what will be the temperature of the mixture. Thus if a pound of water and a pound of mercury be mixed at different temperatures, the result will not be the mean temperature; but it will be found that the mercury loses 28°, while the water gains only 1°. Water is therefore said to have 28 times the capacity for heat that mercury has, because it requires 28 times as much to produce the same change of temperature; or, to use a different, and perhaps a more correct phraseology, we say that the specific caloric of water is to that of mercury as 28 to 1. Proceeding upon this principle, and taking water as a standard of comparison, numerous experiments have been made on the specific heat of various substances, particularly by Crawford, Irvine, and Wilcke.

Crawford's experiments. PLATE CCLI. Fig. 4, 5.

The method employed by Crawford was to mix together, at the same temperature, the substance to be examined and water, the specific heat of which is considered as one, being that with which all the rest are compared. He then multiplied the weight of each body by the number of degrees between its original temperature, and the common temperature obtained by their mixture, and the capacities will be inversely as the products: (*On Animal Heat*, 2d edit. p. 96, *et seq.*) It is generally more convenient to employ a definite weight of the substance to be examined, than to measure it by its volume; but when we examine the specific heat of equal volumes of different bodies, we find the same want of correspondence between the results, so as to prove that the capacity for heat is a property which bears no exact ratio to any other physical quality. In the performance of these experiments, much dexterity is requisite, in order to ensure even a tolerable degree of accuracy; and after all, the results of different trials, made upon the same substance, will not always be found to correspond, yet there seems to be no doubt of the correctness of the principle, and, in many cases, we may conceive that we arrive at a near approximation to the truth. See CHEMISTRY, vol. vi. p. 153.

Leslie's experiments.

Mr Leslie has proposed another method of ascertaining the specific heat of bodies; it consists in comparing the time which they occupy in cooling with the cooling of water placed under precisely the same circumstances. The apparatus which he employed was a thin glass globe, furnished with a neck capable of receiving a delicate thermometer. He observed the time necessary for water to cool a certain number of degrees in this globe suspended in the air, then he fills the instrument with another fluid, the specific heat of which he wished to examine, and heats it to the same degree, and suspends it in air of the same temperature, and observes the time necessary for it to cool the same number of degrees. It was found, that, under the same circumstances, water cooled in 70 minutes, while oil required 32 minutes only; therefore, by estimating water at unity, as the standard of comparison, the specific heat of oil will be .46, if we estimate it by bulk, or .5 if we estimate it by weight. *Inquiry*, p. 170.

Lavoisier and Laplace's experiments.

The great difficulty there is in executing experiments, like those of Crawford's, where the substances are mixed together, and the specific heat calculated from the temperature of the mixture, induced Lavoisier and Laplace to attempt to solve the problem by a new method. They proceeded upon the fact, that when ice is melted it must always absorb the same quantity of heat, and therefore that the caloric which is disengaged from any body, by a change in its form, or from the union of two or more bodies, may be accurately measured, by placing the substance in such a situation as that all the heat must necessarily pass into a stratum of ice; and from the amount of water produced by the melting of the ice, the quantity of heat given out may be estimated. The apparatus which they invented to accomplish this purpose, they called a *calorimeter*; it consists of three vessels inclosed one within another, so as to leave a cavity between each of them. The substance which is to be the subject of experiment is placed in the innermost vessel; the second is filled with pounded ice, and is provided with a tube at the bottom through which all the water that is formed is conducted into a suitable vessel, where it may be collected and measured. The outermost space is also filled with ice, in order to preserve the interior of the apparatus at the proper temperature: (*Mem. Acad. Scien.* 1780, p. 368.) This instrument is constructed upon scientific principles, and seems both simple and ingenious; yet we are informed that there are some circumstances which interfere with its practical utility, and we believe it has never been employed except by the inventors. See Wedgewood in *Phil. Trans.* 1784, p. 371, *et seq.*; and CHEMISTRY, vol. vi. p. 154.

Calorimeter. PLATE CCLI. Fig. 7.

Capacity of the gases.

The capacity of gaseous bodies for heat, like that of liquids and solids, varies according to the nature of the individual gas; but the determination of their respective capacities requires a delicacy of experiment, proportionate to the difficulty of operating upon substances

* The late Mr Southern found, from numerous experiments, that the latent heat of steam at the temperatures 229°, 270°, and 295°, is 912°, 942°, and 940°. See Mr Watt's Annotations on Dr Robison's article STEAM in Robison's *System of Mechanical Philosophy*, vol. ii. p. 166.—ED.

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Crawford's experiments.

of so subtle a nature. It has, however, been attempted by Crawford, and prosecuted by him with much perseverance and ingenuity, and made the foundation of some very important doctrines, both in chemistry and physiology. It must indeed be confessed, that the extreme nicety of the process necessarily makes the conclusions liable to much uncertainty; yet the general results have been, for the most part, acquiesced in, although they have been considerably altered since they were originally brought forward. Of late, however, they have been controverted by MM. Delaroche and Berard, who have published a very elaborate set of experiments, which they performed upon the specific heat of the gases, in which they employed an apparatus of a new construction. It is in fact a calorimeter; but instead of measuring the heat which is extricated by the quantity of ice which it will melt, they endeavour to ascertain what quantity of heat the gas will impart to a mass of water; and for this purpose a current of the gas is sent along a serpentine tube, which traverses a cylinder of water. The instrument appears to us to be very complicated, and to require a great share of manual dexterity in the operator, a circumstance which we always consider as very objectionable: (*Ann. Chim.* lxxxv. 72.) But although their results differ considerably from those of Crawford, they agree with him in the general principle, that the specific heat of the gases is different from each other, whether we attend to their volumes or their weights, and that there is no relation between the specific gravity of the gases and their specific heat. See Description of Plates at the end of the Volume.

Delaroche and Berard's experiments.

PLATE CCLXXXIX. Fig. 12, 13, 14, &c.

Capacity of gases affected by their density.

Besides the difference in their capacities for heat, which gases possess in consequence of a difference in their nature, this property is also much affected by the degree of compression which they experience, or is in proportion to their density. It is consequently observed, both in experiments performed for the purpose, and in many natural processes, that the sudden condensation of air generates heat; and, on the contrary, that sudden dilation produces cold. Whenever an expansion of air takes place, either from the removal of pressure, or from any other cause, the particles are more widely separated from each other, in consequence of their elasticity being now at liberty to exert itself; and it would appear, that a quantity of caloric necessarily rushes in to supply the vacuity. This, although merely a mechanical view of the subject, appears to be rendered probable by the fact, that the emission and absorption of heat are respectively produced by causes, which can only be supposed to act, by bringing the particles of the gas nearer together, or removing them farther asunder. If a thermometer be placed in the receiver of an air pump, and the air be quickly exhausted, the mercury will sink several degrees; and if, on the contrary, air be rapidly condensed by the appropriate apparatus, the mercury is considerably elevated. (Dalton in *Manch. Mem.* vol. v. p. 515.) The heat which is excited by condensing the atmosphere in the barrel of an air-gun is well known; and by employing it in the most advantageous manner, sufficient heat may be extricated to set fire to a piece of tinder. If a part of the apparatus be composed of glass, a flash of light is perceptible, when the stroke of the piston is made with great force and rapidity. The effect of the rarefaction of air in promoting the absorption of heat, is well illustrated in Professor Leslie's new method of forming ice. (See our article COLD, for a full account of this process.) In this process, water is placed in a shallow dish over a vessel containing sulphuric acid; the whole being enclosed in the receiver of an air-pump, and a vacuum produced. As the exhaustion proceeds, the quantity of heat abstracted from the water, in order to supply the evaporation, quickly converts the whole into ice. The sulphuric acid, in this case, promotes the effect, by its attraction for the aqueous vapour, which it absorbs as fast as it is generated. A still more striking effect of evaporation has been exhibited by Dr Marcet. He enclosed a quantity of mercury in a bulb of thin glass; this was wrapped up in cotton, which was soaked in the very evaporable fluid, the sulphuret of carbon; the apparatus was then placed under the receiver of an air-pump, and the exhaustion produced, when the mercury was completely frozen: (*Phil. Trans.* 1813, 252.) The ingenious instrument invented by Dr Wollaston, which he called the *cryophorus*, acts upon the same principle. It consists of a glass tube of some length, each extremity of which terminates in a globe about one inch in diameter, and bent at a right angle to the tube; one of the globes is half filled with water, while all the remainder of the apparatus is carefully exhausted of air. If the empty globe be plunged into a freezing mixture, the aqueous vapour with which it is filled is so rapidly condensed, that a portion of the water in the second globe is immediately frozen. *Phil. Trans.* 1813, 71.

Heat and cold by condensing and rarefying air.

Leslie's method of forming ice.

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Marcet's experiment on freezing mercury.

Wollaston cryophorus.

PLATE CCLXXXVII. Fig. 10.

Watt on the capacity of steam.

The condensible vapours, such as the steam of water, are more expansible than the permanent gases; and it has therefore been conceived, that they will acquire a greater degree of heat when they are permitted to enlarge themselves, by removing from them the pressure of the atmosphere. Mr Watt proved that this was the case, in some experiments which he performed on the distillation of fluids *in vacuo*; a process which has been recommended as an economical project, in consequence of the smaller quantity of caloric which is necessary, under these circumstances, to convert the liquid into a vapour. But this he found was counterbalanced by the greater capacity for heat of the vapour, when in its most rarefied state. By taking off a considerable part of the atmospherical pressure, water could be distilled at a temperature of 100°; but its latent heat then appeared to be 1048°, instead of 840°, the latent heat of steam generated in the atmosphere. With the most perfect vacuum that could be formed, water may be distilled at 78°; but then the latent heat is still farther increased, so as to be about 1300°. Mr Watt estimated, that when water is converted into a vapour, under the ordinary pressure of the atmosphere, it is expanded into about 1800 times its former bulk. *Phil. Trans.* 1784, 335; and Black's *Lectures*, vol. i. p. 190.

Irvine on the real zero.

Dr Crawford, from his experiments on the specific heat of bodies, was led to form the conclusion, that while their state remains unchanged, their specific heat continues to bear the same relation to their absolute heat. Taking water as the standard of comparison, if we can discover what proportion the specific heat of this fluid bears to mercury at the usual temperature of the atmosphere, we may suppose that the same proportion will exist at all temperatures. Upon this principle was founded the proposal of Irvine, for ascertaining the real zero, or that point of the thermometric scale at which, if it be supposed to be sufficiently extended, bodies would be deprived of the whole of their heat. Thus it had been found by experiment, that the capacity of ice is to that of water as 9 to 10, and the actual quantity of latent heat in water was estimated at 140°; therefore ten times 140°, or 1400° below the freezing point, was supposed to be the temperature at which water is absolutely deprived of all heat. (Nicholson's *Chemistry*, p. 16; Crawford *On An. Heat*, p. 435.) The

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proposal of Dr Irvine is certainly ingenious; but we conceive the problem to be one, which we are still very far from being able to solve with any degree of accuracy. Indeed, the fundamental positions, upon which the whole hypothesis rests, are themselves very dubious, and the experiments which have been performed on the subject by different philosophers, have been attended with such very discordant results, as to show, that either the theory or practice must be extremely imperfect. Besides Irvine's, the principal experiments which were performed, are those of Crawford, Gadolin, Lavoisier in conjunction with Laplace, and Seguin. Of these, Gadolin's seem to have been executed with the greatest care and accuracy, and they approach the most nearly to those of Irvine. His method was to ascertain the capacity of common salt, and also of its solution in water, and then he observed the degree of cold which is produced during the solution. He afterwards examined the quantity of heat which was absorbed by the mutual action of common salt and snow, and the heat extricated by the mixture of sulphuric acid and water; and, by comparing these with the capacity of the bodies before their union, he endeavours, as before, to determine the proportion which their absolute bore to their specific heat. (Crawford *on An. Heat*, p. 457, *et seq.*) Lavoisier and Laplace employed the calorimeter, to measure the quantity of heat disengaged during the mixture of certain substances, comparing this with the capacity of the bodies separately; but it would appear, that their experiments were more liable to inaccuracy than those of Gadolin, and their results are completely at variance with each other: (*Mem. Acad. Scien.* 1780, p. 384, *et seq.*) Mr Dalton has attempted to discover the real zero, by a calculation depending upon his idea of the constitution of an aeriform fluid, and the relation which subsists between its basis, and the caloric which enters into its composition. Without attempting a detail of his hypothesis, we shall merely state his conclusion, that the absolute quantity of caloric in elastic fluids at different temperatures, is in the direct ratio of the cube roots of their bulk at the same temperature: (*Manch. Mem.* vol. v. p. 601.) How far this hypothesis may have any foundation in fact, we do not feel at present competent to decide; but it has been asserted, that experiments made upon this principle at different temperatures, and upon various substances, do not correspond to each other.

Gadolin's experiments.

Cause of the capacity of bodies.

From the remarks that have been made, it will appear, that Dr Black's discovery of the existence of what he called latent heat, or of a difference in the capacity of bodies for heat, is a fact completely established by experiment, and one of the most important in the whole range of chemical science. Very different opinions, however, have been entertained respecting the manner of accounting for the fact, and especially the question has been warmly agitated, whether the absorption of heat when a solid is converted into a liquid, is to be regarded as the *cause* or the *effect* of this change of state. Dr Black conceived that it was the cause of the change; that the body in question, as for example, a portion of ice, being exposed to the influence of caloric, this principle necessarily enters into it, becomes combined with its particles, and is not capable of producing any effect until it be again extricated by the liquid changing its form, or entering into some new combination. Dr Irvine adopted the contrary opinion, and regarded the absorption of heat as the consequence of a change of capacity which the ice undergoes when it is converted into water, which change of capacity necessarily causes it to absorb, and render latent a quantity of heat: (Black's *Lect.* vol. i. p. 194.) Dr Irvine's opinion seems to be supported by the fact, that there actually is this difference of capacity in the substance; but then it does not appear to assign any cause for the change of state which the body undergoes. If we adopt it, we are obliged to assume as a principle, that when the solid is so situated as to receive above a certain quantity of heat, its particles are suddenly forced to a considerable distance from each other, in consequence of something peculiar in its nature and constitution; and that when this separation has been effected, the capacity becomes increased, and the caloric of course absorbed. Dr Black conceived, that the caloric was united to the body by a power similar to chemical attraction; and if we adopt this opinion, it would follow, that at certain temperatures substances acquire different degrees of affinity for heat, and form with these quantities an intimate union, which renders it no longer cognizable by the ordinary means.

Black's opinion.

Irvine's.

4. Ignition.

4. The last effect of heat, which yet remains for us to consider, is *ignition*. Ignition, or, as it is sometimes called, *incandescence*, is the property which some bodies possess, after being exposed to a high temperature, of becoming luminous, without any chemical change taking place in their composition. In this respect, it differs essentially from combustion, where the body extricates light, but where it is found to have experienced a complete change in its chemical nature. Combustion also differs from ignition in another particular, that, in the former process, the co-operation of the atmosphere, or some other external substance, is necessary; whereas the latter is capable of existing without the intervention of any other body. It has been conceived, that, by proper management, all solids, and even liquids, may be rendered luminous, or brought into the state of ignition; and Mr Wedgewood performed some experiments, which lead to the conclusion, that they all undergo this change at the same temperature. Many philosophers have attempted to find out the exact degree at which ignition commences; and although their processes do not furnish precisely the same result, yet they correspond so far, as to render it probable, that it must be somewhere between the 800° or 1000° of Fahrenheit. Mr Wedgewood supposes, that a body becomes just luminous in the dark at 947°; and that a full red heat, visible in open daylight, takes place at 1077°. According to the intensity of the temperature, the colour of the ignited body is altered. At first, it exhibits what has been called a cherry red; afterwards, the red acquires a yellowish tinge; and, lastly, all colour disappears, and we have only a brilliant white light: (*Phil. Trans.* 1784, p. 370.) It is generally supposed, that aeriform fluids are not capable of being ignited. A quantity of air, heated to such a degree that a piece of metal, when suspended in it, was rendered luminous, was itself quite invisible.

Wedgewood's experiments.

Cause of Ignition.

Respecting the cause of ignition, two opinions have prevailed; the first, that light is a modification of heat, and that, at a high temperature, the one becomes converted into the other; the second, that light actually exists as a component part of different bodies, and that, when the body is strongly heated, the light is propelled or disengaged from it. It is perhaps impossible to adduce any direct arguments in favour of either of these hypotheses; but the general relations of heat and light are in many respects so different from each other, that we are induced to adopt the opinion which supposes them to depend upon the agency of principles essentially dissimilar. This, however, we advance as a doctrine which must be confirmed or refuted by future observations and experiments.

Sources of Heat.

SECT. III.

Sources of Heat.

Sources of heat.

After having described the properties and effects of heat, we must now give an account of the sources whence it is derived. Those that are usually enumerated are the following: the rays of the sun,—combustion,—a change in the capacity of bodies, and their chemical union,—the mechanical means of producing heat, as friction, percussion, and condensation,—and, lastly, the electric and galvanic discharge. The great source of heat to our world, and probably to the rest of our solar system, is the radiant caloric which is projected from the sun. When a sufficient number of rays are collected into one spot, either by a concave mirror, or by a convex lens, the most powerful heat is excited of which we have any conception; and we are capable of producing effects by it, which we cannot otherwise accomplish. The effect, however, is necessarily confined to a small spot; and therefore it can only be employed in refined operations of analysis, or for the purpose of delicate philosophical processes. It would appear, from an experiment of Rumford's, that the great heat excited in these cases, depends entirely upon the concentration of the rays, and not upon any change in their nature; because, when he directed a certain portion of the sun's rays against a substance adapted for absorbing them, the total amount of heat communicated to it was the same, whether the rays were received on the surface in a diffused state, or brought into a small focus.

Solar heat.

Combustion.

The most important supply of heat which we have it in our power to produce at pleasure, is that which depends upon combustion. Nearly all the heat which we employ for domestic and manufacturing purposes, proceeds from the burning of fuel; an operation of a strictly chemical nature, in which a union takes place between the fuel and the oxygen of the atmosphere, the result of which is a combination of the combustible matter with the oxygen, and the extrication of a quantity of heat and light. It has been a much controverted question, whence does the heat proceed in this operation? The discussion is strictly chemical, and must therefore be dismissed with a few observations. A part of the heat liberated probably depends upon the less capacity of the product of combustion, than of the substance supporting it, *i. e.* of carbonic acid, than of oxygen and carbon separately; but there are instances in which the quantity of heat extricated appears to bear no proportion to the bulk of the materials consumed, or of carbonic acid formed; and hence we are induced to conjecture, that heat exists as an ingredient in combustible substances, and is disengaged from them in consequence of the changes of composition that take place. It has been supposed, that, besides what necessarily belongs to it as a gas, oxygen contains caloric as one of its constituents, which is liberated by a kind of precipitation; and the phenomena which attend the detonation of gunpowder lead us to conclude, that caloric also enters into the composition of the nitric salts, and others that possess similar properties. Of the heat produced by a change of capacity, in consequence of an alteration in the state of a body, or of new combinations, we have already spoken at sufficient length in the last Section.

Heat produced by mechanical means.

There are few subjects connected with heat, which are more inexplicable, than the manner in which it is generated by those means which appear to act mechanically, as friction, percussion, and condensation. The latter of these operations, condensation, has already come under our notice, in treating of the change of capacity which gases experience, according as their particles are compressed together, or allowed to expand themselves; and the same effect, at least to a certain extent, seems to follow from the condensation of solids. A very familiar instance of this occurs in the heating of a bar of iron merely by repeated hammering, where, by a few smart blows on the anvil, the smith is able to produce a sufficient extrication of heat to kindle a match. It is, however, known that iron does not possess this property of producing heat by being hammered, unless it has been previously heated for some time in the forge, and suffered to cool slowly in the air; and that, after it has been hammered, and lost part of its heat, its texture seems to become harder, and it is rendered less flexible than before the operation. The rolling out of metals into thin sheets or leaves, and the drawing of fine wires, likewise excite heat, which is to be referred to the compression the substance undergoes during these various operations. In all these cases there is some reason to suspect, that the bodies have had their capacity diminished, and that the heat, which becomes sensible, is to be assigned to this change. The effect of percussion may perhaps be explained on the same principle, as we may conceive, that, whenever percussion takes place, it must cause a proportionate condensation. It is to be remarked, that liquids seem to be incapable of extricating heat, either by any attempts at condensation, or by any kind of percussion; and as they are supposed to be nearly incompressible, we may conceive that their capacity is not liable to be affected by these means. Gases, however, which are readily compressible, are capable of having heat extricated from them, to a considerable amount, by condensation; and here we suppose that their capacities are changed, and in this way we account for the effect.

Sources of Heat.

Condensation.

Percussion.

Friction.

This mode of reasoning will not, however, apply to the extrication of heat which is caused by friction. The power of friction in producing heat, in various mechanical operations, is the subject of daily observation, and, if not prevented by different expedients, produces the most fatal consequences. The motion of wheels, and pulleys upon their axes, excites a degree of heat, which would quickly set fire to the machinery, was it not prevented by the application of different lubricating substances, which diminish the friction, by interposing between the hard surfaces a body which readily yields to the impression. The quantity of heat generated in these cases is so considerable, and seems so disproportioned to any effect that can be attributed to a change either in the capacity or chemical nature of the body employed, as to have been always regarded a serious objection to the hypothesis, which regards heat as a substance capable of being transferred from one body to another, like other material agents. The objection was reduced to a more palpable form by Rumford, who estimated the exact amount of the heat, which was produced by a certain degree of friction, where all other extraneous sources for its admission were carefully guarded against. A piece of brass was fixed in a machine used for boring cannon, and a steel cylinder was pressed against the brass, with a weight equal to 1000 lbs. and then made to revolve on its axis with a given velocity. After some preparatory experiments, the apparatus was all inclosed in a vessel of water; and after the friction had been kept up for some time, the water

Rumford's experiments.

Sources of Heat.

was actually brought to the boiling heat. Here a very considerable quantity of heat was liberated, and the only mechanical change effected upon the materials was, that a quantity of brass turnings were formed; but neither these, nor the cylinder itself, appeared to have experienced any change, except a slight degree of compression. Rumford found by experiment, that the capacity of these turnings would not be affected by the operation; and the effect of the compression, which the metal had experienced, must have been very inconsiderable. Yet the power of the substance to extricate heat was apparently unlimited; for there is no reason to suppose that any thing like exhaustion was produced, or that the apparatus would not have continued to evolve heat, until its texture had been destroyed, by the brass being all reduced into small fragments: (*Essays*, vol. ii. p. 469, *et seq.*) Upon this experiment we shall offer some remarks in the next Section, where we treat upon the nature of heat.

Galvanic shock.

The heat excited by the electric or galvanic shock has been commonly referred to a mechanical cause, although, upon this point, a considerable diversity of opinions has prevailed. The effect, however, is well known to be very powerful, perhaps even more so than that produced by the convex lens; but it is still more confined as to the extent of its operation. If the two wires, in the interrupted galvanic circuit, be brought nearly into contact, and any substance, in very minute quantity, be placed upon them, it may be subjected to a temperature more intense than can be produced in any other manner; and by this means bodies have been burned or fused that had been before completely intractable. Whether in this operation the heat is, as it were, merely forced out of the wire by the commotion which its particles experience from the passage of the galvanic influence; or whether, as has been supposed, under certain circumstances, heat and electricity can be converted into each other, or may be separated by a kind of decomposition, are intricate questions of theory, upon which it seems at present beyond our power to decide, and which must depend very much upon the opinion that we entertain respecting the nature of heat. The simple facts, however, independent of hypothesis, seem to indicate, that heat and electricity are distinct from each other, whether they are to be regarded as species of subtile fluids, or only as properties of matter.

SECT. IV.

On the Nature of Heat.

Nature of Heat.

After having made ourselves acquainted with the properties that are usually ascribed to heat, with the effects which it produces, and with the sources whence it is derived, we shall be more competent to enter upon the investigation of its nature. This has been a subject of discussion from the earliest period of philosophical inquiry, and is yet far from being determined; for although the most generally received opinion is in favour of its being a substance, capable of a separate existence, and possessed of a material, although very subtile nature; yet there are, on the contrary, many eminent men who regard it as merely a property, necessarily attached to other matter, and arising from some peculiar modification or affection of it.

Bacon's opinion.

The illustrious Bacon adopted this latter hypothesis, and conceived that heat depended upon a vibration of the particles of matter; an hypothesis which he endeavoured to substantiate by showing, that whatever excited temperature, tended to produce a motion in the particles of the heated body. His description of this peculiar action is, that " heat is an expansive motion, restrained and resisting in the minute parts;" a phrase which, if expressed in modern language, would probably signify a reaction between the expansive power of heat, and the attractive force of the particles of matter towards each other. The idea of Bacon, that heat depends upon a vibratory motion among the particles of matter, received the powerful sanction of Boyle and Newton. As, however, observations on the phenomena of nature were multiplied, and especially as chemical science advanced, the hypothesis which considered heat as merely consisting in motion of the particles of matter, appeared less easy to reconcile with the new discoveries, and consequently a different doctrine was advanced, in which the effects of heat were attributed to a species of subtile fluid, of a proper material nature, although differing, in many important particulars, from any other kind of matter. The first writer who distinctly maintained this doctrine, and applied it in a philosophical manner to the explanation of facts, was Boerhaave; and it was, for the most part, embraced by the French. The general impression that was produced by Dr Black's discovery, was much in favour of the materiality of heat; and indeed it seems very difficult to imagine, how a mere property can be so exactly measured, and can be transferred from one body to another, at one time rendered latent, and again coming into action, without its quantity being either increased or diminished. The successive discoveries of Crawford and Irvine, together with the whole fabric of the Lavoiserian chemistry, strongly favour the same opinion; so that, in the present day, it must be regarded as the hypothesis which is by far the most generally received. It has, however, been zealously opposed by Rumford; and the experiments on the heat excited by friction, of which we have given an account, were brought forward as an unanswerable objection against it. Our limits will not permit us to take a very full view of all the arguments that have been urged on both sides of the question; but we must endeavour to give a sketch of some of the principal points that have been adduced by the advocates of each of the opinions. It will scarcely be denied, that if we admit the existence of a subtile elastic fluid, the particles of which are endowed with a repulsive power, which tends to unite itself to all kinds of matter, to insinuate itself into their pores, to produce their expansion, and, if added in sufficient quantity, to impart to them its own elastic nature, we are in possession of an agent, which very conveniently explains a great variety of phenomena; for excepting the experiments of Rumford on friction, and others of a similar nature, we do not know of any facts which are adverse to the supposition, or which are not better explained on this than on any other that has been adduced. It must, however, be admitted, that it is merely an hypothesis; and as there is no direct experiment which proves the existence of this subtile elastic fluid, it must be abandoned, if there be any single phenomenon which is absolutely irreconcilable to it. But before we can allow this to be the case, in the present instance, it is necessary to shew, that our acquaintance with the phenomenon in question is complete; that we thoroughly understand all its relations, and are competent to decide upon the connexion which it has with all the other actions

Nature of Heat. Boerhaave's. Black's doctrine. Rumford's opinion. Heat excited by friction supposed to prove its immateriality.

Nature of Heat.

to which it may be referred. Now we believe that few persons will assert that this is the case; on the other hand, we conceive every one will admit, that any attempt to explain the intimate nature of the motion supposed to produce heat, and the manner in which vibrations can excite a sensation such as that which we refer to this principle, must be a most arduous task. Still more so will it be to explain, how it can be the immediate cause of liquidity and of elastic fluidity; how it can be transferred in definite quantities from one body to another; how this can be done even while it is lying dormant, or while we have no proof that the motion actually exists. In short, we shall find, that the hypothesis of vibrations is far from being unencumbered with difficulties; and that we have only removed one, to become involved in a much greater number. Besides, although we have admitted, that there is no direct experiment to prove the independent existence of heat, or at least none against which some exception has not been taken; yet there are facts brought forwards, perhaps as decisive on this side of the question as those respecting friction are on the other. We refer to the transmission of heat through a vacuum. Pictet proved that this takes place in the vacuum of the air-pump; and Rumford, the great advocate for the immateriality of heat, has shown that it is capable of passing even through the Torricellian vacuum. There seems no method of reconciling this fact with the hypothesis, except by taking for granted the existence of some kind of vapour or elastic fluid, along which it is propagated; a supposition equally gratuitous, and equally unsupported by direct and independent facts as that for which it is substituted. Indeed, the same remark may be applied to all the phenomena in which the radiation of heat is concerned; it seems extremely improbable, if not impossible, that these rays are carried along by the air, even when near the surface of the earth, and they must necessarily traverse an immense track totally devoid of air. If we, in this case, suppose the existence of a subtile medium, invented for the purpose of carrying them through space, we are here, as in the former instance, creating an agent at least as hypothetical as the matter of heat. Upon the whole, we are strongly inclined to the opinion which regards heat as an elastic fluid, of a proper immaterial nature, although of extreme subtilty, the particles of which are repulsive with respect to each other, but are attracted by other bodies, with different degrees of force, according to their respective nature.

Proof not complete.

Heat passes through a vacuum.

Is heat possessed of gravity?

Before we conclude this discussion concerning the immateriality of heat, it will be proper to notice the experiments which have been made, in order to ascertain whether it be actually possessed of gravity, or rather, whether its weight can be measured by a balance. The best contrived experiments of this description were those of Fordyce. He very carefully weighed a quantity of water, froze the water, and then again weighed it. Now he argued, that in this process, the water must have parted with the latent heat which maintains it in the liquid form; so that if heat be a ponderable substance, it might be expected that the ice would exhibit a diminution in its weight, equivalent to that of the caloric which had escaped. The result, however, did not correspond with this idea; and indeed, in some of the most accurate trials, it seemed as if the body that had parted with its heat had even acquired a slight addition of weight. It is, however, generally admitted, that no decisive conclusion can be drawn from such experiments; and that, from the conception that we have of the extreme tenuity of the particles of heat, it is not probable, that any portion which we can have it in our power to impart to a body, could be detected by the instruments that we employ in ascertaining the weight of bodies. Our preference, as we stated above, is certainly in favour of the hypothesis of the materiality of heat, because we think it explains the phenomena in general with greater facility, and is encumbered with less difficulties than the immaterial hypothesis. Yet we must remember, that it is not decisively proved by any direct and unexceptionable experiments; and it must also be acknowledged, that it has not received the sanction of some eminent philosophers, both at the revival of letters, and in our own times. We have already mentioned the opinion of Rumford; and Professor Leslie, to whom science is so peculiarly indebted for his numerous experiments and discoveries on the subject of heat, also adopts the hypothesis, which ascribes its effects to a certain motion among the particles of bodies. He conceives that the propagation and transmission of heat, is very similar to that of sound, and that it in fact consists in certain aerial undulations. A hot body communicates a portion of its heat to the contiguous stratum of air; this immediately expands, and by this expansion, a vibration is excited in the adjoining stratum; this is propagated to the next, and so on until the equilibrium is produced. The passage of heat is therefore of the same velocity with the undulation of the air, or rather is identical with it; and according as the surfaces of bodies act upon the air in contact with them, so will they radiate heat with greater or less readiness. The facility of radiation is supposed to be principally owing to the approximation of the air to the surface; those bodies radiating the best, to which the air comes into the closest contact. This view of the subject explains why the best radiators should likewise be the best absorbers of heat; and it is also supposed to afford a reason for the effect of roughening the surface, or covering it with substances which destroy its polish. Professor Leslie seems to have advanced his hypothesis, merely as a convenient manner of accounting for some of his own experiments; he has not stated it in such a way as to apply to all the phenomena of heat, nor has he attempted to reconcile it with the experiments of Herschel, and others which appear decidedly adverse to it. Indeed, we much doubt whether it can be adapted even to some of his own experiments on the radiation and reflection of heat; for it must be supposed, that the undulations of the air are propelled from the surface of bodies, impinge upon others, and are again reflected, exactly as they radiate heat, with the same velocity, and in the same direction; a circumstance which we apprehend it would be extremely difficult to prove. It may be farther remarked, that although Professor Leslie's hypothesis supposes that the undulations of the air are the cause of heat, or that which produces the phenomena in question; yet there are many expressions which would seem to imply, that this heat is something distinct from the undulations themselves, and that the heat is transferred or transmitted from one wave to the other, not that the waves are themselves the actual cause of the effect. The farther consideration of this question would involve us in a discussion that would exceed the limits to which we are necessarily restricted.

Fordyce's experiments.

Leslie's hypothesis.

Chemical properties of heat.

In the former part of this article we alluded to the chemical properties of heat, but we proposed to defer the consideration of them until we had made ourselves more fully acquainted with its nature and its effects. On this subject there are two points to be determined:

Nature of Heat.

first, Does heat possess any properties, or any relation to other bodies, which can strictly be called chemical? And, secondly, What are these relations? When we speak of a substance being possessed of chemical properties, we mean, that by its being separated from, or added to another substance, the two substances, in the case of their decomposition, or in the other case, the compound of the two, manifest different chemical relations from those which they possessed before the operation. By some philosophers it has been supposed that this change takes place with respect to heat, that when it enters into combination with a body, as for example with oxygen, and forms oxygen gas, a compound is produced, possessed of new properties that are not merely mechanical, while at the same time the heat itself has entirely lost its former qualities by its union with the oxygen, and, like other bodies after a chemical composition, has imparted to the compound properties quite different from its own. If we again decompose the oxygen gas, as by uniting its base to carbon, the heat is precipitated, and resumes all its former properties, which had been entirely destroyed, or rendered latent, while it remained in the combined state. But although there may appear to be a considerable degree of plausibility in this method of reasoning, it has not been generally acquiesced in. The great objection which has been urged against the opinion that heat unites chemically to bodies, is that it may, in all cases, be separated from them, merely by a reduction of temperature, without the intervention of a more powerful affinity; a circumstance which is conceived to be essential to a proper chemical decomposition. With respect to the new properties which heat imparts to other substances, by its union with them, these have been said to be merely mechanical, or to be such as must necessarily result from these particles being placed at a greater distance from each other. As to the heat itself, there is undoubtedly something more analogous to chemical union, in the changes which it experiences; as by entering into combination with other bodies, its characteristic properties are all destroyed. Yet this involves a discussion rather about words than ideas, and in a great measure depends upon the meaning which we attach to certain modes of expression. The fact is, that heat seems to have elective attractions for different bodies, independent of any of their relations to other substances; that it combines with them, and produces a change in their state, which perhaps may be regarded as merely mechanical; but that by these combinations its action is destroyed, and it no longer possesses the properties it previously exhibited. Upon the whole, we are inclined to the opinion, that the effects of heat are not referable to the usual laws of chemical affinity, but must be referred, partly to those of mechanical impulse, and partly to what we may denominate specific action, *i. e.* an action peculiar to itself, and essentially different from what we can observe in other natural objects. See our articles Cold and Expansion. (α)

General conclusion.

APPENDIX.

Appendix.

In the preceding article, we have given an account of the experiments of Dr Herschel, Sir H. Englefield, and M. Berard, from which it follows, that there exists beyond the red extremity of the spectrum a set of invisible rays, which affect the thermometer more powerfully than even the red light of the spectrum.

Sir H. Davy's experiments on the invisible rays.

These experiments were repeated, under the most favourable circumstances, by our celebrated countryman Sir H. Davy, who favoured us with an account of them when we had the pleasure of seeing him at Geneva. Availing himself of the fine climate and the serene sky of Italy, he resolved to inquire into the cause of the difference between the results obtained by Dr Herschel and Berard; the former having placed the point of maximum intensity beyond the red rays, while the latter found the heat greatest within the extremity of the red space. It occurred to Sir Humphry, that thermometers with circular balls of the size used by Berard, must necessarily shew the maximum of heat to be within the red space, as a cooling agency must always be exerted by that part of the bulb which is out of the limits of the calorific rays; and hence the diminution of temperature which this occasioned would compensate for the greater effect produced by the invisible rays. In order to remove this source of error, Sir H. Davy employed extremely slender thermometers, not more than $\frac{1}{12}$th of an inch in diameter, with very long bulbs filled with air confined by a coloured fluid; and in this way the bulb was affected only by the invisible rays. The general results of these experiments, which were repeated also at Geneva, confirmed those of Dr Herschel, and may be considered as removing the objection of Professor Leslie, that, in our climate particularly, there must always be a concentration of extraneous light beyond the red extremity of the spectrum.

We regard it, therefore, as a point established in physics, that there is a distinct effect produced upon the thermometer beyond the red extremity of the spectrum; but we cannot admit for a moment the conclusion which has been universally drawn from it, that it is produced by a separate set of heat-making rays, refracted by the prism, and having a greater refrangibility than red light. Dr Herschel has attempted to prove that invisible culinary heat is also susceptible of refraction like the invisible rays, and M. Prevost and M. Delaroche have likewise endeavoured to shew that this kind of heat is capable of permeating glass. We have no doubt that this opinion will be found to be erroneous, and we think it is demonstrated * that invisible culinary heat is incapable of refraction, or of permeating glass like light, and hence we cannot suppose that the invisible rays of the sun are capable of being refracted by glass. If this shall be found to be the case, it will follow that the invisible heat of the sun is a substance possessing properties essentially different from those of invisible culinary heat. As radiant heat, therefore, possesses very different properties from light, we think it will be found, that light, like all other matter, whether gaseous, fluid, or solid, is capable of being heated, and that the solar rays are nothing more than *heated light*. Hence the least refrangible rays, having the greatest velocity, or momentum, will produce the most powerful calorific effect. We shall have occasion to resume this subject in another part of our work. See Optics. Ed.

Heat is incapable of permeating glass.

* See *Phil. Trans.* 1816, p. 105.

INDEX.

Hebrews || Hebrides, New.

HEBREWS. See Jews.

HEBRIDES See ARGYLESHIRE, ARRAN, BUTE, STAFFA, and SCOTLAND.

HEBRIDES, NEW, a cluster of above twenty islands in the south Pacific Ocean, extending about 375 miles in a direction from N. W. to S. E. and situated from 14° 29′ to 20° 4′ S. Lat. and 166° 41″ to 170° 21′ E. Longitude.

The appellation which is now bestowed on this groupe, results from its complete recognition by Captain Cooke in 1774. So long ago as the year 1606, the Spanish navigator Quiros landed on the most northern island, which he seems to have considered as a continent, and called it *Tierra Austral del Espiritu Santo*, or the southern land of the Holy Ghost. Bougainville, in his voyage of discovery in 1768, found it an island; and after a partial examination of the group, named it the Archipelago of the Great Cyclades; but almost all geographers seem inclined to admit the nomenclature of Captain Cook, who was occupied 46 days in the survey; and considering these islands the most western of the Pacific, he named them Hebrides. Nevertheless, Fleurieu questions Captain Cook's right to change the appellation of Great Cyclades, bestowed by Bougainville, and expresses a hope that the name given by both will be superseded by restoring that of Quiros.

These islands are of unequal dimensions, and separated from each other by channels of different breadth. But the following list, obtained from collating the narratives of successive navigators, will more briefly explain these peculiarities, making some allowances for the whole not being seen exactly under the same aspect.

Pic d'Etoile, 14° 29′ S. Lat. 168° 9′ E. Long.—Tierra Austral, 66 miles long, 36 broad. St Bartholomew.—Isle of Lepers, 54 to 60 miles in circuit, 15° 20′ S. Lat. 168° 31′ E. Long. Aurora Island, 36 miles long, 5 broad, 15° 6′ S. Lat. 168° 24′ E. Long. Whitsuntide Isle, 33 miles long, 8 broad, 15° 45′ S. Lat. 168° 28′ E. Long. Mallicolo, 54 miles long, 24 broad, 15° 50′ S. Lat. 169° 38′ E. Long. Ambrym, 60 miles in circuit, 16° 15′ S. Lat. 168° 20′ E. Long. Apee, 60 miles in circuit, 16° 42′ S. Lat. 168° 36′ E. Long. Paoom, 15 miles in circuit. Three Hills Island, 12 or 15 miles in circuit, 17° 4′ S. Lat. 168° 32′ E. Long. Shepherds Isles. Monument. Two Hills.—Montague Isle, 9 miles in circuit. Hinchinbrook Isle, 14 miles in circuit. Sandwich Island, 75 miles in circuit, 17° 40′ S. Lat. 168° 30′ E. Long. Erromango, 90 miles in circuit, 18° 48′ S. Lat. 169° 20′ E. Long. Tanna, 72 miles in circuit, 19° 30′ S. Lat. 169° 38′ E. Long. Irronan.—Immer, 15 miles in circuit. Annatom, 30 to 36 miles in circuit, 20° 3′ S. Lat. 170° 5′ E. Long.

Some of these islands contain volcanoes, such as Ambrym and Tanna; that on the latter throws up prodigious columns of fire and smoke, attended with loud explosions at frequent intervals, and huge stones are sometimes seen in the air. Native sulphur is found on the island, and nephitic vapours arise from the ground. Quiros affirms that he and another Captain saw silver and gold on the Tierra Austral; but this has not been confirmed; nor are we particularly acquainted with the mineralogy of the New Hebrides, unless in their exhibiting volcanic products, red ochre, and chalk. Hot springs issue from the rocks of Tanna, raising the thermometer to 202°.

Vegetables grow throughout these islands in great profusion and variety. Quiros, who wrote a recommendatory memoir to his own court regarding the island upon which he landed, describes it as of greater fertility than Spain; and later navigators have remarked that the hills of other islands were covered with woods to the very top. Trees occur 150 feet high. Figs, nutmegs, and oranges, which Captain Cook found nowhere besides, grow here, as well as cocoa-nuts, bananas, the bread fruit, and the sugar-cane.

Fish are numerous on the shores, but many are poisonous; and the crew of different ships have suffered severely, though not fatally, from having fed upon them.

Large and beautiful parroquets, of black, red, and yellow plumage, are seen on the islands; and, among other birds, that species of pigeon which feeds on the nutmeg, and is described by Rumphius as disseminating the real plant in the Spice Islands. Quiros speaks of goats; but the only quadrupeds observed by later visitors are hogs and rats. No dogs have been observed by strangers on any of the islands visited by them; nor have the natives any name for the animal, which shews that it is unknown.

The New Hebrides are evidently inhabited by different races of people, whose origin some navigators are inclined to derive from Papua or New Guinea. None possess that symmetry and stature seen in other parts of the Southern Pacific Ocean. Those of the Tierra del Espiritu Santo seem more robust and better formed than most of the rest. Bougainville describes the natives of Lepers Isle as small, ugly, and ill made, and the few women observed were altogether as disgusting as the men. The inhabitants of Tanna are of middle size, their limbs well made and rather slender; and some are tall, stout, and strong. Their features are large, the nose broad, eyes full, and in general with an agreeable expression. The hair is black; but, in several instances, with brown or yellow tips. Brown and reddish hair has appeared here and elsewhere; but it is frizzled and woolly for the most part. The women of the Mallicolese present the most disagreeable features of any seen in the South Seas; and the daubing of their whole bodies, or covering their heads with the orange powder of turmeric root, has a dirty appearance. All the inhabitants of the group are of a deep chesnut brown colour, and their skin is uncommonly soft and smooth to the touch. M. de Bougainville says, those of Lepers Isle are of a black or Mulatto colour, the hair of some being a yellow wool, which, it is not unlikely, might have been the consequence of disease; as he gave the island its name from the inhabitants being much afflicted with leprosy.

The language of the New Hebridians is different from that of all the other tribes of the South Sea; it abounds in consonants, and even in the united duplication or triplication of them. But they have a remarkable facility in understanding and imitating strangers, and have a very quick and ready apprehension. Their admiration is expressed by hissing like a goose. They are singularly honest, unlike all savages; and most of them have a manly, good natured, open aspect.

In general these people go nearly naked; boys and girls absolutely so. The greater part of the women have a short petticoat; many only a cord about the body with a bunch of straw. A decided characteristic of the Hebridians consists in a rope tied round the middle, which, being put on at a very early age, makes a deep groove, dividing the belly as it were into two parts, so that the one almost overhangs the other. Cap-

Hebrides, New.

tain Cook, in describing the Mallicolese as "the most ugly and ill-proportioned people I ever saw, and in every respect different from any we had met with in this sea," and specifying "their long heads, flat faces, and monkey countenances," continues, "but what most adds to their deformity, is a belt or cord which they wear round the waist, and tie so tight over the belly, that the shape of their bodies is not unlike that of an overgrown pismire" They are less acquainted with the art of tattooing than many other islanders, and they obtain a similar effect by incisions of the flesh, producing elevated scars, which resemble external objects. A number of personal ornaments are employed by them, more generally by the men than the women. The face and body are frequently painted black, brown, or red; and bracelets, ear-rings, or a bone through the nose, are worn among both sexes. The women and children are in general shy; the former are held in subserviency by the men, and condemned to the more laborious operations.

The disposition of the Hebridians seems to be courteous and liberal; they are not equally prone to revenge injuries, as many other savages, and are more willing to be satisfied. The English circumnavigators were treated with great hospitality, and it seems doubtful in any misunderstandings which was the aggressor. M. de Bougainville considered an attack on him at the isle of Lepers, followed by a flight of arrows, as the consequence of premeditation. They are evidently often at war, from the number and variety of their arms; and during the visits of strangers, they are always on the watch, keeping their bows constantly bent. These are very strong and elastic, made of the best club wood, and highly polished. The arrows are made of reeds nearly four feet long, and pointed with a piece of hard brittle black wood, twelve or fifteen inches in length. Some have three points for shooting birds, others are discharged at fish, and pointed with a bit of bone two or three inches long. They have also clubs, spears, and darts; the first of different sizes and shapes, from two feet and a half in length to six feet, and are slung from the right shoulder by a rope. Their arrows are shot with great force and precision to the distance of 8 or 10 yards, but are little to be dreaded at 25 or 30. Their darts also are thrown with much power and accuracy to a short distance. Some arrows exhibit a greenish gummy substance on the points, which the natives affirm is poison; but in experiments made with it by the English on animals it was not fatal.

The arts are in a very low state; navigation is little understood, and fishing seldom resorted to. No fishing tackle whatever was observed by the English in the largest islands; and their canoes consisted of several pieces of wood clumsily sewed together. Only 14 belonged to the whole island of Mallicolo. However, that of Immer is chiefly inhabited by fishermen, and the various canoes are from 20 to 30 feet long, but all of indifferent workmanship. The dwellings on shore are miserable huts of rude construction, or, properly speaking, large sheds about 35 feet long open at both ends, and of which the roof, ridged at top, reaches to the very ground. Captain Cook compares them to a house without walls. They seem to contain no furniture except mats, palm leaves, and dry grass, which cover the floor. The quality of the climate is such that the inhabitants can almost dispense with artificial shelter, and all their pursuits concentrate in warfare and in procuring subsistence.

Hebrides, New.

A large portion of the New Hebrides is well cultivated. Whole islands are covered by woods and divisions, indicating much industry and a correct notion of property; and extensive grounds are laid out in regular plantations of the sugar-cane, bananas, and plantains, all kept in good order, and sometimes protected by stone fences two feet high.

It is not ascertained that the natives have any religion, or any form of government. They offer the branch of a tree as a sign of pacification, and pour water on their heads, as indicating a desire for conciliation, or in token of contrition. They dance round fires to the sound of drums; and these are heard in the woods on occasions of alarm. Their music is of a lively turn; they have pleasing airs embracing a considerable compass, and it is said they sing in parts,—a fact worthy of being ascertained, as the music of savages is so limited. An instrument consisting of eight reeds, like the syrinx or Pan's pipe, and extending throughout an octave, has been seen here.

It is singular that in some of the islands, as Tanna, iron is of no value, while in others it bears the highest price. Looking-glasses prove the source of great amusement to the natives, and their complacent self-contemplations have induced their visitors to affirm that they are extremely conceited.

All those who have reached the New Hebrides bestow the warmest commendations on their soil, climate, and productions. The later navigators have thought that a settlement might be profitably made on Sandwich Island; and Quiros, two centuries ago, sought to interest the avaricious court of Spain, by pointing out the benefit which would result from one on the Tierra Austral del Espiritu Santo. "In a word," he says, "the union of so many advantages would produce such power and riches, that these territories would not only support themselves, but afford an overplus for the assistance of America, aggrandize your majesty's dominions in general, and very speedily elevate Spain to the highest degree of prosperity. All this I will undertake to answer for, if I shall be assisted and supported in my enterprise." The north side of the island is penetrated by a capacious bay, which he considers capable of being a harbour for 1000 vessels; and after acquainting his sovereign, that, amidst its numerous properties, "the dawn is ushered in by a most delightful concert of millions of birds from the forests wherewith the shores are shaded, and that every evening and morning the air is perfumed with the odours of all species of flowers intermixed with those of aromatic plants," he concludes with these words: "Finally, sire, I can with confidence assert, that this harbour, which is situated in 15° 20′ South Latitude, presents the greatest natural advantages for the establishment of a large city and a numerous colony.

None of these anticipations, however, have been realised, and the New Hebrides, yet unoccupied by Europeans, are only resorted to, as we learn, at rare intervals, for cargoes of wood from their forests.

Navigators have been so much mistaken regarding the population of the South Sea Islands, as to warn us against listening to conjectures. The inhabitants of Mallicollo were computed at 50,000 in 1773, and those of Tanna at 20,000; but we cannot forget, that while about the same time the population of Otaheite was supposed above 200,000, calculations of tolerable accuracy reduce it at this day to 5000; towards which, however, several causes, perhaps unknown to the New Hebridians, may have contributed. See *Torquemada*

Monarquia Indiana, t. i. p. 738. De Brosse's *Navigations aux terres australes*, t. i. p. 306, t. ii. p. 243, 348. Bougainville *Voyage*, p. 242. Dalrymple's *Historical Collection*. Cook's *Second Voyage*. Forster's *Voyage*, vol. ii. (*c*)

HECLA. See Iceland.

HEDGE. See Agriculture, vol. i. chap. xii. sect. i.

HEDJAS. See Arabia, vol. ii. p. 275. *et seq.*

HEDWIG, John, a celebrated botanist, was born at Cronstadt in Transylvania, on the 8th of October 1730, and was the son of one of the magistrates of that town. His love of botanical pursuits shewed itself at an early period; and while his school-fellows were busy with their amusements, Hedwig was actively employed in collecting wild plants, and transplanting them to his father's garden. After studying four years at the public school of Cronstadt, he was enabled, notwithstanding the loss of his father in 1747, to go to the university of Presburg to continue his studies. He remained here two years following his medical pursuits, and then went to Zittau to attend the lectures of Gerlach. In 1752, he entered himself as a student at the university of Leipsic, and attended the lectures on medicine, philosophy, and mathematics. Here he gained the particular friendship of the celebrated Ludwig; and such was the opinion entertained of him by Bose, the professor of botany, that, in 1756, he took him into his own house, gave him the charge of his garden, and allowed him, during three years, to attend for him at the hospital. Upon the completion of his studies, he was naturally anxious to settle as a physician in his native place; but upon applying for license to the magistrates, he was mortified to find that no physicians could practice in Transylvania, who had not been members of the university of Vienna. His friend Bose, however, having advised him to commence practice in some small town in Saxony, he presented his dissertation *sur l'emploi des emetiques dans les fievres aigues*, and was admitted doctor of medicine. Having a friend resident at Chemnitz, he fixed upon that town, where he settled, after marrying Miss Sophia Teller, a lady from Leipsic. Hedwig now devoted his mornings to the collection of plants, and his evenings to their examination, while the rest of the day was employed in his professional pursuits. The cryptogamic plants particularly attracted his attention; and having had occasion to write to the celebrated Schieber, who was then publishing the Flora of Leipsic, for the explanation of some difficulties, a correspondence immediately commenced between them, and Hedwig received from his friend several books, a single microscope, and afterwards a compound one made by Rienthaler the optician. By means of this instrument, on which he made some improvements, he was enabled to determine the male and female flowers of the mosses. See our article Botany, vol. iv. p. 30, and Musci.

His wife, who had brought him nine children, died in 1776; and though he was oppressed with grief at such a loss, yet as he was unable to continue his pursuits, and attend to the education of his six surviving children, he yielded to the advice of his friends, and married, in 1777, Miss Salzberger of Leipsic. In 1779, he published at Leipsic, in a German periodical work, his great discovery, under the title of "Observations on the true parts of generation in Mosses, and on the multiplication of Mosses by seed." At the urgent desire of his wife, who considered his talents as lost at Chemnitz, he removed to Leipsic in 1781, and, in the following year, he published his work entitled *Fundamentum Historiæ naturalis Muscorum frondosorum*, illustrated with 20 coloured plates.

The Petersburg academy having offered a prize of 100 gold ducats, for a determination of the parts of fructification of the cryptogamic plants, Hedwig sent a large treatise on the subject, which gained the prize, and which was published at St Petersburg, in 1784, under the title of *Theoria generationis et fructificationis plantarum Cryptogamicarum Linnæi*. A new and enlarged edition of this work afterwards appeared in 1798.

Hitherto Hedwig had lived in a state of obscure poverty; but his talents were now about to receive their proper reward. In 1784, he was made inspector of the military hospital at Leipsic, and in 1786 he was appointed professor extraordinary to the faculty of medicine. In 1789, Frederick Augustus, elector of Saxony, nominated him professor of botany, and superintendant of the public garden, and at the same time gave him apartments at the academy.

Having been occupied more than 35 years in the study of nature, Hedwig published the results of his observations in the following treatises.

1. A Treatise on the origin of the parts of fructification, in which he shews that the stamens and pistils are not produced by the pith, as Linnæus believed, but by the same vessels as the other parts of the plant.

2. A Memoir on the Cotyledons.

3. A Dissertation on Bulbiferous Plants.

4. A Memoir on the Organs of Transpiration in Plants.

5. An Examination of the distinctive Characters of Plants and Animals.

6. An Answer to certain Questions proposed by Dr Arthur Young, on the Irrigation of Meadows with spring-water.

7. A Dissertation on the Origin of the Vegetable Fibre.

8. Observations on the use of the Leaves in Plants.

9. A Memoir, in which, after having described the sexual organs of several *Cucurbitacea* at the time of fecundation, he considers the manner in which the pollen impregnates the ovaries, and the changes which this phenomenon produces in plants.

10. Notes on the Aphorisms of Humboldt, in which he lays down several principles of vegetable physiology.

11. Lastly, Considerations on the present and future state of the Science of Botany, and on the best means to be pursued in the study of it.

Between the years 1787 and 1797, Hedwig published his great work, entitled *Descriptio et Adumbratio Microscopica analytica Muscorum frondosorum, necnon aliorum Vegetantium, classe Cryptogamica Linnæi novorum dubiisque nexatorum*, in 4 vols. folio, the first of which appeared in 1787, and the last in 1797. This work contains an analytical description of 148 species of mosses, and 50 other cryptogamic plants, all of which were examined with the microscope, and figured with great elegance and truth. Each volume is illustrated with 40 excellent coloured plates. He likewise prepared a general History of the Mosses; but this work, which he did not live to finish, was arranged and published by Frederick Schwægricher, one of his pupils. It contains notices of 360 species, of which 157 are figured. Out of six children by his second wife, five died at an early age, and one of his daughters, whose education he had superintended, was carried off by the small-pox in December 1797. This severe blow affected his health; and having neglected to take proper care of himself during the severe weather of 1798 when he was visiting his patients, he was attacked by a catarrhal fever, from which he had scarcely recovered, when he was carried off by a nervous fever, on the 7th of February 1799, in the 69th year of his age. Out of 15 children, only four survived him, two sons and two daughters. One of his sons, M. Romain Adolphus, professor of botany at Leipsic, published two fasciculi of a splendid work on ferns, with coloured plates; but he did not long survive his father.

Hedwig was distinguished by all the social virtues. He was neither elevated by the high reputation which he had acquired, nor depressed by the illiberal criticisms with which he was assailed. His enjoyments and his sufferings were of a higher class. They were the luxuries and the sorrows of domestic life. See Deleuze's *Account of the Life and Writings of Hedwig*, published in the *Annales du Museum d'Histoire Naturelle*, vol. ii. and in Brande's *Journal of Science and the Arts*, vol. i. p. 103.

HEGIRA, or Hejera, is an epoch to which the Arabs and Mahometans refer historical events. It comes from an Arabic word, which signifies *fled*, and the epoch is dated from the night between the 15th and 16th July A. D. 622, when Mahomet was forced to leave Mecca to avoid the persecutions of his enemies. The year of the Christian era, corresponding to any year of the Hegira, may be found by the following formula, H being the year of the Hegira, and C that of the Christian æra, $C=\frac{H\times354}{365}+622$, or $C=H\times.9692+622$. Thus if we wish to know what year of our æra corresponds with the year of the Hegira 1232, we have $C=1232\times.9692+622=1816$.

Tables shewing the correspondence between the years of the Hegira and those of the Christian æra, have been given by Greaves in his *Epochæ Celebriores*; by Riccioli in his *Chronologia Reformata*, 1659; and by Beckius in his *Ephemerides*, 1695. A more correct table has been published by Mr Marsden, in his paper *On the Æra of the Mahometans called the Hejera*, printed in the *Philosophical Transactions* for 1788, vol. lxxviii. p. 414, or in the Abridgment, vol. xvi. p. 509.

HEIDELBERG, is a city of Germany, in the circle of the Lower Rhine, formerly the capital of the Palatinate, and recently forming a part of the grand duchy of Baden. It is a long and narrow town, and is situated at the foot of a mountain on the south side of the Neckar. This river is crossed by a fine bridge, which cost 170,000 florins, and from which there is a fine view upon the river. It is surrounded with walls, which have six gates. The citadel, called Fort l'Etoile, was long ago destroyed by the French. It contains three churches for Roman Catholics and Protestants, an university, an economical society, an anatomical theatre, a military hospital, a cabinet of minerals models and physical instruments, a botanical garden, and more than 20 fountains. The university was founded in 1386, and has been under the direction of 20 professors, 16 Catholic, and four Reformed. When the Bavarians took it in 1622, its library was transferred to the Vatican, by Robert Maximilian of Bavaria. The fine statue of the Elector, the church of St Esprit, the church of St Peter, with the sepulchral inscription of the celebrated Olympia Fulvia Morata, are worthy of being seen. The castle and the garden of Heidelberg, situated near the town, are now in ruins. The statues of the ancient Electors and Count Palatines are still to be seen on the front of the castle; the remains of the hall of the chevaliers are still visible; and the granite columns which formerly supported a part of the imperial palace at Ingelheim near Mayence, are seen supporting the roof of the fountain of the castle. The subterraneous passage extends to the great square in the town. A Restaurateur is now established in the middle of these ruins. Heidelberg has been celebrated for its wines, called *vin du Neckar*, obtained from grapes which grow on both sides of the mountain; and for its capacious tun, which originally contained 528 hogsheads, and 600 when it was rebuilt, and which is still shewn to strangers. It has manufactures of camblets, silk stockings, and silk handkerchiefs, wax lights, soap, cotton, clothing, paper hangings. The population, which is principally Lutheran, amounts to 12,000.

HEIGHTS. Methods of measuring heights by the Barometer, will be found in our article Pneumatics, and trigonometrically in our article Trigonometry.

HEILBROUN, or Hailbron, is a town of Germany in Suabia, which belonged to the King of Wirtemberg. It is situated in a very pleasant and fertile country on the banks of the Neckar, which is crossed by a covered stone bridge. The town is strong and well built, and has some fortifications, three churches, two convents, and public baths. The principal objects of curiosity in this town are the Gothic tower of the church of St Kilian, which is remarkable for its architecture, the public library, the house of correction, the great fountain, and the fine promenade before the gates of the town. In the archives of the town are preserved the letters of the two celebrated Chevaliers François de Sickingen and Goez de Berlichingen, the last of whom was imprisoned in a tower, which still remains, and was interred in the convent of Schoenthal near the town. The town carries on a great trade in tartar and all sorts of glass. It contains distilleries of brandy, paper manufactories, tannaries, oilmills, and wheels for tobacco. Population, 8000.

HELENA, St, generally ranked by geographers among the islands of Lower Guinea, is situated in 15° 55′ South Latitude, and 5° 49′ 45″ West Longitude from Greenwich. It is 600 miles from Ascension Island, the nearest land, 1200 from the coast of Africa, and nearly 2000 from that of America. In sailing from Europe, it is generally necessary, in order to make the island, to stretch along the Brazil coast quite out of the tropics, till it can be gained by the aid of the south-east trade winds; but of late years the inner or eastermost passage has frequently been followed, and has not uncommonly been made in 7 or 8 weeks from England. A bird, called the St Helena pigeon, which is seen only to the windward of the island, generally indicates its vicinity to the navigator, long before the land can be discerned by the telescope. *Situation.*

St Helena was discovered by the Portuguese commander John de Nova, on St Helen's day, May 21st 1501. It was then inhabited only by seals, sea-lions, sea-fowls, and turtles. The interior of the island was one entire forest, and even many of the rocky precipices on the coast were covered to the brink with the gum wood tree. Its first settlement and improvement are ascribed to the following interesting occurrence: Several Portuguese noblemen, who had deserted in India to the native princes, were punished by Albuquerque in the most cruel manner, by having their noses, ears, and right hands cut off; and in this mutila- *Discovery.* *History.*

ted condition, were put on board the ships returning to Europe. Fernandez Lopez, one of the sufferers, preferring a voluntary exile to a life of ignominy in his native country, was, at his own request, landed on the island of St Helena in the year 1513, with a few negro slaves. Many of his countrymen, commiserating his sufferings, exerted themselves to contribute every comfort and convenience which his forlorn situation would admit. Hogs, goats, and poultry, were landed for his sustenance. Partridges, pheasants, guinea-fowls, peacocks, and other wild fowl, were let loose in the woods. Figs, oranges, lemons, peach trees, and various vegetables, were planted in the infant soil. By his skill in botany and gardening, the fruit trees were brought to great perfection; and the live stock and feathered tribes increased so abundantly under his protection, that, in a short time, they entirely overspread the face of the country. After a residence of four years, Fernandez was removed from the island by orders from the court of Portugal; but the spots which he had cultivated continued to supply the ships of his country with seasonable and abundant refreshments in their Indian voyages.

The Portuguese succeeded in concealing the situation of St Helena from other European nations, till the year 1588, when it was descried and visited by Captain Cavendish on his return from a voyage round the world. It soon became well known also to the Dutch and Spaniards; and the crews of the different nations are accused of having wantonly laid waste the plantations, and destroyed the live stock, as if grudging to succeeding visitors any participation of the benefits which themselves had enjoyed. After the Portuguese had acquired so many ports on the eastern shores of Africa, they removed entirely from St Helena, which remained for a long time in a desolate condition; but, according to other accounts, they were expelled from it by the Dutch, by whom it was again abandoned upon the establishment of their colony at the Cape of Good Hope in 1651. Upon their departure, the English East India Company immediately formed a settlement upon St Helena; and about ten years afterwards, obtained a charter for its possession from Charles II. Many settlers were induced, by the offer of lands, to emigrate thither from England; and slaves were imported from Madagascar to work in the plantations. In 1665, the Dutch succeeded in an attack upon the island, but in a few months were obliged to give place to the English; and after the destructive fire in London in 1666, numbers of the ruined families, who sought relief in distant countries, removed to the new settlement on St Helena. It was once more retaken by the Dutch in 1672, through the treachery of one of the planters, but was almost immediately recovered by an English squadron under Captain Munden, and again restored to the East India Company. The first fortification was erected by the English in 1665, and a few lines formed across the valleys, and batteries, slightly elevated above the level of the sea, were at different times constructed; but more than a century was suffered to elapse before its impregnable heights were employed as posts of defence.

Till the beginning of the 18th century, the history of the settlement contains little else than a succession of petty contentions, insurrections, and mutinies. A general spirit of insubordination appears to have infected all ranks on the island, planters, soldiers, and slaves; and though every attention was paid by the Company to support the interests of good order, morality and religion, yet two causes chiefly seem to have defeated all the good effects of their regulations, viz. the injudicious conduct of the governors in failing to check the first symptoms of disaffection, and the profligate character of the persons who presided over the religious instruction of the inhabitants. An abundant distillation of spirits from potatoes was no inconsiderable auxiliary to the spirit of disorder; and this source of depravity became at length so great a nuisance, that, in the year 1700, all the stills were suppressed by an order from England. But, by the wise and vigorous measures of Governor Roberts, from 1708 to 1714, and by the pious exertions of Mr Tomlinson the chaplain, a degree of tranquillity hitherto unknown was established in the settlement, and a new era commenced in the history of the island. The Company's lands were brought into a promising state of improvement; planting and inclosing encouraged among the settlers; the culture of vines and sugar canes introduced; lime quarries discovered and wrought; a manufactory of bricks and tiles set on foot; a code of the existing statutes arranged and published for the information of the inhabitants; and the exercise of martial law in a great measure abolished, except in times of alarm or attack.

From the year 1727 to 1731, great encouragement was given under Governor Byfield to the planting of furze fences, both with a view to afford protection to the lands, and to secure a supply of fuel. The increase of trees also was greatly favoured by a resolution to withhold the liberty of keeping sheep and goats, which were so injurious to the young plantations; and in place of the general privilege, grants were given to individuals of keeping goats on certain parts of the Company's waste lands, called goat-ranges. About the year 1749, the Scotch and spruce firs were introduced by Governor Hutchinson; and acorns were at the same time planted, from which oaks have grown to the size of 8 or 11 feet in circumference. The same gentleman succeeded, after repeated attempts, in introducing the coffee plant, which is now regularly cultivated. The importance of St Helena became daily more manifest, as the trade and prosperity of the East India Company increased; and, in the year 1759, many important regulations were introduced into both the civil and military establishments. Towards the close of the year 1783, the tranquillity of the island was seriously interrupted by an extensive mutiny among the soldiers, occasioned by a few trifling regulations respecting their punch horses, which appeared to them of an insulting and degrading tendency. After a slight skirmish, the insurgents were reduced, and the ringleaders executed. The mutinous disposition of the garrison was afterwards entirely suppressed, and the whole character of the troops highly improved, under the judicious management of Governor Brooke. The place became even a nursery of excellent recruits for the East Indies; and, during his government from 1788 to 1800, more than 12,000 soldiers were sent to India. The same gentleman made great additions to the defences on the heights, established a code of signals, built a new and safer wharf for the shipping, improved the regulations relative to the treatment of the slaves, gave encouragement to many useful suggestions for the improvement of agricultural operations; and by his active enterprises, at the commencement of hostilities with the Dutch in 1795, rendered the little island of St Helena peculiarly serviceable to Great Britain. His successor Colonel Patton evinced a similar

St Helena.

zeal and ability, in whatever concerned the welfare of the settlement. He particularly erected telegraphs, rendered the guns on the heights more efficacious for annoying an enemy, introduced the use of terra puzzolana in the formation of aqueducts, and applied his attention, by means of honorary rewards and religious instruction, to improve the character of the slaves. Many important agricultural improvements were introduced by Governor Beatson, and particularly the use of the plough in the tillage of the soil. In a volume of tracts relative to the island, he has minutely pointed out its various capabilities, and suggested divers plans for its better administration and culture. The greatest want under which the settlement labours, is the scarcity of fuel, and coals have actually been carried thither from England. But the last mentioned writer maintains, that, with ordinary care, the island might be made to produce in a few years a sufficiency of wood for its own consumption in fuel, and for all the other purposes of life.

Appearance.

The island of St Helena, when first seen at sea, presents the appearance of a naked and rugged rock, extremely abrupt at its northern extremity, but more shelving towards the south. Upon a nearer approach, the central eminences are perceived clothed with verdure, and towering to the clouds. Upon drawing still nearer, these are again shut out from the view, and nothing is beheld but a girdle of inaccessible precipices overhanging the ocean, some of them exhibiting the most fantastic shapes, and others, rent down to their base, disclosing the most hideous chasms. These rocks are principally basaltic; and the strata are observed to lie in every possible variety of direction. The whole mass has every appearance of having been produced by a submarine volcano; or, what some consider more probable, being the summit of a great submarine mountain, which had formerly been a volcano. The sea around the coast is of an unfathomable depth, and vessels may pass within a cable's length of almost perpendicular cliffs 1600 feet in height. The only anchorage is in Chapel Valley bay on the north-west and leeward side of the island, where ships may lie in smooth water from 8 to 25 fathoms deep. The tide rises sometimes to the height of five feet; and the surf upon the shore, especially about the season of Christmas, is very tremendous. Many lives were lost in approaching and leaving the land in boats, till the new wharf was constructed by Governor Brooke in 1790; but there is only one instance of a shipwreck upon the island, which happened at the time of its discovery; and only one also of a vessel being windbound in the roads. The variation of the compass on the coast in 1768, was 12° 47′ west; in 1777, 13° 15′; in 1796, 15° 47′ 30″; in 1802, 16° 30′. The principal inlets by which the island can be approached, are James's Town, Rupert's Bay, Lemon Valley on the north-west side, and Sandy Bay on the south-east; all of them regularly and strongly fortified. There are likewise several ravines where it may be possible, though with great difficulty, for individuals to effect an entrance; but even these are either protected by batteries, or easily defended by rolling stones from the heights. The island is 10½ miles at its greatest length, 6¾ in breadth, about 28 in circumference, and contains 30,000 acres on its surface. There are only two plains in the whole of this extent; the largest of which, at Longwood, comprises 1500 acres of fine land, sloping gently to the south-west.

Description.

St Helena is unequally divided by a lofty chain of hills, which runs in a curved direction nearly east and west, bending towards the south at each extremity; and from which alternate ridges and valleys branch off in various directions, but chiefly north and south. Towards the eastern termination of this chain is Diana's Peak, the highest point of land on the island, rising nearly 2700 feet above the level of the sea. On the same ridge are Cuckold's Point, 2672 feet; and Halley's Mount, 2467. Nearer the coast, and overhanging the sea, are Flag-staff, 2272; and Barnscliff, 2015. In the centre of the island is the alarm house, 1960. High Knoll, to the southward of Ladder Hill, is 1903; and Longwood-house, the official country residence of the lieutenant-governor, is 1762 feet. On coming round to the north-west and leeward side of the island, James's Valley opens to the view. It is bounded by two rocky mountains, Rupert's on the east, and Ladder Hill on the west, which gradually recede from each other as they approach the coast, where they terminate abruptly in two stupendous and perpendicular cliffs. The space inclosed between these heights is of a triangular form, about a mile and a half in length, and 350 yards broad its base, which faces the sea. In this confined spot is situated James's town, which presents in its whole appearance, a peculiar combination of military strength, and rural simplicity. A fortified line extends from cliff to cliff, fronting the anchorage, and covered with cannon, nearly level with the water's edge. After passing the draw-bridge, and advancing between a double row of Peepel trees, (a species of India banian,) you enter the town by an arched gate-way, under a rampart or terrace, which forms one side of a handsome parade, about 100 feet square. On the left side is the government-house, usually named the Castle, inclosed with a wall; and directly fronting the gate-way is the church, a plain but not inelegant structure. The principal street, containing about 28 houses, commences between the church and the Company's garden; and, in its progress, divides into two other streets, one on the east side leading into the country, and the other, which has a number of well furnished shops, proceeding towards the upper part of the valley, where the barracks, hospital, and new garden are situated. The houses, generally two stories high, are neatly built in the English style, and well white-washed. The town contains many little gardens, groves, and shaded walks, and extends the whole length of the valley, which gradually decreases in breadth, till at last there is room only for a single house. The view on each side, from the streets, is awfully sublime, and discovers enormous masses of rock impending over the valley, in a manner sufficiently alarming to the mind of a stranger. The roads which give access to the interior of the island, and which have been formed with incredible labour, by blowing up the rocks, are carried along the sides of Rupert's and Ladder Hill in a zig-zag direction; and the ascent to the summit is so easy, that oxen and carts pass along the apparently perpendicular precipice without difficulty or danger. For the space of two miles, nothing but naked sterility and a rocky wilderness meets the eye of the traveller; but the sight is soon gratified by the sudden prospect of woody heights, verdant lawns, cultivated plantations, and handsome little country seats. The summit of High Knoll, particularly, presents a beautiful series of such prospects, surrounded by a lofty ridge of hills and precipices, which completely close in the view, and finely contrast with the softer and richer scenes which they inclose. On the south side of the Knoll, about three miles from the town, is the governor's country residence, called Plantation House, a

James's town.

Interior of the country.

St Helena.

handsome and well-built edifice, erected in 1792. Its environs, by the combined efforts of nature and art, have been rendered the most beautiful spot in the island. Besides the indigenous productions of the place, the pine of the north, the mimosa of New South Wales, the coffee plant of Arabia, the banian and bamboo of India, the African aloe and prickly pear, the apple, peach, and mulberry of Europe, with various other plants and trees, from the most opposite and distant climes, are to be found within the inclosures. Longwood, the country residence of the lieutenant-governor, on the opposite side of Ladder Hill, and also about three miles from the town, is situated on an elevated plain, or rather gently rising ground, on the summit of which is a flag-staff, from which the place takes its name. The adjoining space was once nearly covered with gum-wood trees, which, upon the opening of avenues among them, were gradually destroyed by the south-east wind; but young trees which have been since planted are thriving well, and the whole scenery bears a greater resemblance to that of England, than any other spot on the island. There are here about 1500 acres of good meadow land, of excellent soil, and capable, if supplied with water, of proving highly productive. From Sandy Bay, which is about an hour's ride from Plantation House, by a winding road along the declivities of little green hills, a still more romantic and beautiful scenery opens to the view, of which actual observers have given the most enraptured descriptions. "Though in general," says Mr Brooke, "a bird's eye view lies before the spectator, hills rise above him to an elevation much greater than the spot on which he stands. Those on the left, richly clothed with trees to the very summits, display a wonderful contrast to the wild and grotesque nakedness that triumphs on the right, where shelving cliffs, surmounted by huge perpendicular and spiral masses of rock, are multiplied under every shape and aspect. The downward view consists of a variety of ridges, eminences, and ravines, converging towards the sea into one common valley. Among this scenery are interspersed the dwellings of planters, the different forms of gardens and plantations, and the pasturing of cattle; the prospect closing with the distant sea, rushing in between two black craggy cliffs, which the surf whitens with its spray. The infinite diversity of tint that overspreads the whole of this extraordinary picture, the majesty of one part, the reposing beauty of another, and the horror of a third, cannot fail to delight and astonish every observer of nature." "One feels," says Mr Johnson, "as if transported into a new planet, where every object strikes by its novelty, and is altogether unlike any thing which he had ever before seen. All the surrounding hills, cliffs, rocks, and precipices, are strangely fashioned, and so fantastically mixed and blended, that they resemble more the aerial shapes which we see among the clouds, than any thing composed of denser materials." But it is from the summit of Diana's Peak, which is nearly in the centre of the island, that the most complete view of St Helena is brought under the eye. Nothing intercepts the horizon; and all the detached scenes and prospects are beheld at once, forming a picture inconceivably diversified, and full of the most interesting groups.

Climate.

The climate of St Helena is remarkably temperate and salubrious, and peculiarly adapted to the constitution of Europeans. In James's town, the thermometer seldom rises above 80°; but, in calm weather, the heat reflected from the sides of the valley is frequently oppressive. In the country, the temperature is more mild and uniform; scarcely so hot, and never so cold, as in England. In some seasons, the highest point of the thermometer, during the summer, has been only 72° in the interior of the island; and the ordinary range of Fahrenheit's scale, during winter, is from 55° to 56°. The average temperature through the whole year is from 66° to 78° of Fahrenheit at James's town; from 61° to 73° at the Plantation-house; and from 56° to 68° at Longwood. The rains also fall more equally through the whole year than in most tropical climates, but most abundantly in the month of February. In the vicinity of some of the higher points, especially of Diana's Peak, which, by being covered with trees, is supposed to attract the clouds, scarcely a day passes without a shower. Cloudy days are more numerous than those of clear scorching sunshine; a circumstance which has been remarked as propitious to the growth of trees and pasturage, but unfavourable to the ripening of European fruits. Thunder and lightning are scarcely ever experienced; and the atmosphere is generally so clear, that a ship may be descried at the distance of 60 miles.

Soil.

The soil is of a clayey nature, and well suited both for European and Indian productions. It is in many places of considerable depth, and always most productive in spots which are most elevated, and farthest removed from the sea. Even on the summits of the interior hills, the grass is often so luxuriant, as to reach the knees of the oxen. Clear and wholesome springs issue from the sides of almost every height; but they form only very inconsiderable rills. A few of these, especially those at Fisher's Valley and the Briars, are not observably diminished in dry weather; but, in general, they are wholly dependant on the rains, or the clouds, which are almost perpetually in contact with the tops of the mountains.

Minerals.

Iron ore has been found in some parts of the island; but the scarcity of fuel prevents it from being brought to the furnace. Appearances of gold and copper have been observed, and some stones capable of taking a beautiful polish. Limestone is plentiful; and some of it, a concretion of sand and shells, is of an excellent quality; but the cement used in ordinary buildings is mud or earth, which is found to answer the purpose extremely well, perhaps from its containing a mixture of terra puzzolana. This last mentioned substance, which abounds on the island, forms, in conjunction with lime, a cement remarkably retentive of water, and acquiring, from the contact of that fluid, the solidity of rock: hence it is much used in the construction of aqueducts.

Vegetable productions.

The summits and sides of the interior hills are covered with furze, of which the seed was brought from England, and with various indigenous trees and shrubs. Of these, the most abundant used to be the gum-wood, of which there are three kinds, all evergreens, the common, the bastard, and the dwarf gum-tree. The last is generally called *scrub-wood,* and seldom grows higher than three feet; but the common kind has a tolerably straight stem from 20 to 30 feet in height, and throws out its branches and leaves in the form of an umbrella. The bastard species has less of the gummy texture, and is farther distinguished by having a smooth leaf, and bearing its blossoms in small bunches. All the kinds contain a highly aromatic gum, which renders the wood extremely pleasant as fuel, for which

St Helena.

purpose it is chiefly calculated, though not altogether unfit for building, if protected from the weather. From the trunks of the common and bastard species, a sweet-flavoured liquor, called by the natives *toddy*, issues spontaneously; and a bottle, so placed as to catch the natural exudation, may be filled in the course of a night. Of the other native trees, may be mentioned string-wood, dog-wood, red-wood, or ebony, and the cabbage-tree, of which the two last are very durable, and much valued in building. Oaks, cypress, and pinaster, have been introduced into the plantations, and thrive well. The first, particularly, grows up very quickly, but decays with equal rapidity, though the wood, when cut in a sound state, is said to be of a very close grain and firm texture. The ferns of St Helena are very numerous and beautiful; and one species, called the *tree-fern*, grows to the height of 14 or even 20 feet, with leaves five feet in length. The myrtle, to which the climate is peculiarly adapted, grows to the height of 30 feet, and the cotton plant thrives very readily. A shrub, which the natives call *samphire*, but supposed to be the barilla, grows spontaneously on the thin crust of soil generally found near the sea, and yields from its ashes a large quantity of the marine alkali for the manufactories of soap. The English vernal grass prevails in the higher parts; but, in the low grounds, the wire-grass, or droop, is more abundant. This last is sweet and nutritious, and suffers less than the other sorts from hot or dry weather; but, instead of it, a coarse herb, called *cow-grass*, originally from the Cape of Good Hope, has been introduced into many of the pastures. Lucerne has succeeded in some situations, and is considered as well calculated for general cultivation.

Fruits.

Fruits, in general, ripen best in the vallies near the coast; but almost on every farm are produced vines, figs, limes, oranges, lemons, citrons, guavas, bananas, peaches, quinces, pomegranates, tamarinds, mulberries, melons, water-melons, and pumpkins. Mangos, cocoa-nuts, sugar-cane, pine-apples, and strawberries, are also raised in the island, but only in small quantities. Apples have not succeeded generally; but one orchard, particularly, about three acres in extent, has been known, besides other fruits, to yield in one season 24,000 apples of a large size. Cherries have been tried, but without success. Gooseberry and currant bushes when planted, become evergreens, and yield no fruit; but the common blackberry, which was introduced in the year 1780, has found the soil and climate so congenial, that it has completely overspread large tracts of ground; and, as the only remedy against its encroachments, a public order was issued, and has uniformly been in force, for its entire extirpation. A species of yam, originally imported from Madagascar, is commonly cultivated in the vallies; but it requires almost continued moisture for fifteen months to bring it to perfection. During the last twenty years, however, the culture of the potatoe has more profitably occupied the attention of the farmer; and three successive crops of this valuable root are frequently produced in one season. Cabbage, peas, beans, and other garden vegetables, are raised everywhere in great abundance. Attempts have more than once been made to introduce the cultivation of wheat, barley, and oats; but probably from drought, or some unknown peculiarity in the soil or climate, the experiment did not succeed. It is more from this failure, than from the alleged voracity of the rats and mice, that grain is not raised. Indeed, as the principal value of the island consists in its being a place of rendezvous and refreshment for the homeward bound ships from India, the cultivation of grain has been deemed of less importance, and less anxiously encouraged, than the rearing of live stock, and the production of wholesome vegetables.

Cattle, &c.

The breed of cattle and sheep on the island is originally English; but, in consequence of the large demands from the India ships, the stock is very scanty; and the inhabitants during the greater part of the year subsist upon rice and salt provisions issued below prime cost from the Company's stores. Goats are numerous, and their flesh well-tasted; but pork, except what is reared by the more opulent inhabitants, is of a very inferior quality, as the animals are chiefly fed with the heads and offals of the coarser kinds of fish. Rabbits abound in some spots. Rats and mice are amazingly numerous, and frequently very destructive. In 1756, they are said to have barked the trees at Longwood for food; and in 1700 actually devoured one another, so as almost to clear the island of the whole tribe. With a little ordinary care, however, Governor Beatson cleared his farms and gardens of vermin, as completely as could have been done in England.

Birds.

The canary bird abounds in the island; and the Java sparrow is a great annoyance to the farmers. Red linnets are also numerous; and are observed to build two nests, in the uppermost of which the male bird takes his station, and serenades the female with his song during her incubation. Pheasants and partridges, in consequence of their having been protected by government, have become numerous; but the guinea-fowl, with which the island was formerly well stocked, are now seldom to be seen. The shores abound with sea-fowl, which deposit their eggs among the cliffs; and these, which are collected in the months of October and November, greatly resemble in flavour those of a plover. One species of these sea-birds make their nests in the more central and woody eminences, whether they are often seen flying across the country with fish in their bills.

Fish.

More than seventy kinds of fish are found on the coast; but those, which are commonly caught, are mackarel, albicore, cavalloes, jacks, congers, soldiers, old-wives, bull's-eyes, &c. The coal-fish, from two to three feet in length, are singularly delicate and high flavoured; but seldom more than eight or ten of them are taken in the course of a year. The flying-fish, when pursued by their various enemies, often drop upon the rocks; and some have been picked up, measuring more than two feet in length. Whales are frequently seen in the vicinity of the island; and have sometimes been killed in the roads by the south-sea whalers. Turtle frequent the coast in the months of December and March, and are often taken by the fishing boats. Shell-fish are not uncommon, especially one species resembling lobster; and rock-oysters are found in some situations in a solid mass, which may be separated into distinct fish.

Agriculture.

The whole superficial extent of St Helena is calculated at 30,000 acres, of which the greater part is a barren waste. About 8000 acres have been brought into cultivation; and much more might be improved as pasture-ground, if water were conveyed to it, which in many situations is perfectly practicable. Of the cultivated portions, about 1500 acres are in the occupation of the governor, the lieutenant governor, and the Company; 4000, besides goat-ranges, have at different times been let in leases at a low rent, seldom exceeding

St Helena. 16s. per acre; and about 2300 have become free by original grants to settlers. In no country is farming a more profitable employment than at St Helena, when droughts and other causes do not occasion a failure in the crops. The richest lands produce three crops of potatoes in the year, amounting in all to 400 bushels per acre, which will sell at 8s. per bushel. The price of labour, however, is high. The wages of a carpenter are 6s. or 7s. a day; of a mason, 4s. or 5s.; of a common labourer 2s. or 2s. 6d. A black servant may be hired from £10 to £20 per annum; but must in addition be supplied with clothing, maintenance, and medical attendance in case of sickness. The price of a slave of good character, and acquainted with husbandry work, is £150; but others of inferior qualifications may be procured for £30. Even with all these expences of cultivation, the lands in general are estimated to yield a profit of seven or eight per cent.; and, if wisely improved, as supposed by Governor Beatson, to be capable of affording an inexhaustible supply of fresh provisions and vegetables for the trade of the southern and eastern world. The use of the plough, drawn by oxen, so recently introduced by this officer, may tend to diminish the expences of the farmer; but only 2000 acres are said to be capable of being tilled in this manner, of which not more than 88 have been brought under cultivation. As the roads are in general inaccessible to carts, particularly in the inland districts, the produce of the farms in the country is carried on men's heads, occasioning a great waste of labour. Asses, however, have lately become an object of attention, as suited for this service; and their price has risen from £5 to £25. They are well adapted to the island, as they prefer those vegetables which the other animals refuse to eat.

Government. By repeated charters from the crown of Great Britain, the island of St Helena is assigned to the East India Company as perpetual proprietors, with all the powers of sovereignty and legislation. The supreme authority on the island is vested in the governor and a council. The council is composed of the lieutenant-governor, and senior civil servant, with the addition occasionally of a fourth and sometimes a fifth member as the Court of Directors may judge proper. These represent the lords proprietors, superintend all the concerns of the island, act as justices of the peace, and exercise the ordinary jurisdiction of the ecclesiastical court. When the council is not assembled, the whole authority of the board centres in the governor, who may also exercise, as occasion requires, all the powers of Captain-General. The civil establishment consists of an accountant, pay-master, store-keeper, and the secretary to government with their assistants, some of whom are at the head of inferior departments, and among whom promotion takes place according to seniority. The ordinary military force is composed of a corps of artillery, commanded by a lieutenant-colonel, a regiment of infantry, and five companies of white and black militia, who are at times rather on the footing of volunteers. There are also a head surgeon, an engineer, and a chaplain.

The whole island forms only one parish, but is divided into three districts, the East, West, and South or Sandy Bay divisions. There are two churches, one in the town, and the other in the country; and the ministers of religion in the settlement have, of late years, been as highly distinguished for the excellence of their character, as, in the earlier period of its history, they were noted for their incompetency and profligacy.

Revenue. The civil and military establishments cost at an average £40,000 per annum;* and there is generally an additional expenditure of £10,000 on the head of contingencies. The only revenue of the Company is derived from the rents of their lands, which may amount to about £1100, but gradually increasing as the old leases expire; and from the profits of a monopoly of arrack, which are estimated at £6000. But they have a dead capital of £200,000 sunk in public works, naval and military stores, &c.; and also warehouses for all kinds of articles useful to the natives or the shipping, which, though sold at a profit of ten per cent. do not cover the expences. But the best returns from the island must be sought in the accommodation which it affords to the Company's shipping, and the security which it provides for their commerce, against the hazards of the sea, and the attacks of an enemy. Its water, † climate, and vegetable productions, are so excellently adapted, particularly for scorbutic diseases, that many who have been sent to the hospital in the last stage of the scurvy, have, in the space of two weeks, been restored to perfect health. It is generally acknowledged, however, that the spirit of monopoly renders all the necessaries of life immoderately expensive, especially to strangers; and that a more abundant supply of fruits and vegetables might be provided for the vessels which arrive in the roads, if it were not that the persons who raise these articles for sale, prefer a high price to a large disposable crop; and would rather, it is affirmed, allow them to rot, than sell them at a lower rate. Fresh beef, which, by a regulation of the government, is fixed at a certain rate, (of late years about 6d. or 6½d. per pound,) is the only kind of provisions which can be procured at a moderate price. Other articles of food, in the year 1805, were purchased at the following prices, which vary, however, considerably, according to the demand.

	£	s.	d.		£	s.	d.	
Turkeys, from	1	10	0	to	2	0	0	each.
Geese, from	1	5	0	to	1	10	0	each.
Ducks, from	0	8	0	to	0	12	0	each.
Grown fowls, from	0	9	0	to	0	12	0	each.
Mutton, from	0	1	2	to	0	1	6	per lib.
Pork, from	0	1	6	to	0	1	8	per lib.
Potatoes, from	0	8	0	to	0	10	0	per bushel.
Eggs,					0	5	0	per dozen.
Cabbages,					0	1	6	each.
Pumpkins,					0	2	6	each.
Milk, from	0	0	4	to	0	0	6	per quart.
Turtle and coal fish,					0	0	8	per lib.
Fish of other kinds, from	0	0	2	to	0	0	3	per lib.

Strangers residing in the town can be accommodated in private houses, at the rate of thirty shillings, or one guinea a-day, with an excellent table, good wines, and comfortable lodgings.

Population. By the registered returns for the year 1805, the population of St Helena, exclusive of the garrison and

* The late additions to the officers and garrison, in consequence of Bonaparte's residence on the island, are said to have raised the annual expences of the settlement to £300,000.

† The water is excellent and abundant, and can now be conveyed so easily into the boats by pipes, that a fleet has been known to take on board 2000 tons in less than three days.

Company's civil establishment, amounted to 2064, of which number 504 were white inhabitants, and 1560 blacks: Of the latter, 329 were free. In 1814, the whole population, including the garrison, which ought always to be about one thousand men, was estimated at 4000 souls. Upon an average of five years, from 1801 to 1805 inclusive, 165 ships touched annually at the island; and in time of war, when fleets are detained for convoy, the crews and passengers frequently equal the whole amount of the population. No strangers are permitted to settle on the island, without permission from the East India Company. It has been recommended to allow the soldiers, whose time of service may have expired, to remain as husbandmen; and to import Chinese labourers, who might be bound to serve the Company in the first instance, but permitted to hire themselves to others, when not required to work for government. No importation of slaves has been allowed for a long time; and those who belong to the island, being generally treated with much kindness, are rather increasing in number. The inhabitants are in general a robust and healthy race, but rarely attain to a great age. The diseases to which they are subject, are principally of a catarrhal nature; and yet it has been observed that the driest seasons are frequently the most unhealthy. The inhabitants of the town retire to their farms and gardens during the greater part of the year; but, upon the arrival of the homeward bound India fleets, they flock with alacrity to the town, open their houses for the accommodation of the passengers, and entertain their guests with plays, dances, and concerts. They are a worthy, humane, and cheerful race of people, superficially accomplished, and sufficiently fond of gaiety. The young women are described as very smart and agreeable in their manners. They are bold and expert riders, galloping up and down the most formidable precipices. Their complexions are fine, and they are said to be very successful in procuring hasty matches among those who touch at the island, on their return from India. Most of the settlers, more recently arrived from Europe, employ their capital rather in mercantile than in agricultural concerns; and considerable gains are made among them by the sale of European articles to the India fleets.

This extraordinary spot of ground, independent of its political and commercial advantages, may justly be regarded as a most interesting natural curiosity, and, notwithstanding all that has been written respecting it, there is still wanting a scientific survey, and accurate classification of its natural history. But it has recently become a peculiar object of curiosity to the nations of Europe, in consequence of its having been selected as the prison of Napoleon Bonaparte; and as there appears to be but one opinion as to the justice and policy of his detention, the principal point of enquiry generally relates to its adaptation for the security of his person. In addition to the almost inaccessible ramparts with which it has been provided by nature, its eminences are covered with telegraphs and watch towers, and its various fortifications defended by nearly 500 pieces of cannon, so that, with ordinary vigilance and a competent garrison, it may be pronounced impregnable by any external force. But though a rescue may be next to impossible, an escape is not accounted impracticable. There are various points on the coast, where one or two individuals, with a certain degree of naval assistance from without, (which the multitude of fishing boats, and ordinarily favourable state of the weather must tend to facilitate,) may, without much difficulty, leave the island; and instances have occurred to prove, that, even in an open boat, a run might be accomplished, with little hazard, to the island of Ascension, or even to the coast of Brazil. See Lord Valentia's *Travels*, vol. i. Forbes's *Oriental Memoirs*. Campbell's *Travels in Africa*. Brooke's *History of the Island of St Helena*. Johnson's *Account of St Helena*. Beatson's *Tracts relative to the Island of St Helena*. (*q*)

HELIACAL, is a term derived from ἥλιος, *the sun*, and applied to the rising and setting of the heavenly bodies. A star is said to *rise heliacally*, when, after having been in conjunction with the sun, it gets to such a distance from that luminary as to become visible in the morning before sun-rise. A star is said to *set heliacally*, when it approaches so near to the sun that it can no longer be seen in the evening after sunset.

HELICON, is the ancient name of a mountain in Bœotia, near the Gulf of Corinth, sacred to Apollo and the Muses, who thence received the name of Heliconides. Its modern name is *Sagara*, pronounced *Sacra*, an obvious corruption, as Dr Clarke has stated, of *Ascra*, a town upon Helicon, and the birth-place of Hesiod. Dr Clarke, who visited this mountain, has favoured the public with a very interesting description of it. Instead of proceeding to Lebadea, by the usual circuitous route along the level country, he ascended the mountain from Neocorio, passed by the monastery of St Nicholo to Sagara, and afterwards descended by the monastery of St George to Lebadea. He ascended in a north-west direction above the village of Neocorio, and passed a chapel in ruins. On his right hand, there was a rivulet flowing from Helicon towards the plain of Neocorio, or Thespia; and beyond this, on the opposite side of the dingle through which this rivulet fell, he saw from an eminence a village called Panaja. After travelling along the north-east side of the mountain, he reached in about an hour the little monastery of St Nicholo, situated within a sheltered recess of Helicon. The mountain surrounded it on all sides, a ruined tower belonging to Panaja appearing in front through a small opening. The aromatic plants filled the air with their spicy odours. A perennial fountain threw its limpid waters into the rivulet below; and the monastery was almost concealed amid trees, no less remarkable for their variety than for their beauty and luxuriance. The fountain was covered with moss and with creeping plants, forming a pendant foliage over all the fabric constructed around it. In a church near the monastery, Dr Clarke found a long inscription on the shaft of one of the pillars, distinctly mentioning that the ΜΟΥΣΕΙΑ, or games sacred to the Muses, according to Pausanias, were celebrated near a grove upon Mount Helicon. This inscription, and other evidence, convinced Dr Clarke that he had now discovered the fountain Aganippe, and the Grove of the Muses. Hence it followed, that the rivulet below was the Permessus, parent of Aganippe, called Termessus by Pausanias, and flowing, as he describes it, in a circuitous course from Mount Helicon.

A path winding through the grove, conducts from the monastery to the spot where, upon the left hand, the water gushes forth in a clear and continued stream. "The work about the fountain," says Dr Clarke, "was until lately very ancient, and not long ago there was an antique cistern in front of it; but the present monks, finding the work in a ruined state, undertook to repair it, and thus destroyed much of its original and venerable appearance. In its state of restoration, however, it is not without picturesque beauty; for they have

Helicon.

merely erected an arcade of stone, whence the water issues, and this is already adorned by moss and creeping plants. The walks about the fountain, winding into the deep solitude of Helicon, are in the highest degree beautiful. All above is grand and striking, and every declivity of the mountain is covered with luxuriant shrubs, or tenanted by browzing flocks. Higher up the mountain, at the distance of two miles and a half from this grove and from the fountain Aganippe, was the fountain Hippocrene, fabled to have sprung from the earth when struck by the hoof of Pegasus."

From the Grove of the Muses, Dr Clarke descended to the Permessus, and crossing that rivulet, he ascended in a north-west direction towards the higher parts of Helicon. Wherever the surface was laid bare, he found the rocks to consist of primary limestone. By proceeding with difficulty along a craggy narrow path, he reached the heights of Sagara, where he observed part of the ancient paved causeway, which formerly led from Thespia to Ascra and to Lebadea. From this point, which was two hours journey from Neocorio, the whole of Bœotia was seen. The road now extended south-east and north-west, and another hour was necessary to descend into the deep valley in which Sagara is situated. This valley is entirely surrounded by high rocks, and by the towering summits of Helicon. A level plain is seen below, having its woods and corn fields almost buried in the deep bosom of the mountain. A steep and rugged descent now conducted Dr Clarke to the village of Zagara, which is divided into two parts by a river flowing across this valley, one part of the village being high above the other. The lower part stretches into the level plain; and above the upper part a small white edifice, the monastery of Panaja, appears embosomed among trees. Dr Clarke has shewn, we think very satisfactorily, that this village is the Ascra of the ancients, the place of Hesiod's nativity.

After passing Zagara, Dr Clarke advanced among the boldest rocks, and ascending by a narrow, steep, and stony path, he reached the highest part of this road over Helicon, "commanding a prospect," as he remarks, "which, in the grandeur of its objects, and in all the affecting circumstances of history thereby suggested, cannot be equalled in the whole world. The eye ranges over all the plains of Lebadea, Chæronea, and Orchomenus, looking down upon the numerous villages now occupying the sites of those and of other illustrious cities. From the spot where the spectator is placed, the most amazing undulations of mountain scenery descends in vast waves, like the swellings of an ocean, towards Parnassus, whose snowy bosom dazzling by its brightness, was expanded before us with incomparable grandeur."

After passing another fountain, and travelling a quarter of a mile over an ancient paved way, Dr Clarke reached a magnificent terrace, elevated as it were above all Greece, and continuing to descend, the monastery of St George appeared in view, bearing north and by west. He then arrived at the village of Kotumala, about 1¼ hour from Zagara, and commanding the most sublime views. After passing the remains of an aqueduct, and the ruins of a city upon a hill, he reached Panori, two hours distant from Kotumala. He then passed two bridges, and came in sight of Lebadea, which will be described under that article.

We have thus given our readers a very brief account of Dr Clarke's most interesting examination of the antiquities of Mount Helicon. They will naturally turn to the original work for an ampler account of his journey. The classical reader will feel himself inspired at every step, and will share the fine sentiments which the sight of ancient Greece awakened in the first of modern poets.

Where'er we tread, 'tis haunted holy ground;
No earth of thine is lost in vulgar mould;
But one vast realm of wonder spreads around,
And all the Muses' tales seem truly told,
Till the sense aches with gazing to behold
The scenes our earliest dreams have dwelt upon;
Each hill and dale, each deepening glen and wold,
Defies the power which crushed thy temples gone:
Age shakes Athena's power, but spares gray Marathon.
Long to the remnants of thy splendour past
Shall pilgrims pensive but unwearied throng;
Long shall the voyager with the Ionian blast,
Hail the bright clime of battle and of song;
Long shall thine annals and immortal tongue
Fill with thy fame the youth of many a shore;
Boast of the aged! Lesson of the young!
Which sages venerate, and bards adore,
As Pallas and the Muse unveil their awful lore.

Byron's *Childe Harold*, Canto II.

See Clarke's *Travels*, Part ii. Sect. iii. p. 92—118.

Heligoland.

HELIGOLAND, or Helgoland, is a small group of islands belonging to Great Britain, and situated opposite the mouths of the Elbe and the Weser, and at the distance of nine German miles from each. The islands of Heligoland consist, 1st, of the island of Heligoland; 2d, the Sandy Island, called the Downs; and 3d, of several reefs and rocks, of which that called the Monk is the most remarkable. The island of Heligoland is divided into the High Land or the Cliff, and the Low Land. It is said to be in a state of rapid destruction from the encroachments of the sea; and it is reported among the inhabitants, that during the last century, it has been reduced from 11 miles in length to its present dimensions of 1 mile. The high land or cliff, according to the measures taken by Dr Heinemeyer, is 166 feet at its greatest, and 88 feet at its least height, and has a circumference of 4200 paces. It is ascended by a flight of 203 steps. The low land, which increases sensibly every year, is connected with the eastern part of the cliff by a rock about 500 paces long. The circumference of the low ground was 1400 paces in 1800. The circumference of the whole island, including the high and low ground, is 4600 paces. The Downs, or Sandy Island, is about two-fifths of the size of Heligoland; but its extent is constantly varying.

Mineralogical structure.

According to Dr Macculloch, Heligoland consists of strata of indurated clay alternating with beds of gray limestone, forming an angle of 30° with the horizon, and dipping to the north-east. The clay is of a strong red colour, and contains much oxide of iron, and some carbonate of lime. The limestone is in some parts formed of various marine remains, and in others it is uniformly granular. Through both these are dispersed in various places deposits of copper ore in small quantities. These consist of carbonate of copper diffused through the earthy matter, and of crystallized masses of the same substance; and more rarely there are found lumps of red oxide, mixed with particles of gray ore and native copper. The beach is covered with various siliceous pebbles, containing grains of the same substance imbedded in them, together with variously coloured porphyries and hornstones. On the shore are found belemnites, and other calcareous and flinty fossil remains; and considerable quantities of pyrites, and carbonized and pyritaceous wood, are contained in the clay strata.

This island is said to have suffered great physical re-

Heligoland. volutions in the years 800, 1300, and 1500. The Downs, or the Sandy Island, was not only connected with the low ground of Heligoland, but even a part of the reefs was covered with earth. Other revolutions took place in 1649 and 1720. Before the first of these epochs, the low land of Heligoland contained the isle called the Downs; and even before 1720, there existed between the two islands a narrow isthmus, which was seldom covered with water, except during very extraordinary tides. Since 1720, the two islands have been separated by a strait called Waal, which is from 18 to 20 feet deep.

Physical revolutions.

Soil and productions.

The soil which covers the rock is from 3½ to 4 feet deep, and is rather fat than sandy. It produces annually about 300 tons of barley, and a little oats. The uplands afford good pasture for about 60 cows, and 400 or 500 sheep. In the north-west part of the island there are three ponds of rain water, called *sapskulen* by the inhabitants. The water of the two springs in the low ground is fit only for cattle, and is scarcely of use for washing. The principal revenue of the island is derived from the fish which are caught. About 120,000 Lubeck marc of fish, amounting to about 230,000 francs, are exported annually.

Harbours.

There are two good harbours in the island, which could be improved at a trifling expence. The northern harbour, where the larger vessels of the islanders lie, varies in depth from 7 to 42 feet at half-tide, and the southern harbour, which receives the chaloupes, has a depth of from 10 to 24 feet. To the east of the Downs is a road, which has 48 feet of water. The tides ordinarily rise 9 feet, but with a north-west wind they rise to a great height.

Batteries.

The island was defended in 1800 by four batteries, that of the south-east, that of the south, and the high and low battery on the north. The two first were directed to the landing place for large vessels, and the other two against the current between the islands. They mounted 19 cannon, and 4 howitzers, with 56 regular troops. The light-house serves to direct all vessels that wish to enter the Hever, the Eyder, the Elbe, the Weser, and the Jade.

Lighthouse.

Buildings.

There are no fewer than 342 houses in the high ground, and 78 on the low ground, making in all 420. The church, the magazine, and the public buildings, are erected on the high ground. Those on the low ground are merely the huts of the fishermen. A building has been erected on the sandy island for the accommodation of those who may be shipwrecked upon it. The population was 2200 in the year 1800. In the same year there were 11 sniggs (small vessels) on the island, 97 chaloupes, and 80 yoles.

Natives.

The natives of Heligoland are descended from the Frisians, and have preserved their language and their principal customs. They are chiefly employed in fishing and piloting vessels up the Elbe, the Weser, and the Eyder. They live in huts, and lie upon planks placed one above another, though some of the houses in the high ground are clean and well furnished. The women plough and sow the ground, thrash the grain, and grind it for food. They have neither carts nor horses. They obtain from Nordhovet in Eyderstedt, forage for their cattle in winter, and their fuel is got from the ports on the Elbe.

History.

This island is supposed by Malthe Brun to be the Alokiai islands of Ptolemy. It appears also to have been the *Fosetisland, Fosteland,* or *Phosteland,* which appears in the history of the 7th, 8th, and 9th centuries to have been the seat of a peculiar worship paid to the idol *Foseles,* who is supposed by some to be the Vesta, or Festa of the Romans, and the Hertha of the Scandinavians. The altars of this deity were, however, overturned in A.D. 866, and his temple changed into a monastery. In 1403 and 1417, two famous pirates endeavoured to establish themselves on this island, in consequence of which it was put into a state of defence in 1539. The town of Hamburg was afterwards anxious to obtain possession of it, but the Dukes of Holstein and Gottorp, claimed with success this ancient dependency of Denmark, and it passed with the Duchy of Sleswick into the possession of the Danes in 1714. The Danish government, however, neglected the great advantages of this position, and did not put it into a state of defence till the canal of Holstein was opened.

In September 1807, a small English squadron under Admiral Russel blockaded the island, which surrendered a few days afterwards, for the want of provisions. Thirty-two pieces of cannon, besides field-pieces and mortars, and a large stock of ammunition, were found on the island. By the arrangements in the treaties of Paris in 1814 and 1815, Heligoland has been transferred to Great Britain. East Long. of the lighthouse 7° 53′ 13″, North Lat. 54° 11′ 39″. See Malthe Brun's *Annales des Voyages;* Carr's *Northern Summer;* and the *Geological Transactions,* vol. i. p. 322.

Heliocentric ‖ Heliopolis.

HELIOCENTRIC. See Astronomy, vol. ii. p. 654.

HELIOGABULUS. See Rome.

HELIOMETER from ηλιος the *sun,* and μετρειν to *measure,* is the name given by M. Bouguer in 1747, to an instrument for measuring the diameters of the sun and moon. It differs in no respects from the divided object glass micrometer, which had been previously invented by Mr Savary, excepting that in the heliometer, two whole object glasses were used instead of two semilenses. The object glasses are separated by a screw, as in Savary's instrument. See the *Memoirs of the Academy of Sciences* 1748, and our article Astronomy, vol. ii. p. 734. A new heliometer, in which the semilenses are fixed at a certain distance, and the variation of the angle produced optically, is described in Brewster's *Treatise on New Philosophical Instruments,* p. 31. and 173. See also Micrometer.

HELIOPOLIS, from ηλιος, and πολις, *the city of the sun,* is one of the most ancient cities in the world of which any vestiges can now be traced. The most enlightened philosophers of Greece and Rome were attracted to this celebrated seat of learning. It was here that Herodotus became acquainted with the sciences and mysteries of Egypt. Plato was here taught philosophy, and about 30 years before Christ its ruins were visited and described by Strabo.

Strabo describes Heliopolis as built upon an artificial mount of earth, so as to be out of the reach of the inundation of the Nile; but owing to the accretion of soil from the annual inundations of that river, the place where it stood is now a perfect plane. In this city was erected a temple to the sun, where a particular part was appropriated for the feeding of the sacred ox, which was here worshipped under the name of Mnevis. There was also another splendid temple, with avenues of sphinxes and superb obelisks before the principal entrance. Out of the four obelisks which were erected here by Sochis, two were carried to Rome, one was destroyed by the Arabs, and the fourth still remains.

When Pococke visited Heliopolis, he observed the fragments of sphinxes still remaining in the ancient way leading to the eminence on which the temple of the sun, Heliostate.

stood. These sphinxes are, however, no longer visible. They are no doubt covered with the soil deposited by the Nile; and we agree with Dr Clarke in thinking, that not only the sphinxes, but even the pavement of the temple, might be disclosed by a very trifling excavation.

The obelisk or pillar of On, which is now the only piece of antiquity that marks the site of Heliopolis, is about 68 feet high, and 6½ feet wide on each side. According to Dr Clarke, who has given a very correct engraving of it, it is one entire mass of reddish granite. Each of its four sides exhibits the same characters, and in the same order. Those which face the south have been the least affected by the decomposition of the substance in which they are hewn; and it is from the southern side that Dr Clarke's engraving is taken. For a particular account of this obelisk, and the hieroglyphics which it contains, the reader is referred to Kircher *Syntagma* VIII. *Theat. Hieroglyph. Œdipi Egyptiaci*, tom. iv. p. 330; Pococke's *Description of the East*, vol. i. p. 23; Shaw's *Travels*; Norden's *Travels*; but particularly Dr Clarke's *Travels*, part ii. sect. ii. p. 98.

HELIOSTATE, or Heliostata, from ηλιος the *sun*, and ιστημι *I stand*, is the name of a very ingenious and useful instrument, invented by Dr s'Gravesande, who was professor of mathematics at Leyden. The object of it is to give such a motion, by means of clockwork, to a polished mirror, that the beam of the sun which it reflects may be fixed, or remain in the same position during the diurnal motion of the earth. Hence it is of great use in all optical experiments, in which it is required to transmit the solar rays into a dark room.

Plate CCXC. Fig. 1.

The heliostate, which is represented in Plate CCXC. Fig. 1. consists of two principal parts; 1st, A plane metallic speculum, supported by a stand; and, 2d, A clock for giving motion to the speculum. The speculum S, contained in a wooden frame, is placed in the brass case *a, a*, and is suspended by the handle AA, so as to have a free motion round an axis *a a*, which should pass along the surface of the speculum. The handle AA is joined to the cylinder C, whose axis is coincident with the middle part of the axis *a a* of the speculum. The axis of the tail DF, joined perpendicularly to the back of the speculum, is directed to the same point. This tail is made of a cylindrical brass wire, about the sixth part of an inch in diameter. The cylinder C is put upon the wooden stand P, the upper part of which is shewn separately in Fig. 2. The smooth iron cylinder *e* goes into a cavity in the copper cylinder C, so that by the motion of the tail DE, the position of the speculum may be altered at pleasure. The wooden stand P is raised and depressed by the three brass screws B, B, B, turned with a key, and moving in a plate of brass.

Fig. 2.

The clock is represented at H, with an index which revolves once in 24 hours. The plane of the clock is inclined to the horizon, at an angle equal to the co-latitude of the place. The copper pillar FG, which supports the clock, consists of two parts, joined by the screws *d, d*, between which, as in a sheath, is moved an iron plate, in the middle of which there is a slit through which these screws pass. This plate is fixed to the lower plate of the clock itself, so that it can be raised and depressed, and fastened at any height by the screws *d, d*. The same effect may also be produced by the screws I, I, I passing through the copper plates L, L, M. The extremities *b c*, *b′ c′* must be in the same straight line, and a vertical plane passing through them must be perpendicular to the horizontal lines drawn on the plane of the clock, such as *f g*, *h i*.

Heliostate. Plate CCXC. Fig. 1.

When the plane of the clock is inclined at an angle equal to the co-latitude of the place, the plane LLM must be brought into a horizontal position by the plummet Q, the point of which is made to coincide with a point *o*, marked on the foot M. But if it were required to use the instrument in another latitude, another point *o* would require to be marked; and it would be necessary to incline the plane LLM to the horizon. The axis of the wheel which moves the index has a cylindrical perforation, but a little narrower below than above. The index, shewn separately at ON, in Fig. 3. is made of brass, and has a tail *p q* exactly filling the above mentioned perforation, into which it is thrust tight, so as to stick and be carried along by the wheel. The tail *p q* has also a cylindrical hole, through which passes the small brass wire *l k*, which remains in any position into which it is put. At the end *o* of the index there is a small cylinder *n* perforated cylindrically. The length of the index *n n′* was six inches in s'Gravesande's machine. Fig. 3.

The iron tail *t* (Fig. 4.) of the piece T goes into the cavity *n*, Fig. 3. as shewn in Fig. 1. and moves in it freely, though not loosely. The small pipe R, Fig. 5. through which the tail DE of the speculum may be moved freely, may be suspended at different heights between the legs of the piece T (Fig. 4.) by the screw *r r* going into the parts *m m* of the pipe. The pipe can then turn freely round *m m* as an axis. Fig. 4. Fig. 5.

In order to fix the machine, another part, called the *placer*, must be used. The cylinder and the speculum being removed from the stand P, the brass pillar VX (Fig. 6.) is stuck tight upon *e*, Fig. 2. The ruler YZ moves round a centre at X, so as to remain in any position in which it is placed. The arm XZ has a peculiar construction and a certain length, but the length of XY is determined at pleasure. The end X*y* of the ruler, which does not extend beyond *y*, is included between other two, viz. *x* Z, and are on the opposite side. They are joined at Z, and are kept together by the screws *z, z*, which pass through a slit in the enclosed ruler X*y*. On this ruler is marked the small line *v s*, whose length is equal to $\frac{90}{1000}$ parts of the length of the index. The arm XZ is equal to the length of the index, reckoning from the centre of motion at X to the end Z, when *x* coincides with *v*, where the divisions on *v s* commence. The line *v s*, which is unequally divided, serves to determine the length of the arm XZ for different times of the year, by bringing *x* to the division corresponding to the given day when the machine is used. Fig. 6.

In order to mark the divisions, the arm is supposed to be divided into 1000 parts, hence *v s* will be 90 parts. The distances corresponding to different times of the year, are set down in the following table.

21st March. 21st Sept.	1st March. 11th Oct.	21st Feb. 21st Oct.	11th Feb. 1st Nov.	1st Feb. 11th Nov.	21st Jan. 21st Nov.	11th Jan. 1st Dec.	21st Dec. 21st Dec.
Parts.	Parts.	Parts.	Parts.	Parts.	Parts.	Parts.	Parts.
0	8	17	32	47	64	77	90

On the opposite side of the ruler is drawn another line corresponding to *vs*, the divisions for which are given in the following Table.

21st March. 21st Sept.	11th April. 1st Sept.	21st April. 21st Aug.	1st May. 11th Aug.	11th May. 1st Aug.	21st May. 21st July.	1st June. 11th July.	21st June. 21st June.
Parts.	Parts.	Parts.	Parts.	Parts.	Parts.	Parts.	Parts.
0	11	22	36	51	66	79	90

Method of using the instrument.

Plate CCXC. Fig. 1.

The instrument being thus constructed, is used in the following manner. Having adjusted the point *x* of the placer to the division for the day of the month, place XV upon the stand P, and put the ruler Y into the position and direction in which it is wished to fix the solar ray. The lines *bc*, *b'c'* are placed in a meridian line drawn on the plane, and the point of the plummet Q is brought to *o*. The index NO is then turned till the sun's rays pass directly through the pipe R, which may be varied in its position till this is effected. The brass wire *lk* is then raised or depressed till the shadow of the end of it *l* passes through the middle of the pipe R. This part of the machine is then moved to the *placer* as formerly adjusted; but the clock is moved and raised in such a manner that the end *l* of the brass wire *l k* may coincide with the end Z of the ruler YZ. The sun's rays, and the shadow of *l* passing through R, and the point of the plummet corresponding with *o*; the pillar VX with its ruler is removed, and the cylinder C, carrying the speculum S, is substituted in its place, without altering the position of the stand P. The piece T is taken out of its place, that the tail DE of the speculum may be put through the pipe R; and when the piece T is replaced, the machine is then ready for use. The rays reflected from the speculum have the same position and direction as the ruler of the placer; and while the tail of the speculum moves with the clock, whose index follows the sun, its situation is altered with respect to the sun, but the ray reflected from the centre of the speculum remains fixed. By substituting the index K, Fig. 7. in place of NO, the machine becomes a common clock For a demonstration of the truth of the preceding construction, the reader is referred to s'Gravesande's *Physices Elementa Mathematica*, tom. ii. p. 714.

Fig. 7.

Simple heliostate proposed by Dr Young.

Plate CCXC. Fig. 8.

A very simple substitute for the heliostate, as proposed by Dr Thomas Young, is shewn in Fig. 8. A mirror C is fixed on the outside of a window facing the south, opposite the aperture D, through which it is required to transmit the solar rays. Another mirror is fixed by a joint to a rod AB, moveable about its axis, and parallel to the axis of the earth. The mirror A being placed in a position required for the day, so that the light which it reflects is received at such an angle upon C, that it may be transmitted through the aperture. In order to keep the ray in this position, nothing more is necessary than to turn the axis BA round on its socket. See Young's *Nat. Phil.* vol. i. p. 426, 785. Analogous contrivances by Peyrard will be found in the *Phil. Magazine*, vol. xxxvii. p. 183, &c.

HELIOTROPIUM. See Mineralogy.

HELIX. See Conchology, vol. vii. p. 79.

HELLESPONT. See Turkey.

HELMINTHOLOGY, is a term in zoology, derived from ελμινς, an *earth-worm*, and λογος, *a discourse*. Under this head are included those animals which Linnæus called *vermes*. For an account of the different orders of this class, see Animalcule, Conchology, Intestina, Mollusca, Radiata, and Zoophytes.

HELOISE. See Abelard, vol. i.

HELSTON, a town of England in the county of Cornwall, is situated on the side of a hill, which slopes gently to the little river Cober. The town consists principally of four streets, which meet in a centre, and form a cross, and a channel of water runs through each of them. The market-house and town-hall stand near the middle of the principal street. The church, which was erected in 1762 on an eminence to the north, has a pinnacled tower 90 feet high, which forms a conspicuous sea mark. There was formerly a priory and a strong castle at Helston. Some vestiges of the castle were seen in the time of Leland. The priory of the knights of St John of Jerusalem was at St John's village, near the town. The remains of it were destroyed some years ago to make room for a Methodist meeting-house. The town is governed by a mayor, five aldermen, a recorder, and sworn freemen, amounting to 36. Helston was one of the original stannary towns, but very little tin is now stamped here. Vessels take in their lading at a good harbour, a little below the town. Near Helston is a curious heap of stones, piled up in the form of a circle. It is called Earth Castle, and was formerly used as a fortification.

The population of the burgh and parish, in 1811, was,

Number of inhabited houses . . .	328
Number of families	531
Ditto employed in agriculture	119
Ditto in trade and manufactures . .	166
Males	935
Females	1362
Total population in 1811	2297

See the *Beauties of England and Wales*, vol. ii. p. 455

HELVETIA. See Switzerland.

HELVETIUS, Claude Adrian, a celebrated metaphysician of the modern school, was born at Paris in January 1715. His ancestors, originally of the Palatinate, had been obliged, by their attachment to Protestant principles, to remove to Holland. His father, grandfather, and great grandfather belonged to the medical profession, and were all men of eminence. His grandfather in particular obtained celebrity by the introduction of ipecacuanha into the Materia Medica. M. Helvetius, the father of the subject of this article. was physician to the Queen of France, and held in great honour at court, was well known through Europe as a man of talents, and highly esteemed by all who knew him, for the probity of his character. He gave his son an excellent education, by placing him very early under the care of an intelligent tutor, M. Lambert. The young Helvetius was remarkably docile, and rapidly imbibed the spirit of the different authors whom he read; and from his exquisite sensibility to praise, he rendered himself an early proficient in literature, dancing, fencing, and the various other accomplishments which produce admiration. At college he became warmly attached to the philosophy of Locke. To trace all mental operations to sensation, appeared to him a happy explanation of these complicated phenomena; and he became animated with an ambitious desire to improve and extend the principles which he so much admired. At the age of twenty-three, he obtained the very lucrative situation of a farmer-general. He indulged the habits of a man of pleasure, but not without maintaining a degree of masterly prudence, which enabled him to manage his fortune without incurring inconvenience, and to give efficiency to the feelings of a noble humanity, by devoting a great part of his income to benevolent acts. He assiduously sought out and rewarded talent and merit, and always observed a delicacy of manner which avoided the slightest wound to the pride of the most fastidious of those whom he served. Intent on the improvement of his own powers, he cultivated the society of Fontenelle, discussed along with him the doctrines of Locke and of Hobbes, and with his aid successfully cultivated the talent of expressing his ideas with perspicuity. He also became acquainted with Montesquieu and Voltaire, and profited in a similar manner by his intercourse with each of these eminent scholars. The earliest literary labour of Helvetius, was his poem on Happiness, in the composition of which Voltaire gave him great encouragement, and inculcated on him maxims which he himself had felt to be important, particularly on the indispensible necessity of truth of description, and regularity of language.

In the office of farmer-general, Helvetius was the uniform advocate of humanity, and exerted his influence to obviate the hardships to which individuals were so often liable, from the persons employed to collect the revenue. Here he had to contend with men long inured to an unfeeling system of procedure. In many of his remonstrances with the other farmers-general, his perseverance was rewarded with success: but his employment was on the whole accompanied with much disgust, and was further rendered unpleasant by the time which it occupied, and which he was desirous of devoting to philosophical studies. He therefore resigned its advantages, and with a sum of money which he had saved, he purchased an estate in the country, to which he retired. He married Mademoiselle Ligniville, after an acquaintance of 12 months, formed at the house of Madame Graffigni, the authoress of the *Peruvian Letters*. In compliance with the wishes of his father, he still passed a few months annually in the metropolis, attended court, and accepted of the situation of Maitre d' Hotel to the Queen. He took as inmates of his house two persons who had been his secretaries, chiefly from motives of benevolence. One of these, an unhappy cross-tempered and sarcastic character of the name of Bandot, presuming on his knowledge of Helvetius in his infancy, habitually treated him as a harsh schoolmaster treats a child. This circumstance is worthy of mention, for the light which the indulgence given to him throws on the character of Helvetius. Bandot's great delight was to discuss with his master the whole conduct, talents, character, and works of the latter; and the discussions uniformly ended with satirical abuse. Helvetius, after retiring with his wife on such occasions, sometimes said, " is it possible that I am so deficient as this man represents me? I do not believe it, but I labour under these defects to a certain degree; and if I did not keep Bandot, I should have no one to point them out."

In his rural retreat, he composed his work *De l'Esprit*, or " An Essay on the Mind and its Faculties," which was published in 1758. In this work, he developed with much eloquence, and followed to some bold conclusions, the principles which he had imbibed from Locke, that all thought is a modification of physical sensation. He makes this the foundation of a system of public and private morals. This work had a powerful political effect. It was written under an impression, that the numerous evils of society are the offspring of corrupt institutions and strongly protected prejudices, and that the true source of them had been concealed by the want of analytical views of human nature and society. These fruits of his studies were presented to the world in a style and manner which were fitted to make a deep impression. His mode of representing the subject was favourable to that rage for pleasure, and that tendency to licentiousness in some points of morality which had long prevailed in France. The author, however, in publishing it, gave a pledge of his sincerity, by risking all his honours, his property, and the whole peace of his life. His opinions were in some points wrong, and some of their tendencies were injurious; but we do not see in his mode of stating them, marks of such haste or obstinacy as would have disinclined him to sacrifice any passion which he found really hurtful, or from renouncing the eclat of a philosophical reformer, if truth and consistency had been shown to lie on the opposite side. The points at issue between him and his adversaries were of equal importance to all, and the prohibition of his writings can only be attributed to the love of power on the part of others, and a senseless dread of the consequences of free inquiry.

He was first attacked in some of the popular journals, with criticisms which contained some truth and plausibility mingled with marks of the lowest superstition and ignorance, and which were animated with the bitterest style of denunciation and invective. The doctors of the Sorbonne issued their censures against his heresies, which they enumerated in such concise propositions as the following: That physical sensibility produces our ideas; that pain and pleasure are the sources of thought and action; that the desire of happiness is sufficient to conduct men to virtue; that morality is, like physics, an experimental science; that vices and virtues proceed from different modifications of the desire of happiness; that virtuous actions are those which are useful to the public; that it is by good laws that mankind are rendered virtuous; and, that the chief cause of all existing vice is the ignorance of legislators, who set the interests of individuals in opposition to that of the public.

His first and most zealous enemies were the Jansenists, whose influence in the parliament of Paris procured from that body a condemnation of his work. Their rivals the Jesuits, who had been spared by Helvetius, and with some of whom he had lived on friendly terms, made no public appearance against him till called upon by the general voice, and a regard for the character of their order. One of their number, a friend of Helvetius, conceived the plan of procuring from him a retractation of his errors. To gratify this friend, Helvetius subscribed a sort of apology, and afterwards another, which was ampler and more humiliating, with a view to save from persecution the public censor, who had suffered his work to pass the ordeal required by law. This, however, was not satisfactory: Helvetius was deprived of his situation at court; Tercier the public censor lost his office; and the interference of the council was necessary to save both of them from further severities meditated by the Jansenists and the parliament of Paris.

The philosophical doctrines to which this author was attached, comprehend a subject too extensive to be discussed in this article: (See METAPHYSICS.) But we find his opinions reprobated even by some liberal minds, along with those of some of his cotemporaries, as tending to degrade human nature, and destroy the dignity of moral truth. We do not apprehend, that such tendencies arose from any metaphysical opinions on the nature of matter and mind, subjects wholly unknown, and on which no opinion can be said to exist. The practical evils complained of seem to arise from a particular mode of employing words, tending to discourage all elevated conceptions, and thus generate in some individuals a degree of indignation, while its plausibility seduces others, and insensibly mars their love of moral order. An inordinate propensity to dwell on analytical views, sometimes withdraws the attention of the mind from the acknowledgment of magnificent objects. When the phenomena of mind are minutely dissected, and shown to consist of the same materials with others of a trivial nature, such as the puncture of a pin, or the titillation of a feather, all the pleasure arising from the novel exercise of acuteness implied in the tracing of these general analogies is of short duration, and the utmost circumspection is afterwards necessary, to resist an exclusive tendency to cherish detached sensibilities, and degenerate into a mean direction of sentiment and conduct. Persons thus influenced, consider all differences betwixt higher and meaner objects as depending on differences of arrangement, without duly acknowledging the importance of that principle of arrangement which deserves their veneration much more than minor insulated objects. The error of not acknowledging the importance of differences, merely because we are pleased with the generalization implied in the discernment of analogies, is also a radical fault in the use of the intellectual powers tending to the same moral confusion. It is not the mere pointing out of such analogies that does harm, but the undue rank that is assigned to them. To say that virtuous and vicious actions are equally explicable on the principle of self-interest, has an apparent tendency to smooth over the difference between them. Our previous sense of their difference renders us averse to consider them as possessing any thing in common. But if any person should think it worthy of mention, that these two sets of phenomena agree in possessing the essential quality of activity, and are reducible to the varied motions of the human organs, no dangerous consequences could be apprehended, because such a position never could make a prominent figure in a moral treatise, so as to distract the mind from distinctions of essential importance.

Even a general test of morality is not sufficient to obviate the noxious effects of magnifying such analogies. The annunciation of this summary doctrine, that public utility, or the promotion of the greatest sum of pleasure, is the ultimate end of virtue, is even productive of some disadvantage. Although it may have been tacitly acknowledged, those who are averse to innovation feel in it something different from what they have considered as a definition of virtue; while those who are dazzled with it as an important discovery, satisfy themselves with vague appeals to this general test, in cases which require more minute discrimination, or perhaps the spirit of morality evaporates amidst the interminable disputes which those who trust in the all-sufficiency of that principle maintain about its particular applications. Some launch into an ocean of the wildest confusion, and merely because they associate their actions with the acknowledgment of this generalizing principle, imagine that they are men of superior virtue. This mode of thinking has proved a frequent source of imprudence, unhappiness, and misanthropy.

The works of Helvetius are probably less read now than formerly. This may be partly the effect of the influence of indiscriminate acrimonious censure; and, although their merit is not of the highest order, it may in a short time give way, among some readers, to an equally indiscriminate admiration. It is therefore useful to be aware of some of their tendencies, which must, on consideration, be allowed to be injurious by men of all varieties of theoretic opinion. One of the most untenable of the opinions of Helvetius was, that any differences in the original endowments of men are of no account in giving origin to the differences between mind and mind which appear on the great theatre of the world.

The conflict which took place between the sentiments of this author and those of the age in which he lived, only afforded a specimen of a scene of hostility in moral literature, which was much more extensive; and, when we consider the spirit of mutual defiance in which both parties indulged, we cannot wonder at the antipathies which it created, and the dismal political dissensions which flowed from it as soon as the restraints imposed by existing institutions were withdrawn.

The works of Helvetius were, through the influence of the French clergy, condemned by the Roman inquisition; but they were universally read and much admired in Italy and the whole of Europe. Even the dignitaries of the church, among whom was Cardinal Passionei, wrote complimentary letters to thank the author for the fund of instruction and delight which he had afforded them.

The tide of popular sentiment, however, was so adverse to him in France, that he found it prudent to leave that country for a time. He visited England, and was much pleased with some favourable features in the state of English society as contrasted with that of France, particularly the happiness and contentment of the lower orders, the prevalent warmth of parental affection, and he even construed the want of free association among adults to their exemption from ennui, and from all dependence on frivolous amusements. He also visited Prussia, where he was received with great attention by the king, lodged in his palace, and freely admitted into his familiar parties.

When the storm raised against him in France had subsided, he returned home, and prosecuted his studies at his estate of Voré. He employed himself in extending the doctrines of his first work, in a "Treatise on Man, his Faculties and Education;" but had the prudence to give nothing more on the subject to the public. Being attacked with the gout in his stomach, he died in December 1771.

The private character of Helvetius was distinguished by great humanity. He was a most indulgent landlord; and Madame Helvetius and he concurred in the execution of continual plans of beneficence. His lands being infested by poachers, he sometimes was provoked to punish them; but the slightest appearance of suffering produced instant reconciliation, and awakened all his benignity.

After his decease, his poem *De Bonheur,* on which he had long laboured, was given to the public. The object of this poem is to recommend literary improvement as the only source of true enjoyment. For this he has been blamed as restricting happiness to the possession of advantages which are confined to a small part of mankind. But, when we consider the life which he recommends as opposed to gross sensuality, vulgar ambition, and the pursuit of wealth, we shall find his poem to contain much valuable truth. It is equally true that, if we withdraw our attention from these limited contrasts, and leave out of view the interests of persons who, in consequence of indulging in an inordinate passion for particular objects, have become the victims of chagrin and disappointment, we shall find happiness an object which is better secured by measures of a different kind, but which were condemned by Helvetius as haughty, stoical delusions.

His work on Man was also published after his death. It is in some respects more profound than his former work; but it is written in a similar strain, and liable to the same objections. His disquisitions were conducted on a limited scale: he was betrayed, by a love of simplicity, into precipitate conclusions: and his pretensions were by far too gigantic, either for the extent of his talents or the success of his researches. (*H. D.*)

HEMIDIAPENTE, in music, is an interval whose ratio is $\frac{45}{64}$, = 311 Σ + 6 f + 27 m, or the *minor* Fifth, which see.

HEMIDITONE, in music, is an interval whose ratio is $\frac{5}{6}$, = 161 Σ + 3 f + 14 m, or the *minor* Third, which see.

HEMIOLIUS, in music, an interval whose ratio is sesqui-alterate, or 1 : 1½; that is, $\frac{2}{3}$, = 353 Σ + 7 f + 31 m, or the *major* Fifth, which see.

HEMIPTERA. See Entomology, vol. ix. p. 76.

HEMITONES, in music, are a class of intervals of one degree of the scale, called also Half-*tones*, Half-*notes*, or Semitones, by different writers, (see these articles,) all of which single degrees of the scale, although of such different magnitudes that the largest of them are more than three times as great as the smallest of them, are yet all regularly expressed by only one f, in our notation, viz.

Hemitone of *Aristoxenus*, or ancient hemitone, is an interval whose ratio is $\frac{243}{256}$ = 46 Σ + f + 4 m, or the Limma, which see.

Hemitone *artificial* of Holder, has the ratio $\frac{19}{20}$, = 45.270982 Σ + f + 4m; see the Semitone of *Feytou*, &c.

Hemitone *chromatic* of Holder and Tartini; its ratio is $\frac{24}{25}$, = 36 Σ + f + 3 m, or the Semitone *minor*, which see.

Hemitone *elementary* of Overend; its ratio is $\frac{15}{16}$, = 59 Σ + f + 5 m, the Semitone *major*, which see.

Hemitone *greater*, of Euclid's genus Diatonum molle, $\frac{3}{10}$ths of a 4th, = 76.27168552 Σ + f + 7 m; its common logarithm is .96251813,7912, = .1245114 in Euler's logs. (VIII.) and 6.947433 in major comma logs. (c).

Hemitone *greater*, of Ptolemy's genus Chromatic molle, has the ratio $\frac{14}{15}$, = 60.047096 Σ + f + 5 m; its log. = .9700367,7662, = .09953567 × VIII, = 5.553855 × c.

Hemitone *greater* of Quintilian, has the ratio $\frac{16}{17}$, = 53.53181 Σ + f + 5 m; see the Semitone of *Malcolm*, &c.

Hemitone *lesser*, of Euclid's genera Diatonum syntonum or intense, and his Diatonum molle and Toniæum chroma, $\frac{1}{5}$th of a 4th, = 50.80314496 Σ + f + 4 m; its log. = .9750122,5268, = .0830076 × VIII, = 4.631622 × c.

Hemitone *lesser*, of Ptolemy's genera Diatonicum tonicum, and his Chromatic molle, has the ratio $\frac{27}{28}$, = 32.052904 Σ + f + 3 m; its log. = .9842057,3282, = .05246742 × VIII, = 2.927559 × c. This is also the minor hemitone of Archytas; and in some experiments by Messrs Kirby and Merrick, on the sound of a pipe blown by a mixture of carbonic and hydrogen gases, and by atmospheric air, this interval resulted. See our article *Sounds* of the Gases.

Hemitone *major*, of Archytas's chromatic genus, has the ratio $\frac{224}{243}$, = 71.947096 Σ + f + 6 m; its log. = .9646417,4474, = .1174576 × VIII, = 6.553858 × c.

Hemitone *major* of Aristides and Feytou, has the ratio $\frac{16}{17}$, = 53.53181 Σ + f + 5 m. See the Semitone of *Malcolm*, &c.

Hemitone *major* of Boethius and others, has the ratio $\frac{2048}{2187}$, = 58 Σ + f + 5 m, or the Apotome. See that article.

Hemitone *major* of Euler, Holder, Liston, Smith, &c. has the ratio $\frac{15}{16}$, = 57 Σ + f + 5 m, or the Semitone *major*, which see.

Hemitone *major*, of Eutosthenes' chromatic genus, whose ratio is $\frac{18}{19}$, = 47.729018 Σ + f + 4 m. See the Semitone of *Feytou*.

Hemitone *major*, of Ptolemy's genus Chromatic intensum, has the ratio $\frac{11}{12}$, = 76.897955 Σ + f + 7 m. See the Half-*tone* of Brougham.

Hemitone *maxima* of Webb, has the ratio $\frac{25}{27}$, = 68 Σ + f + 6 m, or the Semitone *maximum*, which see.

Hemitone *maximum*, or greatest, of Holder, has the ratio $\frac{25}{27}$. See as above.

Hemitone *medium* of Holder, has the ratio $\frac{128}{135}$, = 47 Σ + f + 4 m, or the Semitone *medius*, which see.

Hemitone *minor* of Archytas' chromatic genus, has the ratio $\frac{27}{28}$, = 32.052904 Σ + f + 3 m. See Hemitone *lesser* of Ptolemy.

Hemitone *minor* of Aristides, Feytou, Quintilian, &c. has the ratio $\frac{17}{18}$, = 50.46819 Σ + f + 4 m. See Semitone of *Malcolm*, &c.

Hemitone *minor* of Boethius, Sauveur, &c. has the ratio $\frac{243}{256}$, = 46 Σ + f + 4 m, or the Limma, which see.

Hemitone *minor*, of Euclid's genera Chromatic toniæum, and his Diatonum molle, $\frac{1}{2}$ of T, whose ratio is 2 √ 2:3, = 52.0039312 Σ + f + 4m; its log. = .9744237,3877, = .034962 × VIII, = 4.74070 × c. It is also the Chromatic diesis of Hoyle.

Hemitone *minor* of Euler, Holder, Sauveur, &c. has the ratio $\frac{24}{25}$, = 36 Σ + f + 3 m, the Semitone *minor*, which see.

Hemitone *minor*, of Eutosthenes' chromatic genus, has the ratio $\frac{19}{20}$, = 45.270982 Σ + f + 4 m. See Semitone of *Feytou*, &c.

Hemitone *minor*, of Ptolemy's genus Chromatic intensum, has the ratio $\frac{21}{22}$, = 41.198802 Σ + f + 3 m; its log. = .9797966,1391, = .06711422 × VIII, = 3.744815 × c.

Hemitone *minimum* of Holder, improperly so called, because it belongs to the class of commas (wanting f,) rather than to that of semitones; its ratio is $\frac{625}{648}$, = 32 Σ + 3 m, or 31.8582014 Σ + f + 2 m, the Semitone *minimum* of Overend, which see.

Hemitone *Pythagorean*, or ancient, has the ratio $\frac{243}{256}$, = 46 Σ + f + 4 m, the Limma, which see.

Hemitone *subminimis* of Holder, has the ratio $\frac{243}{250}$, = 25 Σ + f + 2 m, the Semitone *subminimis*, which see. (ϛ)

HEMORRHAGE. See Surgery.

HEMP. See Agriculture, vol. i. chap. viii. sect. iv.

HEN. See Ornithology.

HENFLING'S *Temperament* of the musical scale. In the year 1711, M. Henfling communicated to the Parisian Academy a commensurate system of 50 equal intervals within the octave; of which parts, 29 make the fifth, which therefore, for imperfect instruments, will stand as follows, viz.

11 Fifths; viz. on C, G, D, A, E, B, ※F, and ※C and on F, ♭B and ♭E, each equal to 354.951969Σ + 7f + 31m,	= 3904.471659Σ + 77f + 341m
And the wolf fifth ※D ♭E	= 379.528341Σ + 7f + 30m
Make 7 octaves each, 358Σ + f + 53m.	= 4284.000000Σ + 84f + 371m

And whence all its other intervals may easily be calculated, by help of the theorems, in *Phil. Mag.* vol. xxxvi. p. 41, or the corollaries at p. 374; see also p 50. of the same volume. Dr Robert Smith, in Prop. xvii. of his "Harmonics," has calculated the temperaments of this system, and shewn, that it approaches extremely near to his system of EQUAL *Harmony* in three octaves. See that article.

HENGIST. See ENGLAND, vol. viii. p. 589.

HENLEY UPON THAMES, a town of England, in the county of Oxford, is situated on the left bank of the river Thames, which is crossed by a fine bridge of five arches, with a handsome ballustrade instead of a parapet. The keystones in the centre arch contain two heads of the Thames and Isis, which were sculptured by the Honourable Mrs Damer. The town consists of two principal streets, at right angles to each other, and some smaller ones. The street which extends from the bridge to the cross is not very long, but is spacious, and contains some good houses. The street which extends from the cross along the Oxford Road has a serpentine direction. It is longer than the other, and contains many excellent houses. At the junction of these streets is a simple stone obelisk, pointing out the direction of the roads, and the distances from London. The church, which is a very ugly building, is situated near the bridge, on the west side of the street. It has a tower with semi-octagonal buttresses at each angle, and embattled at the top. It is built of flints and stones. The tower is said to have been built at the expence of Cardinal Wolsey. The other establishments in Henley are a Royal Grammar School, founded by King James V. for educating 25 boys in the classics; a blue coat school, founded by Dame Elizabeth Perians, for educating and clothing 20 poor boys; a green coat school, and an alms house. Henley carries on a considerable trade with London by means of the Thames, in malt, flour, and beechwood. Above 30,000 quarters of flour are annually made here.

The following is the population of the town and parish in 1811.

Number of inhabited houses	522
Do. of families	543
Do. employed in agriculture	93
Do. in trade and manufactures	235
Males	1347
Females	1770
Total population in 1811	3117

HENRY I.—VIII. of England. See ENGLAND.

HENRY I.—IV. of France. See FRANCE.

HENZUAN or HINZUAN. See JOHANNA.

HEPATICÆ. See FUCI and LICHEN.

HEPATITES. See MEDICINE.

HEPTACHORD *major*, in music, an interval, whose ratio is $\frac{8}{15}$, $=555\Sigma+11f+48m$, or the *Majar* SEVENTH, which see.

HEPTACHORD *minor*, has the ratio $\frac{5}{9}$, $=519\Sigma+10f+45m$, or the *Comma-redundant minor Seventh*, which see.

HEPTACHORD *minor* of Galileo, has the ratio $\frac{9}{16}$, $=508\Sigma+10f+44m$, or the *Minor* SEVENTH, which see.

HEPTAGYNIA. See BOTANY, vol. iv. p. 74, 75, 76.

HEPTAMERIS, or EPTAMERIS. In the new musical notation of M. Sauveur, which he laid before the Academy of Sciences at Paris in 1701; he assumed, that the reciprocal logarithm of the octave may, without sensible error, be taken to be .301, instead of .3010299,9566; and which number of his being divisible by 7, he called each of these seventh parts of the octave a MERIDE, (see that article), whose recip. log. =.043; and each of these 43d parts of the meride, or 301st part of the octave, he called a Heptameris. This interval is therefore $=2.04057055\Sigma$; its common log. =.9989999,0035, which M. Sauveur assumed to be .9990000,0000, or 2.0403712Σ: it is equal $.00332226\times\text{VIII}$, $=.185374\times c$: he again divided his heptameris into ten equal parts, and called each of these a DECAMERIDE. See that article.

HEPTANDRIA. See BOTANY, vol. iv. p. 74, 76, 197.

HEPTARCHY. See ENGLAND, vol. viii. p. 589.

HERACLEA. See GREECE, vol. x. p. 459.

HERACLIDES. See GREECE, vol. x. p. 463.

HERALD. In the histories of the heroic ages, we find important functions ascribed to those officers whom the Greeks call κηρυκες, and the Romans *feciales*. Their character is represented as sacred and inviolable; and, in Homer, their common epithet is "*the divine.*" Their duties were not less numerous than important. They could enter without difficulty into cities that were besieged, and mingle without danger among contending armies. They summoned the chiefs to the council; they commanded silence, that the discourses of the kings might be heard; and presented to each of them the sceptre before he commenced his harangue. The herald was charged with the most delicate missions, and accompanied his prince on the most difficult occasions. Agamemnon sent only Talthybius and Eurybates to bring Briseis from the tent of Achilles; and when Priam went to beg the body of his son, he took no one with him but his herald. The herald was distinguished by a long rod or sceptre, which he carried in his hand; and from this circumstance it was, that the Romans gave him the name of *caduceator*. Eckhel has published a beautiful medal of Crotona, from which we may judge of the dress of a κηρυξ, at a time much later than the age of Homer. He is arrayed in a long tunic like that of a priest, and holds in his hands a *patera* and a *caduceus*. The *patera* denotes a libation or offering to the gods, a function with which the heralds were frequently charged. According to Eckhel, this herald is in the act of demanding peace, and the coin was most probably struck at the time when the people of Crotona, humbled by a severe defeat, were obliged to send envoys to beg peace of the Locrians. The attitude of stretching out the right hand seems to have been considered as consecrated to the use of heralds; and it is on this account, that, on the imperial medals, the emperor is commonly represented in the same position when he announces peace and security to his people.

The use of heralds was very long preserved among the Greeks. There were heralds whose office it was to proclaim the laws observed at the olympic games, the names of the combatants and the victors, and, in general, every thing which was commanded by the judges of the games. The best account of the κηρυξ of the Greeks, and the FECIALIS of the Romans, is to be found in the works of Grævius and Pitiscus; or, if ancient authors be preferred, in Homer throughout; in Livy, i. 32; Cicero *De Legibus*, ii. 9; and Dionysius Halicarnass. lib. 2.

In the middle ages also, the heralds perform a part of considerable importance. The origin of their name

Herald. seems to be entirely uncertain, and it is difficult to say which of the sixteen theories mentioned by Edmonstone is the most ridiculous. The date of their institution in the form of a college, in most of the European kingdoms, is equally obscure. The first king of arms of whom mention is made in the French chronicles, is Robert Dauphin, who was alive A. D. 1031. But the conjecture seems by no means unlikely, that the French borrowed the idea of a regular body of men charged with the care of armories, processions, and ceremonies, from the *veterani* of the empire. See *Bertrand Carrioli*. under the word MILITIA, as cited by Upton *De Militari Officio*, lib. i. cap. 8. In England it does not appear that any such officer as the herald was ever employed on missions by William the Conqueror, or either of his sons. Yet there can be no doubt that the office was familiar to Robert Curthose and Richard Cœur de Lion, both of which princes were so renowned in the wars of the cross, and had so many opportunities of mingling with foreign kings, in whose countries the heralds were already openly protected by the law Very shortly, at all events, after this period, we find the heralds in full possession of all the privileges to which they ever attained, either in this island, or on the continent. They were allowed free entrance into the courts of all princes and great lords; they had power to reprove the faults of nobles, knights, and esquires; and if these did not amend, to exclude them from all tournaments and martial exercises. It belonged to the heralds to advertise knights and military commanders of the day of battle, to attend their sovereign's great standard in their best ornaments. They were, during the battle, to retire to an eminence, to witness what was done on either side, and report to the king or general those who behaved most valiantly, and commit the same to writing. When the battle was over, it was their province to number the dead, to ransom the prisoners, to summon cities, and, in case of composition, to march before the captain or governor, for security of his person. At justs and tournaments, it was the office of the heralds to carry all challenges, to lay out the lists, and assign place to the combatants. Such as wronged them, and refused to give full satisfaction, were declared guilty of high-treason, and punished accordingly. An instance of which occurred in Scotland, A. D. 1515, when the Lord Drummond was solemnly forfeited in parliament, *Eo quod Leonem armorum regem pugno violasset cum eum de ineptiis suis admonet;* and it was upon that lord's humble submission, and at the earnest intreaty of the Lyon himself, that he was restored.

The society of heralds in England, consists of four kings of arms, who are called *Garter King at arms*, *Clarencieux*. *Norroy*, and *Bath*, whereof the first and last derive their names from the two orders of knighthood, to which they owe their establishment; and the other two are provincial kings of arms, Clarencieux having power over all the east, west, and south provinces, as far as the river Trent; and Norroy in like manner, over all parts of England north of the Trent; six heralds, viz. Somerset, Chester, Windsor, Richmond, Lancaster, and York; four *pursuivants*, who may be considered as the apprentices of heraldry, viz. Rouge-dragon, Portcullis, Blue-mantle, Rouge-croix. All these persons, (kings, heralds, and pursuivants) are by the King himself, or Earl Marshall, "crowned with crowns, graced with colours, attired with coats, named by names of addition, and with other ceremonies created."

In Scotland there is one king at arms, who derives his name of *Lyon* from the bearing of our kings. Under him are six heralds distinguished by local names, viz. *Snawdon*, *Albany*. *Rosse*, *Rothesay*, *Marchmont*, and *Ilay*; and five pursuivants, viz *Unicorn*, *Carrick*, *Kintyre*, *Ormond*, and *Bute*. Besides these, the great nobility in England and Scotland had formerly heralds and pursuivants attached to their own service: as *Blanche Lion*, the herald to the Duke of Norfolk; *Lion d'or* to the Dudleys; *Percy herald* to the Earls of Northumberland, &c. Le Laboureur is of opinion, that counts and high barons, who are not princes, may have heralds and pursuivants; and that knights bannerets may have pursuivants only, unless they be invested with some high dignity. as marshall or general of the army: (See *Origine des Armoiries*, p. 121.) The king of arms in France, was always known by the name of *Mont-joye St Denis*. His heralds to a considerable number, derived their names from the different provinces of France; and his pursuivants were called. *Plain-chemin*, *Voir disant*, *Haut-le-pied*, *La verdure*, *Gaillard-bois*, &c.

See Æneas Sylvius *De Officio Heraldorum*. *De l'Office des Rois d'Armes*, &c. par Marc de Vulson de la Colombiere, Paris, 1645; and particularly the *Traité du Roi René*, which is there printed; *Le Theatre d'Honneur*, par André Favin; and Edmonstone's *Heraldry*, vol. i..

HERALDRY.

Heraldry. 1. THE art of the herald, known also by the names of "the art of blazon," "the art armorial," and "the art noble," consists, strictly speaking, in the knowledge of armories, and their due application, as ensigns of honour, and tokens of descent. The meaning of the term, however, is often extended, so as to include the knowledge of the ceremonial to be observed in all public assemblies of those who bear arms; such as cavalcades, processions, and the like.

On the Origin of Armories.

2. No subject has given rise to greater diversity of opinion among antiquarians, than the origin of armorial ensigns. The writers of the 16th and 17th centuries, who still continue to be the chief authorities on this subject, seem in general to have been infected with the desire of adding new consideration to their favourite pursuit, by maintaining that the art of blazon, so far from being the production of the middle ages, had been framed by the first masters of science among mankind, and practised in a manner little different from that of their own times, by the most polished nations of antiquity. The disquisitions of several great French and English heralds indeed, and particularly those of Father Menestrier, had gradually brought into contempt the dreams of their more enthusiastic predecessors; and it appeared, that such fanciful opinions were wholly exploded among men of sound understanding, till of late years some of the most ridiculous of them have been re-

vived in all their original extent, and defended with a show of learning more imposing than had ever before been called into their service, by a French writer of eminence, M. Court de Gebelin, in the 8th volume of his *Monde Primitif*. This ingenious author does not indeed, after the example of Mr Sylvanus Morgan, commence his treatise with a description of the armorial bearings of the first parents of our race. He does not affirm, that "Abel quartered with his paternal escutcheon, *argent an apple vert*, for his mother Eve, who was an inheritrix;" nor mention Joseph, as receiving "an honourable augmentation to his coat, in consequence of his being invested with the family order of Pharaoh king of Egypt." But he is seduced, by his fondness for a very untenable theory, into absurdities scarcely less glaring than these, when he talks seriously of the word *ingenuus*, as equivalent to "a person who has a right to armorial bearings;" and refuses to perceive any difference between the personal or political emblems of the Greeks and Romans, and the systematic heraldry of the modern nations of Europe.

3. Since, however, the subject has so lately been agitated by a writer of such learning and reputation, it may not be amiss to examine somewhat more at large into the merits of the case, by investigating not his opinion alone, but the more probable of all those theories which have been supported by the most eminent of the heraldic authors. According to many of these writers, the use of armorial bearings was the invention of the ancient Egyptians; and in support of this opinion two passages from Diodorus Siculus are alleged; in the first of which it is said that "Anubis and Macedon, the sons of Osiris, were the first who carried in war marks of distinction, taken from certain animals symbolic of their valour," (*Bib. Hist.* lib. i.); and in the second, that "the Egyptians, observing that their troops were liable to be scattered in battle, invented certain signs, by which they might be able to recognise each other. And that making use of the figures of animals for this purpose, such a veneration was by degrees conceived for these images, that the animals themselves came to be considered as sacred and inviolable beings."

Theories ascribing the invention of armories to the Egyptians,

A second set of writers assert that this art took its rise among the Hebrews; and the Rabbins of later times have been at pains to lend all their learning to the defence of this opinion, by blazoning, in the most scientific manner, the coats-of-arms of all the principal personages mentioned in holy writ.* The only passage of Scripture which they seem to quote with confidence in support of their theory, is Numbers ii. 2. "Every man of the children of Israel shall encamp by his own standard, with the *ensign* of his father's house." But the weakness of any argument derived from this text will be sufficiently manifest in the sequel.

Jews,

The third opinion is that of those who ascribe the first practice of heraldry to the ancient Greeks. And the defenders of this doctrine never fail to cite with great exultation those verses of the ΕΠΤΑ ΕΠΙ ΘΗΒΑΙΣ, in which Æschylus describes the bucklers of the seven Captains of the assailing army.

Greeks,

The fourth opinion is, that the practice of using armorial bearings was never reduced to any regular system till Augustus instituted legionary marks of distinction, and caused these symbols to be engraved and painted on the shields of his soldiers.

Fifthly, It is by no means an uncommon theory, that Charlemagne was the first patron of the heraldic art, in as much as after regulating the dignities and offices of the imperial palace, and establishing the order of peers, he instituted certain marks of honourable distinction, by which the great personages of his court might every where be recognised. It is true that the history of St Louis, by Joinville, speaks of armorial bearings conferred by Charlemagne on the Viscounts of Conserans, of the house of Comminges, and that the romances are full of those of Orlando, and the other heroes of that age. But it is fair to mention, that these authorities are equally conclusive respecting the coat-armour of Arthur, and the knights of the round table; so that the claims of Charlemagne to the honour of this institution are somewhat dubious even by the admission of his most strenuous admirers.

Charlemagne,

A sixth party ascribe the origin of these insignia to the wars which the Franks carried on in the East against the infidel possessors of the Holy Land; and derive many arguments in support of their opinion from the ancient charters for the foundation and endowment of monasteries.

The crusades,

Seventhly, The Italians are unanimous in fixing the origin of the art in the times of the Emperor Frederic, when their country was torn in pieces by the rival factions of the Guelphs and Gibbelines. The Germans, in the last place, are equally zealous in carrying it back to the days of Henry the Fowler; and think they have sufficient evidence of the justice of their opinion, in the accounts which have come down to us of the ancient tournaments of Germany. The truth is, that it is by no means an easy matter accurately to ascertain the origin, or trace the progress of things which derive their authority from chance and the insensible influence of custom, rather than from reason and the positive institutions of legislators.

Guelphs and Gibbelines,

Henry the Fowler.

4. It is quite evident, that painted shields and military ensigns of some sort, are coeval with the art of war itself. Jews, Egyptians, Greeks, Romans, and Barbarians, must all have made use of some tokens by which the warriors of the same nation might distinguish each other in battle. But there seems to be little reason for doubting that these people were familiar with the use of simple devices alone, or fanciful figures, which were not intended either to distinguish one family from another, or to mark the nobility of those who bore them. So little, indeed, is their nature ascertained, that the same things have been taken indifferently for devices, for emblems, for hieroglyphics, for symbols, and for armorial bearings, as may easily be seen in the treatises of Pierius, of Minos, of Ruscelli, of Bargagli, of Vulson de la Colombiere, and of Father Caussin, who all contrive to twist the same facts into evident testimonies of the truth of the most inconsistent theories. The dove of the Assyrians is, according to all the interpreters of the Scriptures, a figure of Semiramis. Yet this same dove is with Pierius a hieroglyphic, with Alciatus an emblem, with Bargagli a device, with Caussin a symbol, and with M. de la Colombiere a coat of arms. The error of all those who maintain the high antiquity of heraldic bearings seems to have arisen from the circumstance, that a few instances have been preserved by the poets and historians, in which these personal devices

* To such a degree had these follies prevailed, that Father Menestrier complains very feelingly of the interruption which the meditations of pious readers must have received from the perpetual blazoning of the arms of St Gregory, St Augustine, &c. on the margin of prayer books. "Comme si l'on ne pouvoit pas assez pieusement lire une priere dans ses heures sans voir le blazon du Saint pere que en avoit fait usage le premier."

Heraldry.

Instances of ancient hereditary insignia.

had, from some extraordinary causes, become hereditary and transmissible.

5. Aventinus, descended from Hercules, carried a hydra on his buckler; and one of the Corvini is mentioned by Silius Italicus as having the raven of his ancestors for his crest. In Ovid, Egeus recognises his son Theseus by the marks of his family on the pommel of his sword. Hypolitus carried, in the same manner, the marks of his birth; and the children of Jason and Hypsipilus bore as their device the ship of the Argonauts. See *Æneid*, 7.

——Victores ostentat equos satus Hercule pulcro
Pulcher Aventinus, clypeoque insigne paternum
Centum angues, cinctamque gerit serpentibus Hydram.

See also *Sil. Ital.* l. 5.

Corvinus phæbæa sedet cui casside fulva
Ostentans *alcs* proavitæ insignia pugnæ.

Ovid *Metam.* 7.

Cum pater in capulo gladii cognovit eburno
Signa sui generis.

Seneca in *Hypolito.*

Regale parvis asperum signis ebur
Capulo refulget gentis Actææ decus.

6. In like manner, we meet with marks of *dignity* among the ancient writers, the "χρυσους επι της πελτης κετος," was the well-known cognisance of the Median and Persian kings. (Xenophon's *Hellenics*, l. 1.) All these authorities shew that there were figures on the bucklers of the ancients, on the guards of their swords, on their helmets, their standards, and their cuirasses; but they by no means prove that these figures were armorial bearings in the technical sense of the word. The hereditary nature of some of their bearings, merely shews the anxiety of superstitious men to trace themselves to the lineage of the gods; as for instance Coraxes, who made his soldiers bear a thunderbolt on their shields, because he believed himself descended from Jupiter. The verses of the poets whom we have cited, prove nothing more than that certain warriors adorned their shields, and the pommels of their swords, with certain images representing the great actions of their ancestors.

A gentleman who should preserve the cavalry-horn which had been carried by his father in some celebrated war, might call it *insigne paternum*; or if it had belonged to his great-grandfather, he might call it *pro-avitæ insignia pugnæ*, and yet all this might have nothing in common with the family arms. Chryxus carried on his shield a representation of the siege of the Capitol, and the Gauls weighing the gold of the Romans, to shew that he was sprung from Brennus.

Ipse tumens atavi Brenni se stirpe ferebat
Chryxus et in titulos capitolia capta tenebat
Tarpeioque jugo demens et vertice sacro
Pensantes aurum Celtas umbone ferebat.
Sil. It. 4.

Yet who would think of asserting that the Capitol, and Gauls weighing gold, were the armorial bearings of Chryxus? Whoever maintains this, must admit that all the images and figures of ancient casques, cuirasses, and shields, were armorial bearings in the same manner as these, and he will find not a few who bore the whole history of a country, or a few dozens of the metamorphoses, for their blason. It seems evident then, that all these authorities prove nothing concerning the origin of heraldic bearings, more than they do concerning that of emblems or of devices; because the signs of which they make mention do not appear either to have been fixed in their forms, or of any determined colour, or universally hereditary. The far greater part appear to be the mere fictions and ornaments of poetry; such as the chimera on the casque of Turnus; Io changed into a cow; Argus who watched her; and Inachus with his urn, from which a stream descended on his buckler. *Æn.* 7. *

Rabbinical heraldry.

7. The pretended arms of the tribes of Israel are entirely the reveries of the Rabbins of the later times, who have amused themselves with imagining these figures, on the authority of certain allegorical expressions of which Jacob made use, to predict to his children the fortunes of their descendants. They assign to the tribe of Judah a lion, because he said to one of his sons, "Judah is a lion's whelp; from the prey my son thou art gone up," &c. *Gen.* xlix. 9. And to that of Zabulon an anchor, on account of this prophecy, "Zabulon shall dwell at the haven of the sea." *Gen.* xlix. 13. And as they have not been able to find any thing very appropriate for Ruben in the malediction of his father, they blazon for him the mandrakes which he presented to his mother Leah.

To say nothing of the evident absurdity of all this, the authors in whose writings these bearings are mentioned are very far from being consistent among themselves. Some give to Dan an eagle, others a serpent, and some an eagle choking a serpent. Barnabas Moreno de Vargas, indeed, blazons all the tribes of Israel in a manner different from what has been mentioned above; as, "Los de tribu de Ruben porque su padre lo comparo al aqua posieron por armas unas ondas de aqua: Los de Zabulon pusieron una nave," &c. *Discurs.* 18. *De la Noblez.*

Classical heraldry.

8. Neither does there appear any greater certainty among the Greek writers. Ulysses, in Lycophron, carries a dolphin on his buckler, and is accordingly styled δελφινοσημος; but Homer assigns to him the figure of the giant Typheus. Agamemnon, in the Iliad, carries the gorgon's head, but, in Pausanias, the head of a lion; and elsewhere we find him described with one dragon on his helmet and three on his shield. As for the celebrated shields of the seven chiefs against Thebes, it is rather amusing to find, that, after all the many arguments which have been founded on the accurate account of them in Æschylus, that great poet does not coincide, in any one particular, with the equally minute and laborious description of Euripides.

Even when the authors are perfectly consistent, the utmost that can be made out of their report is, that these warriors bore certain emblems, which may perhaps have had some mystical meaning; but can never be proved to have been marks of noble birth, as our armorial bearings are, even though some of them may have passed from father to son; otherwise we must believe, on the credit of Suetonius, that the Domitian

* At levem clypeum sublatis cornibus Io
Auro insignibat, jam setis obsita, jam bos
Argumentumq. ingens, et custos virginis Argus
Cœlataque amnem fundens pater Inachus urnâ.

family carried a *beard or* for their arms; because the historian, in order to mark that a red beard was a common feature in that family, says—"Quod *insigne* mansit et in posteris ejus, et magna pars rutila barba fuerunt." (Sueton. *in Nerone*, c. 1.) And yet nothing can be more certain, than that passages in ancient authors, of a complexion exactly similar to this, are the only authorities for half the *armorial bearings* of the Greeks and Romans. Because Seleucus had a mark on his thigh which resembled an anchor, he and all his descendants are said to have borne an anchor for their arms. It is wonderful that Augustus is not alleged to have blazoned on his shield the Ursa Major, since it is well known that he had on his back as many moles as there are stars in that constellation, and arranged in the same manner: (Sueton. *in Aug.*) The figures on the legionary shields of the time of Augustus were exactly of the same nature with those of the Greeks of the heroic ages, or of the Egyptians, Anubis and Macedo.

The 8th the most rational theory.

And, upon the whole, if we lay aside the dreams of enthusiastic heralds, and scholars, equally enthusiastic, who will not condescend to allow to the moderns the honour of inventing even the arts which they themselves despise, we believe we shall find that to be the most rational theory which maintains, that armorial bearings were invented in the 10th century, perfected in the 11th, and have accordingly been for about seven hundred years only, in any part of the world, the distinguishing marks of families, and of noble birth.

Its proofs from tombs,

9. In many parts of Europe, there remain tombs of princes, lords, and gentlemen of every degree, more ancient than the year 1000; and yet in no one of these can the smallest trace of armorial bearings be discovered. The most indefatigable antiquaries have explored Italy, Germany, Flanders, and the various provinces of France and England, without the least success; and have been obliged to confess, that neither in manuscripts, nor upon the gateways, and vaults of castles, nor upon the altars of the most ancient cathedrals, have they been able to find any thing more early than the well known arms of Varmond, Count of Vasserburg, on his tomb in the church of St Emeran at Ratisbon. He is represented as lying on his back upon his tomb, with a lance in his left hand, and on his right his shield without ornaments—"Coupé of argent and sable, and over all a lion, with this epitaph on the border of it: "Anno D$\tilde{n}$i MX. in die S. Leonis PP Dnus Varmundus nobilis comes de Vasserburgh qui huic monasterio dedit Hofmarchiam in Vogterrereut hic sepultus." There is even some reason for suspecting, that this tomb has been rebuilt by the religious of the abbey. All the tombs of the 7th, 8th, and 9th centuries, have simple inscriptions with the image of the deceased. The greater part of those of the 10th and 11th centuries also are without arms; and the practice of representing them on tombs does not appear to have universally prevailed till the 12th century. The first Pope who can be proved to have borne arms is Boniface VIII. of the house of Cajetano, whose escutcheon is in the church of St John Lateran, and in the vaults under St Peter's at Rome. The bearings of all the Popes before him are now ascertained to have been the inventions of Ciaconius, Antonio Cicarello, and Gian Baptista Cavalieri.

Coins and seals.

Coins before the year 1200 have no arms. The seals of princes and kings before that time bear nothing more than their effigies, and those of bishops and chapters representations of the tutelary saints of their churches; as, for instance, those of the popes, which bear commonly on the one side the heads of St Peter and St Paul, and on the reverse the name of the pontiff.

10. If, before these times, the figures on bucklers had been hereditary and fixed in so many families, why happens it that the sons of so many heroes never carried the devices of their fathers, and the glorious marks of their illustrious achievements? Whence comes it, that when notice is taken of Helenor being introduced in the 9th Æneid without any ensign on his shield, a sufficient answer is supposed to be given, by saying, that young men, who had as yet done nothing illustrious, carried shields without ornament? Could they not then, as at present, carry their father's bearings? The truth is, these marks were altogether personal, or else common to all the individuals of a military corps.

> Cuncta phalanx insigne Jovis, cælataque gestat
> Tegmina, dispersos trifidis ardoribus ignes.
> *Valer. Argon.* 6.

And it was on account of this latter character that they received from the Greeks the appellation of δείγματα.

Objections refuted.

It may however be alleged, (and M. Court de Gebelin has laid much stress on the circumstance,) that there are many cities, the armorial bearings of which are to be found on monuments of very high antiquity; as, for instance, those of Rome, which we every day see represented on so many basso relievos, or those of Nismes, which are so common on the reverse of medals. To this it may be answered, that these cities have, within the last seven or eight hundred years, framed for themselves armorial ensigns out of their ancient devices, and that, before that time, no examples can be found of these marks being placed on escutcheons. S. P. Q. R. was the device of the Romans; but not, as in the present day, disposed *secundum artem* on a band falling down between two fillets. The crocodile attached to a palm-tree was the ensign of Egypt conquered, which the people of Nismes put anciently on their coins, with these words abridged, *Col. Nem.*; and accordingly, the modern city blazons the same on its public edifices. We by no means assert, that no kingdoms or republics had fixed devices before the use of armorial ensigns: on the contrary, the eagle was a common device of the Romans, and composed part of their military standards; but they had also the dragon, the minotaur, the wolf, and the swine. The lion and the eagle have in every age been the symbols of royalty; because the one is the chief of beasts, and the other of birds.*

False documents.

11. It is necessary to be at all times on our guard against the monuments of heraldry, which are produced by our old writers as of a date prior to the 12th century. They are in general the inventions of silly monks, who had little else to do but to gratify their own vanity, and that of their benefactors, by these harmless fictions. Much contempt, indeed, has been thrown on the whole study, by the detection of the gross absurdities which they contain, and by none more than those of the celebrated Chronicle of the Priory of Ely, long preserved in the college of the English Benedictines at Douay. In this MS. we are presented with the history of some chiefs of King Harold's army, who, after the defeat at Hastings, defended themselves for seven years in the isle of Ely. The conqueror,

* Pausanias describes the shield of Agamemnon as bearing a lion's head, with the motto, "ὗτος μεν φοβος εστι βροτων ὁ δ' εχων Αγαμεμνων." *A lion crowned* is in like manner ascribed to Dieterick and the other heroes of the Sagas.

however, at length prevailed, and lodged 40 of his soldiers with the religious persons who had afforded an asylum to these obstinate warriors. Each soldier lodged with a monk; and the story is, that, on their departure, the brethren painted in their refectory the arms of their warlike companions, which are accordingly blazoned with great exactness on the margin of the MS. But, in spite of the zeal of Mathew Paris, the style of the writing, and also of the illuminations, is such, that the authenticity of this record has long been given up.

Proof from the use of the term Blazon.

12. The art of heraldry, in truth, like every thing else of nature or of art, did not all at once spring up to perfection. Its beginning long preceded its universal practice, and its scientific arrangement. The ancient figures on shields, and military ensigns, were the first dawnings of the art. It may be said to have made its first regular appearance in the world at the times of the tournaments; and in all likelihood attained its utmost perfection in the period immediately following these military exercises. The name of Blazon which has always been given to this art, the form of the oldest escutcheons, the metals, the principal figures and divisions of the shield, the crests, the wreaths, the mantles, and the mottos of heraldry, all conspire to prove the general position, that the first practice of the art took place on occasion of the tournaments of chivalry. **Blasen* is a German word, signifying *to blow the horn*; and the reason why this name has been given to the description of armorial ensigns is, that anciently those who presented themselves at the lists of the tournament were announced by the sounding of the horn. The heralds, after having ascertained the nobility of those who offered themselves, blew the trumpet, in order to warn the marshals and their assistants, and then *blazoned* the arms of the aspirants; that is to say, that, after sounding the trumpet, they proclaimed with a loud voice the bearings of their shields. †The *Rimes du tournay de Chavency*, (which took place in the year 1285,) written by Jacques Bretex, furnish an example of this usage.

Les trompeurs si trompoient
Et les Bachelers amenoient
D'armes si empapillonez
Que depuis l'heure que je fu nez
Ne vi a mongré, tel mervoilles
Un chevalier d'armes vermoilles
A cinq annets d'or in ecu.
Vi devant tous qui sans ecu
Vient a voir la premiere jouste
Comment qu'il soit ne coi qu'il couste
Si quier as autres qu'on luy doigne
Lors öi cerier Chardoigne
Et puis Vianne a ces heraux,
Garcons glatir, huier ribaux
Chevaux bannir—tambour sonnir, &c.

In all the descriptions of jousts which Olivier de la Marche gives us, and in all those of the old romances, it is always expressly mentioned, that "les trompettes cornerent et furent faits les cris accoutumez." In describing the "Joustes de l'arbre d'or," he says, "si tost que Mondit Seigneur le Duc fut sur les rangs fut apporté le Blazon de M. le Prince d'Orange neveu. de M. le Comte d'Armignac, et apres fut allé querre par le geant et par le Nain; fut par le geant presente aux dames *et le Nain* sonna sa trompe." When the tournament was at an end, it was a common thing for the knights to hang up their arms and these horns in some church; and many still remain (or at least did within a century) attached to the great altars in the churches of Wirtsberg, Ratisbonne, Mayence, and Cologne, as Menestrier informs us, who saw them himself, and says that they were shewn by ignorant people, who understood nothing of their true nature, and contented themselves with asserting that they had belonged to Orlando, or some of the other heroes of the court of Charlemagne.

When any combatant had once made his appearance at these tournaments, which seem to have been originally held every three or four years in Germany, it was no longer necessary for him to make any proof of his nobility, this having been already sufficiently recognised, and *blazoned*; that is to say, announced by sound of trumpet by the heralds of the lists. The persons who had attained this distinction commonly carried two trumpets by way of crest, in order to mark that they were *gentlemen*, recognised and *blazoned*; and thus when the bearings of shields began to be more fixed than before, many families retained these crests of trumpets. Helmets adorned in this manner are called by Dlugossius and Simon Askolski *Galeæ Hastiludiales*, that is, helmets of tournament. (See Plate CCXCI. Fig. 1.) Many authors, indeed, explain these trumpet figures to be the trunks of elephants. But if there could remain any doubt on the subject, it would be removed by observing that those who still retain these crests, are the very families whose names occur in the ancient tournaments, as those of Bavaria, Saxony, Brandenburgh, Lutzelstein, Mecklenburgh, Swartzenberg, Die Lobl, Noppen, Talheim, Romersheim, &c.

Plate CCXCI. Fig. 1.

To blazon, by a gradual transition, came among the French, who had borrowed it from Germany, to signify every sort of description. Thus Jacques de Fouilloux, in his book on hunting, which he presented to Charles IX. makes in four lines what he calls the "Blason du lievre."

Lievre je suis de petite stature, &c.

Favin uses it as synonymous with "to praise," page 439. "Les habitans disent pour blasonner leur ville, &c." But we elsewhere meet with it taken *in malam partem*, as in the Chronicle of Louis the first Duke of Bourbon, where he is said, in conferring the order of the crown on his knights, to have ordered them to honour the ladies, and not to permit any one to speak ill of them—"*blasonner et mesdire*." The word has the same significations among the Spaniards, who make it signify still farther glory itself: as in Rodrigo Mendez Sylva *Poblacion*, page 7. "Sivra sobre todo de Blazon, aver procreado al memorable cavallero Quinonez." Nothing can be more simple than the analogy by which all these meanings are derived from the primitive *blasen*. Nor is it at all to be wondered at, that the French should have borrowed this term of art from Germany, since it was in that country that the first regular tournaments were held by order of Henry the Fowler, who was either the original institutor, or at least the restorer of these and many other exercises for the young nobility of his empire.

* It is proper to mention, that many are of opinion that the word *blazon* is of Oriental origin; and in the Arabic Dictionary of Gieuharis, we certainly find the word *Bladson* with two significations, 1st, "Gens, famille, maison;" 2d, "Insignia, armoiries, symles d'une maison."—But we cannot help looking on this as merely a casual coincidence, and imagine few will deny that the German root offers so very natural a derivation, that it is ridiculous to look farther.

Heraldry.

Proof from the form of shields, &c.

13. The form of the ancient escutcheons is a second proof of this origin of armorial ensigns; for they are always represented as lying on the one side, and tied up by small strings, exactly as the shields of the jousters were attached to the lists, or to the neighbouring houses, which they called "faire fenestre." They are so represented in the celebrated "Tournay de la Garthuse," in the National Library at Paris. They are also hollowed out on the right side for the reception of the lance, as may be seen in all the old monuments of the churches in Germany and Italy. From the tournaments, in like manner, is derived the custom of joining the shield and the helmet to compose the complete armorial bearings; because they were so arranged in some cloister or public place a few days before the jousts, that the ladies might have an opportunity of seeing them. All these observations are verified by the curious treatise of René of Anjou, King of Sicily, which is printed in the Miroir de la Noblesse, by M. Vulson de la Colombiere. "All you princes, lords, barons, knights, and esquires, who intend to tilt at this tournament, ye are ordained to lodge yourselves in the city four days before the tournament, to make display of your armories, on pain of not being received at the said tournament; and your arms shall be thus. The crest shall be placed on a plate of copper large enough to contain the whole summit of the helmet, and the said plate shall be covered with a mantle, whereon shall be blazoned the arms of him who shall bear it; and on the said mantle, at the top thereof, shall the crest be placed, and around it shall be a wreath of colours, whatsoever it shall please him." "Moreover, when all the helmets are set in order after this fashion, then shall all the ladies come, and the damsels, and the lords, knights, and esquires, who shall visit them in their order, from the beginning to the end. And the judges who shall be there shall lead the ladies three or four turns, to see them well, and to examine the crests; and the herald shall set forth unto the ladies to whom this ensign pertaineth, and to whom that; and if there be any one which belongeth to any reviler of the ladies, the ladies shall touch his crest, and on the morrow it shall be sent away, and he shall have no tilting at this tournament." *Traité de la forme et manier des tournois a plaisance,* &c. *Miroir*, p. 56.

Origin of the tinctures.

14. The colours which enter into the composition of armorial bearings are, by many authors, said to be no other than those of the ancient games of the Roman circus, which passed into the tournaments of the Gothic nations. The different factions of the hippodrome were distinguished by their colours of white, red, blue, and green. To these Domitian added yellow; and the only remaining tincture, viz. black, might be easily introduced by those chevaliers who were in use to frequent tournaments in habits of mourning on occasions of particular distress. Thus King René of Anjou, after the unfortunate war of Naples, went to the tournament of "La gueule du Dragon," in the year 1446, clothed in complete suit of black armour, "his shield sable, semee de larmes, and a black lance in his hand."

Partitions,

The partitions of the shield are in like manner supposed to be deduced from the habits of tournaments, which were frequently of different colours, sometimes the one side of the garment differing from the other, sometimes the top part from the bottom, &c.; a relic of which custom may still be observed in the dresses of many provincial magistrates on the continent. From the barriers and lists, and their various parts, are taken the forms of the pale, the chevron, and the saltier. The ring or annulet is derived from the common reward of the victorious cavalier. The bend and the fess from the scarfs which the combatants wore, and which were often the gift of their ladies, as we read in the romances. The wreath and other ornaments of the helmet, are all connected with the same custom. The lady herself took care to adjust these parts of her knight's equipment, which were generally of *her colour;* and are accordingly known in the romances by the names of "faveurs des dames," "atours de dame," &c.

and external ornaments.

Introduction of heraldry into France.

15. With tournaments, it is probable that the art of blazonry passed very soon into France. Many of the figures indeed, were never introduced into the heraldry of that or of any other country, and remain at this day peculiar to Germany alone. If armorial bearings, however, were first used in Germany, it must be confessed that the French were the first to reduce the method of using them to rules. Accordingly, the only other nations which have made any progress in the art, viz. the English and the Scotch, make use of French terms. The Italians and Spaniards know nothing of the matter; and the attainments of the Germans themselves, are frankly admitted by Spenerus to be altogether contemptible. Sir Henry Spelman says expressly, that the gentry of England had no coat-armour till the time of the Norman conquest; and treats with the utmost derision the fables and reveries of those, who assign arms to the Danes, Saxons, Britons, and the pretended knights of the Round Table. The princes of Anjou, in all probability, introduced the custom into the kingdoms of Naples and Sicily, as may be seen in the treatises of Scipione Ammirato and Philibert Campanili. But although the practice of using armorial bearings may have been considerably extensive before the period of the Crusades, there can be no doubt, that these celebrated expeditions must have been at once the means of rendering their use universal among all the European nations, and at the same time of making the figures more fixed, and consequently the blazonry more scientific. Arms, it is probable, completed their hereditary character from the piety of children, which must have led them to adopt, with religious respect, any temporary devices borne by their fathers in these holy wars. The cross soon became the most common of all bearings, and its form was varied beyond every conception by the ingenuity of the heralds.

Influence of the Crusades.

16. The heraldic writers who approach most nearly to each other, in their opinions respecting the origin of armories in general, are yet much at variance concerning the precise time of their introduction into England. It is needless to refute the statements of such writers as Stow, who can tell us gravely, that "Brute, after a long and wery journey with his Trojans, passing thorow France, building the citie of Toures, arrived in this isle, the which was then called Albion, at a place called Totness, in Devonshire, *bearing gules, two lions gold rampants a contrarie, also a bannar of Vert, a Diane of gold fichele crouned and entronised.*" Edmonstone is of opinion, that armories were probably first used in England by King Edward the Confessor, and afterwards more plentifully practised by William the Norman and his nobles. Camden, however, is inclined to think them of yet later date with us, and says, "that shortly after the Conquest, the estimation of arms began in the expeditions of the Holy Land, when it was accounted an especial honour to retain those arms which had been displayed in the Holy Land in that holy service against the professed enemies of Christianity, and that we received at that time the hereditary use of them; but the

Introduction into England.

same was not fully established until the reign of King Henry III.; for that in the instances of the last Earls of Chester, the two De Quinceys Earls of Winchester, and the two Laceys Earls of Lincoln, the arms of the father still varied from those of the son." Sir Henry Spelman is of opinion, that arms are of a yet more modern growth in England, and says, "there is little reason to be confident in matters of pedigree and arms much beyond four hundred years," adding, "that he has his doubts as to their being entitled even to that antiquity. *Nescio an ea prorsus antiquitate.*" The period of their introduction into Scotland, must of course have been nearly the same with that of their first practice in England.

Origin of particular bearings,

17. The custom being once fairly introduced, it is by no means difficult to see from what causes the great variety of the figures of heraldry must have arisen. Great events, or illustrious actions; the peculiarities of local situation; the partialities for particular employments, offices, dignities, and the spirit of devotion; the nature of fiefs, and the vestiges of ancient devices, factions, pilgrimages, and tournaments, must all have suggested to individuals the bearings which they adopted. Nothing, however, appears to have given occasion to more armorial ensigns, than the names of persons or of families.

From names,

In every nation of Europe the effects of this practice are still abundantly apparent; yet we have no doubt the evidence would have been infinitely more striking. but for the many changes which have taken place in the names of families since the fixing of their arms. Many authors, it is true, treat with ridicule arms of this sort; but it is sufficient to observe, that Spelman, Menestrier, and Gebelin are of a different opinion. The last indeed expressly says, that he has no doubt the armes parlantes are the most ancient of all. The original bearers of these arms, it is probable, thought their names so illustrious, that they could adopt no better means of making themselves known than devices, which would suggest these names to the beholder. Accustomed as they were to shout their names in combat, and hear them proclaimed at the tournament, it was a very natural thing to paint them on their surtouts, their shields, and the caparisons of their horses. There are very few families, whose names retain any meaning, which have not framed to themselves arms in some respect alluding to that signification. The instances of arms of this kind in our books of heraldry are innumerable. The Bollens, in allusion to the first syllable of their name, carry *argent* a chevron gules *between 3 bulls heads sable.* Pope Adrian IV. (whose proper name was Nicolas Breakspeare,) bore gules a lance broken argent. The illustrious family of the Lamberts bear 3 lambs argent; and the practice is equally evident in the bearings of the Lovets, the Bores, the Swineys, the Swintons, the Swallows, the Grifins, the Metcalfs, and the Starkeys; of Bowes, Cockayne, Dove, Askew, Arondel, Ravenscroft, Bulkley, Heron, Beeston, Bird, Horsey, Cheval, Colt, Capraville, Quatremains, Borlase, Troutbec, and Godolphin. In France, the names of Ailly, Mailly, Crequy, Rubempré, Castelnau, Chabot, Gougeux, Hautefort, De la Tour, De Pontevez, De Porcelet, and De Retel, are among the most distinguished of the kingdom. Nor are their bearings a whit more significant than those of the great Italian families of Colonna, Ursini, Frangipani, Anguillara, Sanctacruce, Spinola, Cicala, Barbarigo, Negroni, &c. or of the Spanish houses of Luna, Solis, Zapata, Acuna, Quixada, Torres, and Cardona.

There are several ways in which arms may bear a relation to names. 1st, By the simple cypher or initial letter of the name; as is the case in the arms of many towns on the continent, and of the families of Montenegro in Spain, who bear an M crowned, and Awensberg in Germany, who bear an A, &c. 2d, By the representation of objects either natural or artificial, which express the sound of the name: as the ancient sovereigns of Dauphiny and Auvergne bore a dolphin on their shield; the city of Lyons a lion; that of Berne a bear, &c. 3d, By things which have some likeness to the name: as the Chevriers, who bear a cheveron; the Gouviers, who carry a wolf's head, &c. 4th, By things which have some relation to the signification of the name: as Archer, who carries three arrows; Falconer, falcons; Diane, a crescent; RIDDELL, ears of rye. The family of Law in Scotland have a cock in their arms, in allusion to the common method of expressing the cry of that bird among the Scotch, "*Cocky-leery-*LAW." 5th, There are arms which express the name by way of *rebus*: as *Richarmes*, three casques crested with crescents *or*; Gantelmi at Naples, a glove and a helmet, &c.

Many of these allusions are very far-fetched and absurd; perhaps none more exquisitely so than that of the Paravasini in the country of the Grisons, who bear a goose, because, says Menestrier, that bird has "some resemblance to a swan *par avis Cycno.*" It is worthy of remark, that long before the science of heraldry existed, the ancients, in their marks and devices, affected this sort of resemblance of figures to names. Thus the reverse of a medal of L. Aquilius Florus bears a flower; the Rhodians had a rose on their coins; and the Delphians a dolphin. On the medals of Voconius Vitulus we see a calf; on those of L. Thorius Balbus a bull; and a man's foot on those of L. Turius Crassipes.

From remarkable events,

18. To commemorate any events of a marvellous and unexpected nature, is another very common object of armorial bearings. There is no point, however, connected with heraldic pursuits, in the investigation of which we must advance with greater caution than here. The absurd vanity of particular families has been the foundation of so many idle inventions, that it is difficult to avoid classing with these matters of a very different nature. As an instance of the species of arms to which I now allude, it is sufficient to mention the *three birds* of Lorraine, which are said to take their rise from the circumstance of Godfrey de Bouillon's stringing three birds on one arrow. Important discoveries and illustrious actions have been in all times celebrated in the same manner. Thus after Columbus had returned to Spain from the discovery of the new world, he was allowed by Ferdinand and Isabella to bear under a chappé of the arms of Castille and Leon, in a sea of *Argent* and *Azure* five isles *or* with the motto, "A Castilla y a Leon, Mundo nuevo dio Colon;" which bearings still remain with his descendants of the houses of Veragua and Xamayca.

The Maid of Orleans, when she took arms against the English, carried on her banner a sword surmounted by a crown. This, with the addition of a fleur-de-lys, the king of France afterwards assigned as arms to her brothers, who were ennobled, by letters patent in the year 1429, and took the name of du Lys. The house of Colonna, in Italy, have around their shield the 14 standards taken from the Turks in the famous battle of Lepanto by Marco Antonio Colonna, General of the forces of the Pope. The Douglasses of Scotland bear a bloody heart crowned with a royal crown, in memory of the good Sir James Douglas, who died on his way to the Holy Land, whither he was conveying the heart of King Robert the Bruce. A badge of the same species was assumed by the Earl of Surry, in the year 1515. "A silver lion (the old cognisance of his family) tearing in pieces a lion prostrate gules.

> "If Scotland's coat no mark of fame can lend,
> That Lion placed in our bright silver bend—
> Which as a trophy beautifies our shield
> Since Scottish blood discoloured Flodden-field,
> When the dark Cheviot our proud ensign bare,
> As a rich jewel in a lady's hair, &c."
>
> *Drayton.*

Nicolas Upton mentions an English gentleman who assumed Argent, three ox heads sable, "pro eo quod ipse erat in bello Vernolii cum lancia per membra genitalia totaliter transfixus, sic quod amplius generare non potuit." (*De Milit. Officio*, p. 154.) *

Faction,

The influence of the spirit of faction has also given rise to innumerable bearings. In Italy, during the contests of the Guelphs and Gibelins, things came to such a pass that almost every family was obliged to adopt some method of expressing by their arms to which party they adhered. The Guelphs carried Coupé, the Gibelins party. The Guelphs bore the lily of Florence gules on argent; the Gibelins argent on gules. The fleur-de-lys-in-chief (after the Guelph party had embraced the cause of Charles of Anjou), became a Guelph mark,—and three stars in chief denoted a Gibelin. In France, in like manner, when the kingdom was split into two factions from the year 1409 till 1449, those who espoused the cause of Orleans and Berry, carried a white bend, and were called "bendes," while the adherents of the Duke of Burgundy were known by the cross of St Andrew.

Offices, and

19. Offices of dignity are marked in the same way. Thus the great officers of the empire were all accustomed to bear the tokens of their dignity. The Counts of Oldenburgh, as architects of the empire, gules *two fesses or*, which are supposed to represent two beams. The house of Wirtemberg bore three stag-horns. That of Wernigerode a fish; and the Electors of Hanover the imperial crown, as archtreasurers of the empire.

Vassalage, or Feudal tenures.

When any great family had once assumed a particular bearing, it was very natural for their vassals to bear it, either in whole or in part, as a token of their dependence. Indeed the grants of feudal tenure were commonly made with some such condition. Thus in Brittany almost every family bore Ermine in honour of the ancient sovereigns of that country; and a great many mascles, and billets, in token of their connection with the houses of Rohan and Beau Manoir. In Cheshire sheaves of wheat are very common, and these were the bearing of the old Earls of Chester. A striking instance of this custom is to be met with so late as the time of Edward III. in the case of the four esquires of Lord Audley, who all adopted the bearing of that nobleman, with some little variation. (Vide Spelman's *Aspilogia*, p. 49.) And there is preserved in the notes on the same treatise, a charter, by which Sir Gervase de Clifton makes a similar grant of a helmet to his well-beloved friend Richard de Bevercotes, dated in the third year of Richard II. In Scotland many old families bear stars in those parts of the country where the Douglasses were most powerful. And a large proportion of the families of Renfrewshire bear their figures chequered, in honour of the house of Stuart.

The ancient signiory of the castle of Tunbridge in Kent, belonged to the Clares, Earls of Gloucester, who bare for their arms *or, three chevrons gules;* and therefore the family of Hardress bare *gules, a lion rampant ermine debruised by a chevron or*, to denote that they held their manor of Hardress by knight's service of the said castle of Tunbridge.

Armories were alienable of old

20. Soon after arms had acquired the reputation of being the avowed and established marks of gentility, they came to be looked upon as inheritances alienable. So that although no man could legally assume at his own pleasure the coat-armour which had been granted *per expressum* to another person by the king, yet it was generally supposed that the original grantee or proprietor had, as it were, an absolute freehold in his *arms*, as well as in his lands, and might with equal right transfer the property of either to another person. And accordingly instances are not wanting of the proprietors of coat-armour conveying and assigning by formal grants, and that with a covenant of warrantry, the original paternal ensigns of their own family, as well as the coat-armour of other families which had descended to them by intermarriages, to persons nowise connected with them by blood, *to the exclusion of their own heirs.* Although no doubt could have been entertained as to the truth of these facts, yet the legality of such concessions having been often called in question, it is proper to state that the matter was fully discussed in the court of the Earl Marshall of England, in the case which depended between Sir Thomas Cowgan and Sir John de Norwich, and in that between John Lord Lovell and Thomas Lord Morley.†

Latterly, however, it has been invariably held as indispensible, that arms should be either given or authorised by the prince. The concession of arms by the sovereign may be in the common way, viz. wherein the royal consent is given to the use of such and such arms, whether they have been formerly borne by the grantee or not, as it is expressed in the common words of letters of nobility on the continent of Europe. "In omnibus et singulis honestis expeditionibus, et actibus tam serio quam jocis nobilium, militarium armigerorum modo in tourneamentis hastiludiis," &c.; or the concession may be of a particular kind, by which the sovereign permits his subject to assume some honourable augmentation, often part of his own royal atchievement, in token of his peculiar favour. Thus the double tressure has been granted to several families in Scotland, as the Randolphs Earls of Murray, the Seatons of that ilk, &c.; and the lion, as to the Duke of Lauderdale by way of supporter. When Henry Duke of Brunswick came to England to visit his ally Henry II. who then bore five leopards *or*, King Henry gave two of them to be carried by the Duke, which are still retained by his descendants, and are marshalled with other figures in the fourth quarter of his present Majesty George III. Edmonstone gives at full length the deed by which Queen Elizabeth allowed the Duchess of

Arms of concession;

* "Ob hujusmodo causas insignia concedi satis magno est argumento scutum Coleonum gentilitium quod *icone trium testium* insignitur. Multi enim ex hâc familia tres testes habuisse perhibentur. Vide Aldrovandum de Monstrorum historia, Bauhinum de Hermaphroditis Kornmannum de Miraculis Viventium. Coleonum insignia ex vita Bartholomæi Coleonis huc transtulimus. Deditum fuisse amoribus Auctor satis ingenue confitetur. Et fidem rei fecerit illud evangelicorum ministrorum decretum quod triorchi cuidam apud Germanos principi permisit concubinam Uxori superinducere de quo videas Thuanum." *Notæ in Upton*, p. 57.

† See Anstis's *Register of the Garter*, vol. ii. p. 260.

Suffolk to "assume the arms of England and France quarterly within a border gobony gold and azure," "to be an apparent sign of her consanguinity." Arms granted in this manner are stated by Menestrier to be very common in every kingdom of Europe, and are in a proper sense distinguished by the name of *arms of concession.* We shall have occasion to take more particular notice of some of these bearings in the sequel. In the meantime, we proceed to consider in their order the signs of honour.

Of the Shield, Surcoat, and Ensign.

The shield. 21. These are called by heralds the three principal signs of honour, in as much as *arms* have been commonly placed on them. The *shield* being always deemed to be a necessary instrument in the defence of the body, and an honourable badge was judged by all nations the most convenient tabula to contain marks of valour and honour, and therefore it is considered as the most proper and principal of all the heraldic signs of honour. Historians furnish us with various forms of shields used by the ancients; but at the time when *armorial bearings* were first instituted in the way already described, and came to be considered all over Europe as *tesseræ gentilitiæ*, and hereditary marks of honour, shields, for the most part, were triangular, as may be seen on the most antique monuments, seals, &c.;* accordingly the shield so shaped is called by the French the *ancien ecu.* From this triangular form came the custom in heraldry of putting the greater number of figures above, and the less below, as three, two, one. In subsequent times, a form of shield became more prevalent, square, rounded, and pointed at the end: these are most common in this island, and in France. The Germans make most use of the shield *chancre*, with bulgings and notches derived from their tournaments. The Italians have mostly the oval shield. See Plate CCXCI. Figs. 1, 2, 3, 4, 5, 6.

Plate CCXCI. Fig. 1—6.

The *surcoat* is a loose thin taffety gown, used formerly over armour, upon which the arms of the bearer were commonly painted or embroidered, that they might be distinguished in time of battle; a memorable instance of the use of which we have preserved in the history of the Chevalier Bayard. These surcoats were much like those now worn by heralds.

The third is the Ensign, under which general name are comprehended the varieties of Standard, Banner, Pennon, Gideon, and Gonfanon.

The first two are of a square form, bearing the whole achievement of such as have a right to them; which none hath under the degree of a *knight banneret.*

The *pennon* and *gideon* are of an oblong form, with a sharp point, and carry a part only of the owner's arms; as his device, crest, and motto.

The *gonfanon* is a banner of the church, square, but having three labels, or *fanons*, and the bearer thereof is called the *gonfaloniere.*

Arms have also been represented anciently on the furniture of horses, as in the seals of Alexander II. of Scotland, Edward I. of England, the two De Quinceys, Earls of Winchester, in Spelman, &c. See Plate CCXCI. Fig. 2.

Fig. 7. Women place their arms on a lozenge, (See Fig. 7.) which is a square figure with one of its angles uppermost; or on a fusil, which is a figure of the same nature, but longer than it is broad. The old writers, particularly Sylvanus Morgan, in his *Nobility native, or Adam's coat,* are pleased to derive the common form of the man's escutcheon from the spade of Adam, and of the woman's lozenge from Eve's spindle; but, as Nisbet observes, "these things are mere fancies." Neither is he more pleased with the sentiments of Sylvester De Petro Sancto, who deriveth the lozenge from the cushion used in sewing, &c. *pulvillum in quo exercent mulieres linearia opificia.*

Of the Blazoning of Arms.

22. Blazon, or the art of blazoning of arms, consists in the knowledge of those colours, or metals, which are used in the art of heraldry, and of the several lines of partition, ordinaries, and changes, whereof the coat is composed. The tinctures.

Of Tinctures.

23. The colours and metals thus used are most commonly blazoned by tinctures, which have their proper and fixed terms taken from the French; which tongue has indeed, in consequence of the great excellence of the French heraldic writers, become, in some sort, the common language of heraldry among all the nations of Europe. The terms of these tinctures are these:

Or,	that is	Yellow.
Argent,		White.
Azure,		Blue.
Gules,		Red.
Sable,		Black.
Vert, or *Sinople,*		Green.
Purpur,		Purple.

1. *Or.* This metal is allowed to be the most honourable of all the tinctures. In Latin blazonry it is called, *aureus color, aurum, luteum, croceum, Galbinum.* It is known in engravings by small points or ticks. Fig. 8. Plate CCXCI. Fig. 8.

2. *Argent.* In Latin, *argenteus color, albus,* and *argentum.* To mark this colour in engraving, the field is left blank. Fig. 9. Fig. 9.

3. *Azure.* This is derived from the oriental *lazurd,* which signifies the heaven or its colour. The Latins say, *cæruleus, cæsium, glaucum, cyaneus.* It is represented by horizontal lines. Fig. 10. Fig. 10.

4. *Gules,* evidently derived from the eastern *gul,* or *ghul,* which signifies a rose, red, &c. In Latin, *color roseus, rubor, rubeus, sanguineus, coccineus*; marked in tallyduce by perpendicular lines. Fig. 11. Fig. 11.

5. *Sable,* comes also from the oriental word which expresses the same idea, *zibel, zebel,* still retained in the French, as *maitre zebeline, maitre noire;* marked by cross hatches, perpendicular and horizontal. Fig. 12. Fig. 12.

6. *Vert,* the common French word for green. The French themselves commonly use *sinople,* a term the origin of which has occasioned no small difficulty. Some think it is derived from the city of Sinope, in Asia, as if the earth there were green; others esteem it derived from the Greek Πρασινα οπλα, green arms. This also seems to us to be of Oriental origin, *tsin,* herb, verdure; *bla,* blade: the young blade of grass, which is always of the most beautiful green. Indeed, our own word *green* expresses no other idea but that of *growing.* The Latin writers say, *viridis* or *prasinus.* It is marked by diagonal lines from right to left. (Fig. 13.) Fig. 13.

7. *Purpur,* is marked by diagonal lines from left to

* Spencer gives the Red-cross knight a shield of this form, *Fairy Queen,* 1. 6. 41. "And catching up in haste his three-square shield."

Heraldry. right. This colour is, by the best writers, little approved. Spelman talks of it as of new introduction in his time; and in Scotland it is entirely unknown, except among the *new gentry*, as Nisbet says. (Fig. 14.)

Plate CCXCI. Fig. 14.

Besides these, the English heralds mention two other colours. 1st, *Tenny*, or orange; known, in engraving, by diagonal hatches from right to left, and *e contra* from left to right. 2d, *Sanguine*, or dusky red, marked by diagonal lines from right to left, and horizontal ones. These two colours are, by the English writers, appropriated to *abatements of honour*, and so are called dishonourable stained colours.

When any object is represented not in any of these heraldic colours, but as it is in nature, as, for instance, grapes, peacocks, &c. it is then blazoned *proper*.

Some fanciful heralds, particularly in England, give out a rule, that gentlemen's arms alone should be blazoned in the manner above mentioned, those of noblemen by precious stones, and those of sovereign princes by planets; thus,

Tinctures.	Precious Stones.	Planets.
Or.	Topaz.	Sol.
Argent.	Pearl.	Luna.
Blue.	Sapphire.	Jupiter.
Red.	Ruby.	Mars.
Green.	Emerald.	Venus.
Sable.	Diamond.	Saturn.
Purpur.	Amethyst.	Mercury, &c.

But these niceties seem to be entirely of a piece with the imaginations of another herald, who insisted on blazoning by *flowers*; as rose, jonquil, &c. or with the accurate definitions of virtues, &c. signified by particular tinctures, at one period so much in vogue: as *or*, faith; *argent*, innocency; *blue*, loyalty, &c. It is sufficient to observe, that not only is all blazoning of arms of different degrees in different manners unknown to the heralds of France, Italy, and Germany; but that the practice would tend to confound colours with charges, and the things borne with the colours. Moreover, it would render useless the great rule of not putting *colour on colour*, or *metal on metal*;* for this could not hold, were metals and colours no longer employed or named in certain armories.

Of Furs. Ermine. Vair.

The furs.

23. The use of furs in armories is in all likelihood derived from the habits and garments of military men and civil magistrates, according to the opinion of Sylvester De Petro Sancto, Nisbet, and others, though a different account of the matter is given by Sir George Mackenzie. The antiquity of their use is proved by the circumstance, that when Innocent III. commanded Conrad Bishop of Wurtzburgh, by way of penance, to go and fight against the Saracens, he particularly forbade him to appear in ermine, vair, or any colour employed in tournaments.

Ermine.

These furs, Ermine and Vair, are the principal furs employed in the heraldry of any country, and the only ones known in France or Scotland. Ermine is supposed to take its name from an animal of the same name, the skin of which has long been considered as a royal and noble ornament. In Great Britain, the different degrees of nobility are distinguished by the number of rows of ermine with which the mantle of the peer is trimmed; and Menestrier informs us, that at the coronation of Henry II. of France, for want of true ermines to line his robes, use was made of cloth of silver spotted with patches of black velvet. This fur is represented in blazoning, by a white field powdered with black spots, which spots have the point upward tipped with three ticks of black. (Fig. 15.) *Contre-ermine* is that in which the field is sable, and the spots argent. (Fig. 16.) As for the English furs, *erminois* field *or* spots *sable*; *pean* field *sable* spots *or*; and *erminites* field *argent*, spots *sable*, *with a single hair gules at each side of the spot*, these are unknown in any other country.

Plate CCXCI. Fig. 15. Fig. 16.

Ermine and its kinds have two tinctures. The spots are in place of figures; and it may therefore form a complete *armory* of itself, as is the case with the arms of the Duchy of Burgundy. But ermine may also form a field whereon every charge, either of metal or colour, may be placed; or it may form itself the charges, and be placed without impropriety upon any shield.

The spots of ermine are of an indefinite number, irregularly disposed on the shield: but any certain number of these under ten may be borne after the position of any of the heraldic charges. In this case, they are not to be blazoned *ermine*. The spots being in truth charges, are called by us *ermine spots*; by the French *mushctours*; and in the blazon their number and disposition must be expressed. The Latins call them *maculæ* muris *armeniæ*.

Vair.

Vair is the other principal fur in heraldry. From what its name is derived seems perfectly uncertain. The Latins certainly blazon it, "Arma variata," &c. Its pieces are always *argent* and *azure*, disposed in the manner of rows of little figures, resembling shields or bells, so placed that the point of the bells in the second row is between the base of those of the first. (See Fig. 17.) The *grand-vair* of the French is that wherein the rows of these figures are only three in number. In *menu vair* the rows are above four, and this is the common *vair* of our heraldry. For *countre vair*, see Fig. 18. Fig. 17. Fig. 18.

The species of fur represented in Fig. 19. which consists of pieces alternately arranged of azure and argent resembling cups, goblets, &c. is variously named *meirre*, *vairy cuppy*, *vairy tassy*, or *potent contre potent azure et argent*. Potent is derived from *potence*, a *gallows*, the top of which these figures are supposed to resemble. These furs may all be used in the same manner as the ermines. Fig. 19.

Of the Points of the Shield.

24. For the convenience of blazoning, the different parts of the shield have received particular names, taken from the parts of the human body; of these a scheme is given in Fig. 20. ABC represents the high- Fig 20.

* The rule alluded to is thus traced to its origin by Feron, in that part of bis work wherein he treats of the armorial bearings of Adam. "Telle couleur de rouge est attribuée a notre bon pere Adam, qui porta pour armes de gueulles seullement auquel commensa noblesse, et qui en langue ebraique signifie rouge. Aussi fut il forme de terre au champ de Damascene. Les quelles armes il ne porta longuement transgressant le commandement de Dieu; et lors furent chargées d'une pomme de sable demonstrant le vilain peché par lui commis contre le puissance divine en trangressant son commandement. Qui est le motif que nos predecesseurs ont tenu pour maxime ceste reigle generale, que *armoiries sont faulses ou couleu domine autre couleur*, qui à este observée jusques a present."
Vide *Not. in Uptonum*, p. 39.

Heraldry. est part of the shield, which the French called *chef*, and we *the chief*. D is called *the collar*, or *honour point*, because badges of honour are worn on the breast, as those of the garter, thistle, &c. E is called *the cœur point*, as also the *centre*, or *fess point*. F, *the nombril*, or *navel point*. GH by the French, the *flanque points*, by the English the *base points*. I, the *base point*. A is the *dexter chief point*, or *canton*. B, the *middle chief point*. C, the *sinister chief point*. G, the *right base point*. H, the *sinister base point*.

When arms are blazoned without relation to, or expression of, the point wherein the figures are placed, they are then supposed to occupy the centre of the shield. When figures are ranged as ABC, they are said to be *in chief*. When ranged so as to reach from the dexter chief point to the sinister base point, to be *in bend*; from the sinister base point to the dexter chief point, *in bend sinister*; when placed between the base points, they are said to be *in base* or *in point*.

Of the Lines of Partition.

Of the lines. 24. The field or surface of the escutcheon is divided into parts by various lines.

1. A plain horizontal line.
2. An angle.
3. A Bevile.
4. Escartele.
5. Nowy.
6. Arched, or enarched.
7. Double arched.
8. Wavey, or undé.
9. Invecked.
10. Ingrailed.
11. Battled, embattled, or crenellé.
12. Battled, embattled.
13. Nebule.
14. Potent.
15. Indented.
16. Dancetté.
17. Patte, or dovetailed.
18. Urdé.
19. Rayed, radiant, rayonné, or rayonated.
20. Raguly.

It must be observed, that indented and dancetté are lines of the same form, differing, however, in the size and number of the cuts or indents; those of the former being more numerous and smaller than those of the latter. For example, a Fess *dancetté* should be composed of three indentations and no more, whereas the Fess *indented* may have double that number. These lines are all engraved in Plate CCXCI. from Fig. 21—Fig. 40. Plate CCXCI. Figs. 21—40.

When a shield is by a horizontal line divided into two equal parts, it is said to be *coupe*, or *parted per fess*. See Fig. 41. Fig. 41.

When a shield is by a perpendicular line divided into two equal parts, it is said to be *party*, or *party per pale*. See Fig. 42. Fig. 42.

When a shield is divided into two equal parts by a diagonal line drawn from the dexter point chief to the sinister point base, it is said to be *tranché*, or *party per bend dexter*. See Fig. 43. Fig. 43.

When it is so divided by a diagonal line from the sinister point chief to the dexter point base, it is said to be *taillé*, or *party per bend sinister*. See Fig. 44. Fig. 44.

When the partition line is straight, as in Fig. 21. above mentioned, it has then no additional denomination in the blazon. But if it has any of the other twenty forms, then the term of that form must be added in the blazon, and is of frequent use for the distinction of cadets.

When the first two lines, *parted per pale*, and *parted per fess*, (in French *coupé* and *parti*,) meet in a field, they divide it into two equal parts, or quarters, which are of different tinctures, the first as the fourth, and the second as the third. Thus we say *quarterly gules and argent*; the French *ecartile de gueules et d'argent*; Gerard Leigh and his followers, *parted per cross*. See Fig. 45. Heraldry. Plate CCXCI. Fig. 45.

When tranché and taillé meet in a field, they divide it into four areas, which is blazoned *parted per saltier argent and azure*. The French would say *d'argent flanque d'azure*, or *L'ecartile en sautoir*. See Fig. 46. Fig. 46.

When coupé, tranché, and taillé meet in a field, they make six triangular areas-blazoned *girony of six*. See Fig. 47. Fig. 47.

When the whole four lines, coupé, party, tranché, and taillé, meet in one field, they divide it into eight conal parts blazoned *girony of eight*.

When two half diagonal lines rising from the dexter and sinister points base meet in the collar points, it is *party per chevron*. See Fig. 48. Fig. 48.

When a shield is divided into three equal parts, it is said to be *tierce*. See Fig. 49. Fig. 49.

If by perpendicular lines,	*tierce per pale*. See Fig. 49.	Fig. 49.
If by horizontal lines, . . .	*tierce per fess*. See Fig. 50.	Fig. 50.
If by diagonal lines from right to left, ...	*tierce per bend dexter*. See Fig. 51.	Fig. 51.
If by diagonal lines from left to right, ...	*tierce per bend sinister, or tierce en bar*. See Fig. 52.	Fig. 52.

Repartition lines, are those by which the shield is divided into unequal parts, as *coupé-my-partée*, and *party-my-coupée*. See Figs. 53. and 54. Figs. 53, 54.

Of the Figures of Heraldry.

25. These are either peculiar to heraldry, and derive their names from it, and therefore called *ordinaries*; or they are things natural or artificial used in armories, but retaining their own proper names; these are *charges*, properly so called.

I. *Of Ordinaries.*

All ordinaries are composed of some one or other of the above-mentioned lines, and are in number 19, according to the English heralds, viz. Of Ordinaries.

1. The Chief, which is formed by one line only drawn horizontally across the face of the shield, so as to separate the third part of the escutcheon from the rest. See Fig. 1. Plate CCXCII. Fig. 1.

2. The Pale, which is composed of two parallel lines drawn perpendicular from the chief to the base of the escutcheon, and should contain one third part of the breadth of the shield. See Fig. 2. Fig. 2.

N. B. The *pale* admits of two subdivisions, or diminutions as to its breadth. The half of the *pale* is called a *pallet*; and the half of the *pallet* is called an *endorse* or *verget*. According to the strict rules of heraldry, neither *endorse* nor *pallet* can be charged.

3. The Bend, which is formed by two equidistant lines drawn diagonally from the dexter chief to the sinister base of the scutcheon, according to a rule laid down by Leigh, Holme, Guillim, &c. should, if charged, be in breadth one-third; if not charged, one fifth of the shield. Others make no such distinction, but tell us, that the *bend* possesseth always the third part of the escutcheon from the right chief angle to the left base angle. Fig. 3.

When there are more than *one bend* in a coat, they are called *bendlets*; but when the field is equally divided by 4, 5, 6, 8, or 10 lines, or any even number *bendways*, then it is termed *bendy* of so many pieces.

The *bend*, or, as it may be called for distinction sake, the *bend dexter*, has more subdivisions or diminutives than any of the other ordinaries: 1*st*, The *bendlet*, which should contain one-sixth of the shield; 2*dly*, A *garter*; 3*dly*, A *cottise*; 4*thly*, A *ribbon*, none of which can be with propriety charged. See Fig. 3.

PLATE CCXCII. Fig. 3.

4. The *bend sinister*, which passes diagonally from the sinister chief point to the dexter point in base, has not the same diminutives as those of the *bend dexter*; but, according to some heraldic writers, is subdivided into a *scarp* or *scarf*, which has just half the breadth of the *bend sinister*, and a *batton* or *fissure* containing half the breadth of the scarf. See Fig. 4.

Fig. 4.

Many, however, will by no means admit of the *batton* being said to be a diminutive of the *bend sinister*, or any part of any of the ordinaries. According to many years practice, the *batton* does not touch the extremities of the shield, nor the extremities of the quarter where the paternal arms are placed, as all the ordinaries do, but is, on the contrary, *couped* or cut short, and so borne as a mark of illegitimacy, (as may be seen in the arms of the Dukes of St Albans, Grafton, and Buccleuch, all descended from bastards of King Charles the Second,) and not as an ordinary or charge, or any part of the coat. For although some instances are to be met with of ancient arms, where the *batton sinister* is passed from the sinister chief to the dexter base over all, and others where it passes from corner to corner over the paternal arms, and not over the other quarterings; yet in every one of these it is used as a mark of illegitimacy, and not as either an ordinary or a charge. This mark or batton may, in the arms of royal bastards, be of metal or fur, or both; but, in the escutcheons of those of the humbler sort, of colours only. When both a *bend dexter* and a *bend sinister* occur in the same coat, that is first mentioned which lies nearest the shield; thus *argent*, a bend azure surmounted by a bend sinister.

Fig. 5.

5. The FESS is formed by two lines drawn horizontally across the shield, and is understood to comprehend in breadth the third part of the shield, though less room is often assigned to it. This ordinary cannot be divided or diminished like the *bend*, but may be *voided*, a form to which all the ordinaries are liable. *Voided* is said of an ordinary when its middle is cut away, so that no more of it remains visible than the two outside lines; as *azure*, a *fess voided argent*, by the name of *Bleckall*.

Fig. 6.

6. The BAR is formed by two equidistant lines drawn horizontally across the middle or centre of the escutcheon, after the manner of the *fess*, but containing one-fifth part only of the field. The *bar* hath two diminutives, viz. a *closet*, which is in breadth one-half, and a *barrulet*, which is in breadth one-fourth of the *bar*. When the field is divided into 4, 6, 8, 10, or 12 equal parts, it is then blazoned *barry*; and when the diminutives of the bar are placed in pairs on the shield, they are called *bars gemelles*, from the Latin *gemelli*, twins.

Fig. 7.

7. The ESCUTCHEON itself is deemed an ordinary, and is composed of three lines. It may be carried singly, or with others, as in the coat of Hay, argent, three escutcheons, gules. See Fig. 7.

N. B Inescutcheon signifies the same thing.

Fig. 8.

8. The BORDER hath, by several writers, been refused admittance into the number of ordinaries; they alleging, that it is not a principal figure, but a difference only. Nisbet, however, very properly observes, that this is quite unjust, inasmuch as many coats consist of other charges than the *border* alone. In blazon, borders always give way to the chief, the quarter, and the canton: so that, in coats charged with one of these ordinaries, the border goes round the field until it touches it, and there finishes; but, in respect to all other ordinaries, it passes over them. When a border is of two colours, and divided into squares, it is called a *border compony* or *compony*; if it hath two rows of squares, it is called *counter compony*; if three, it is called *cheque*.

A border *purflewed* is shaped exactly like *vair*: when it is of one row, it is called *purflewed*; when it is of two rows, it is *counter purflewed*; when of three, *vair*. The border *enaleron* is a border charged with birds; the border *entoiré* is charged with *besants*; the border *verdoye* is charged with vegetables; the border *enurney* with lions, &c. But these terms ought all to be discarded as useless.

9. The ORLE is an inner border of the same shape as the escutcheon, and doth not touch the exterior of the shield, the shield being seen within and around it on all sides, so that it appears like an escutcheon *voided*. The edges of the *orle* may be ingrailed, indented, invecked, &c. When any bearings, as martlets, mascles, &c. are placed round an escutcheon on a field, they are said to be *in orle*; and it is needless to mention the number of them, for figures so placed are always supposed to be eight in number. See Fig. 9.

PLATE CCXCII. Fig. 9.

The TRESSURE is a diminutive of the orle, formed by a small line or trace passing along the field, and encompassing the inner part of the escutcheon in the same form as that of the shield. In some coats, the tressure is formed of two lines or traces, *flory counter-flory*, as in the arms of Scotland. Indeed, unless it be of this sort, it may as well be called an orle as a tressure, as Edmonstone has well observed.

10. " The FLASQUE consists of an arched line drawn somewhat distant from the corner of the chief, and swelling by degrees till you come towards the centre of the escutcheon, and then decreasing again with a like descent unto the sinister point base." See Fig. 10. Fig. 10.

" The FLANCH is formed of an arched line, taking its beginning from the corner of the chief, and from thence compassing orderly with a swelling embossment, until it come near the nombril of the escutcheon, and thence proportionably declining to the sinister base point." So says Guillim; but Gibbon and Edmonstone are both of opinion, that these two ordinaries are one and the same. The *voider* is certainly a mere diminution of the flanch, and, by reason of its smallness, cannot be charged.

11. The SALTIER, or *Sautoir*, is an ordinary consisting of a fourfold line, two whereof are drawn from the dexter chief towards the sinister base corner; and the other two from the sinister chief to the dexter base point. If not charged, it containeth one-fifth of the field; if charged, one-third. See Fig. 11. Fig. 11.

12. The CROSS, after the expeditions to the Holy Land, came to be an ordinary of most frequent use. It is composed of a fourfold line, whereof two are perpendicular and two horizontal; so that it seems to be formed of the *pale* and the *fess*, not lying on one another, but corporally united in the centre. The great variety of crosses used in heraldry is such, that in all considerable systems several pages are filled with engravings of them, Fig. 12. The most considerable are the cross *patée*, Fig. 13; the cross *potence*, Fig. 14; the cross *avellane*, Fig. 15; the cross *furche*, Fig. 16; the cross *crosslet*, Fig. 17; the cross *botone*, Fig. 18; the cross *flory*, Fig. 19; the cross *patée fitched*, Fig. 20; the cross *pierced*, Fig. 12. Figs. 12—20.

Heraldry. Fig. 21; the cross *moline*, Fig. 22. The proportions of the cross are exactly the same as those of the saltier.

Plate CCXCII. Figs. 21, 22. 13. The Cheveron is an ordinary formed of twofold lines placed pyramidically, and is resembled to a pair of barge-couples or rafters, such as carpenters use to support the roof of a house. Its diminutives are the *chevronel*, which is half the chevron; and the *couple*
Fig. 23. *close*, which is half the chevronel. See Fig. 23.

14. The Fret is formed of six pieces, two of which compose a saltier, and the other four a mascle, over which the saltier pieces must be interlaced. When the fret is composed of 8 or 10 pieces, we say, *or fretty azure*, &c.
Fig. 24. See Fig. 24.

15. The Pile is an ordinary composed of a twofold line, which forms a long wedge broad at the top, and
Fig. 25. terminating at the base in an acute angle. See Fig. 25.

16. The Giron is an ordinary of a triangular or conical form, composed of two lines drawn from diverse parts of the escutcheon, and meeting in an acute angle in the *fess point*. This may be borne singly, or in couples, to the number of 4, 6, 8, 10, or 12. When there is only one gyron in a coat, it is blazoned thus, *argent a gyron sable*, without mentioning the point from which it issues, that always being supposed to be the dexter chief point; but if it stand elsewhere, it must be expressed. If there be six gyrons in a coat, it is blazoned, *gyrony of six,*
Fig. 26. *or and sable*, and so of any greater number. See Fig. 26.

17. The Quarter is an ordinary composed of two strait
Fig. 27. lines, containing one-fourth part of the shield. See Fig. 27.

18. The Canton is of a square figure less than the
Fig. 28. quarter, containing one-third of the chief. See Fig. 28.

19. The File or Label, though used as a distinction of houses, is very properly placed among the ordinaries by Holme, by reason that it is variously borne and charged.

Of Charges or Figures not peculiar to Heraldry.

Of charges. 26. Anciently arms were simple and plain, consisting of at most a few figures distinctly set forth on the shield; the heralds of those days being universally of opinion, that the plainer a coat is the more honourable it should be esteemed. The arms of the house of France, were simply three fleur-de-lys *or* in an azure field. The
Arms very simple of old. royal arms of England, at most three lions *or* on a field *gules*. The arms of Waldgrave, simply *per pale argent and gules*. Those of Burgundy *ermine* alone, without any charge whatever. As coats of arms increased in number, a deviation from this original simplicity soon became unavoidable; a conspicuous variation from each other was absolutely requisite; and this necessity was never more felt than in camps and tournaments. This at first was effected either by a repetition on the same escutcheon, of some one or other of those particular figures, which had heretofore been used as charges; or by placing in the field two or more distinct bearings. It was not long, however, before this mode proved inadequate to the purpose for which it was intended. The continual multiplication of arms had exhausted all the variations of which armories were, as they then stood, susceptible, and called for additional marks of distinction. Wherefore such a multitude of new charges have been from time to time introduced, that it may be truly said, there is scarce any thing either natural or artificial that is not, or has not been represented in coat armour.

New and mercantile arms. The embarrassments which, from the multiplicity of coats of arms, and the infinity of charges former heralds lay under, in the contriving new armories so as not to have them clash with others already in use, led them, as might well have been expected, into many absurdities; but to their praise it must be said, that they not only avoided, with great caution, all improper or indistinct figures, but blazoned what they did select with so much fulness and nicety, that none could be at a loss to draw them with accuracy and exactness. Modern heralds, however, have not always followed their good example in this respect; on the contrary, they have stuffed the newly purchased coats with such a multitude and variety of charges, and introduced such a medley of novel and extraordinary bearings, that these escutcheons are for the most part crowded, confused, and unseemly, and of consequence altogether inadequate to the original purposes of coat armour.

Possibly they are desirous of giving good pennyworths, and think that as purchasers now pay much dearer for their arms than they used to do, they are entitled to a greater number of bearings on that account. The arms granted to one Edward Chambers of the island of Jamaica, afford a notable instance: "*Argent a negro cutting with a bill a sugar cane, all proper; on a chief azure two pine-apples on, leaved of the last.* But the escutcheon of an officer lately returned from the East Indies, viz. lieutenant John Nathan Hitchins, presented still greater absurdities: "*Quarterly 1st and 4th vert an elephant and tiger rampant combattant, an officer of the honourable East India Company's dragoons standing by with a musket in his dexter hand, and a dead horse couchant in the sinister point base, all proper. 2d and 3d gules between three pieces of ordinance* or *on a cherron argent two oriental tiaras contre embattled proper.*" The motto, "*Auroram et Gangem pauci dignoscere possunt.*" Another grant runs thus: "*Sable on a cheveron between 2 pistols in chief* or, *a silver medal with the French king's bust, inscribed 'Louis XV. par la grace du Dieu Roi de France et Navarre,' tied at the top with a ribbon gules. A laurel chaplet in the centre, a scalp on a staff on the dexter, and a tomahawk on the sinister, all proper.* For the crest: *On a wreath a rock; over the top a battery in perspective; thereon the French flag hoisted, an officer of the Queen's Royal American Rangers climbing the said rock sword in hand, all proper!*"

The arms of one Templar are thus blazoned in the grant: "*Quarterly azure and gules, the perspective of an antique temple; on the pinnacle and exterior battlements a cross moline* or. *In the first quarter, an eagle displayed. In the second, a flag trippant, regardant of the last.*" The arms of Mr William Sitlington, teacher of philosophy in Wapping, are thus: "*Azure on the ecliptic circle* or, *the sign* Libra; *in chief, a terrestrial globe on a stand, all proper; and in the base, on a mount vert,* a male child *extended in bend sinister proper.* Crest, *On a wreath, a holy lamb regardant ermine accolled with a laurel branch vert, holding a banner proper.* Motto, *Have mercy on us, good Lord.*" On the ridiculous parts of these armories, and the incomprehensible jargon in which they are set forth in the grants, it would be absurd to enlarge. The arms are such as no ancient herald, rightly embued with the principles of his art, could understand; and no painter can properly represent without the help of inspiration, unless he can see the painting on the margin of the grant.*

Many other examples of a like sort might be produced; but, to those already mentioned, we shall only

* In the same taste, a late tutor and examining master at Oxford assumed as crest, "*on a cap of maintenance a mark of interrogation nebulé.*" Motto, "*το της πολλης πειρας τελευταιον επιγεννημα.*" The congenial escutcheon—"*gules, a fair exemplar of* The Ethicks *expanded proper!*"

add that of the bearing granted to one Mr Tetlow, which is so extraordinary, in respect to the coat as well as the crest, that it is not, by any means, to be omitted in this place. In the arms are *five music bars*; and the crest is thus set forth: "*On a book erect gules clasped and leaved* or, *a silver penny argent whereon is written the Lord's prayer; on the top of the book a dove proper, in its beak a crow-quill pen sable;* in commemoration, as is said, of the brother of the grantee having written the Lord's prayer within such a compass.

Neither can any one greatly approve of a grant of arms, wherein we find "*a troubled ocean with Neptune rising therefrom, holding in his sinister hand part of the wreck of the ship Royal George,*" to indicate, that the uncle of the grantee had suffered shipwreck along with Kempenfelt; or of a grant, wherein is introduced, "*a China porter carrying on a yoke two faggots of cinnamon,*" to indicate, that the grantee had once made a voyage to the Dutch islands; and yet all these absurdities arise from the present or late system of *charges* adopted in the herald offices.

But to return from this digression, if such it deserves to be called, to notice particularly all those figures which are even, by the most excellent authors, admitted as proper for the practice of heraldry, would be altogether inconsistent with the limits of an article such as this. The principal only can be noticed; and, in the first place, it is fit to observe, that of charges some are round in shape, some square. The former are generally called *roundles* or *roundlets;* and of these, which differ from each other in name according as they are of different tinctures, there are nine; seven of them being perfectly globular, and two of them flat like a piece of coin.

Of roundlets.

The Roundles, or Roundlets.

When they are	1. Or,	are then called	1. Bezants.
	2. Argent,		2. Plates.
	3. Vert,		3. Pomeis.
	4. Azure,		4. Hurts.
	5. Sable,		5. Ogresses, or Pellets.
	6. Gules,		6. Torteauxes.
	7. Purpure,		7. Golpes.
	8. Tenne,		8. Oranges.
	9. Sanguine,		9. Guzes.

1. Bezants, when they are armorial figures, are flat pieces of plain gold, without any stamp or impression upon them. When introduced into heraldry, they had their name from the ancient coin of Constantinople, or Byzantium.

2. Plates are likewise flat, as representing thin pieces of silver bullion when fitted for the stamp.

The other seven figures are always globular, viz.

3. Pomeis, which derive their name from the French *pomme*, an apple.

4. Hurts, so called from their resemblance to a small blue fruit, named hurtle berries.

5. Ogresses, or Pellets, resemble bullets for guns. In blazon, they are generally termed pellets, but some of the ancient heralds call them *gun-stones.*

6. Torteauxes take their name from the French appellation of a certain species of round cakes, which, in England, used to be called wastal-cakes, or wastals, by which name we often find them distinguished in ancient blazons.

7. Golpes, according to Gerard Leigh, are wounds; and Guillim even thinks they may be called so in blazoning.

8. Oranges, the well-known fruit.

9. Guzes are said to represent eye-balls; but these are of very rare occurrence even in English heraldry.

Heraldry.

When any of these nine figures are in a coat, and counterchanged, they lose their beforementioned respective names, and are all indifferently stiled roundles; so that if we look at the painting of a coat-armour, which is blazoned *per pale* or *and gules three roundles,* we shall find, that, of the two figures in chief, one is a *bezant,* and the other a *torteaux;* and that the solitary figure in base being divided *per pale gules and or,* the one half thereof is a *bezant,* and the other half a *torteaux.* When the field is strewed with any of the first five beforementioned figures, or if they are placed on crests, supporters, or any ordinary or charge, they are termed, *bezanté, platé, pometté, hurté,* and *pelletté;* but if the field be strewed, or semée, with any of the four last mentioned roundles, we say, *semé of torteauxes, semé of golpes, semé of oranges,* and *semé of guzes.*

Foreigners have no more than two specific names for all these round figures. When they are of metal, they call them *bezants,* when of colour, *torteaux;* therefore they say, so many *bezants d'or,* or *d'argent;* or so many *torteauxes d'azure, de gules, de sable,* &c. and when they are half metal, half colour, if the metal hath precedence in position, they say *bezant-torteaux* of such metal and colour; and so, *e contra, torteaux-bezants* when the colour precedes the metal.

The roundlet voided, is the *annulet,* or ring. When these pass into one another, the French say *vires.*

Of Guttes.

Another sort of charge very common in armories receives, in like manner as the roundlets, divers names of blazon, according to the variations of its tinctures. This charge is called *guttes,* i. e. *drops* of things liquid, whether by nature or by art. Of guttes.

If they are	or	they are termed	guttes d'or	i. e.	drops of gold
	argent		guttes d'eau		water
	vert		guttes d'olive		oil of olives
	azure		guttes de larmes		tears
	sable		guttes de poix		pitch
	gules		guttes de sang		blood

Guillem, indeed, says these are seldom borne alone; but Edmonstone differs from him, and instances among other examples of *guttes* borne as a charge,

Argent three guttes de poix; for Crosbie.

But it is true they are much oftener borne strewed on fields, ordinaries, charges, crests, supporters, &c. and in such cases whatever is charged with them is blazoned thus, *Argent gutty de sang,* which denotes that the whole escutcheon is sprinkled with red drops, and so in regard to a crest, *a lion's head gules gutty d'orgent.*

There are three square figures deemed to be proper charges, the lozenge, the fuzil, and the mascle. Of these the two former have been already mentioned and described as applied to a different purpose. The field or ordinary may be covered with *lozenges* or *fusils,* and it is then called *lozengy, fusilly.* If fusils are borne in pale, as *a pale fusilly,* or *six fusils in pale,* they must lie fesswise, *i. e.* their acute angles must be dexter and sinister. But if a *fess fusilly,* their acute angles must be in chief and base.

The *mascle* differs from both lozenge and fusil in this respect, that according to the sentiments of all authors it must be pierced through, or *voided.* When any coat, Heraldry. in which one or more mascles occur is blazoned, their number is mentioned; and if they be close together or conjoined, that circumstance is not omitted, thus, *Argent a mascle in fess between three pellets sable.* Osbaldeston, *sable five mascles conjoined in cross or.* Brandreth, *gules seven mascles conjoined or three, three, and one.* The coat of De Quincey, Earl of Winchester, well known by ancient seals. Plate CCXCI. Fig. 2.

The *Billet* is an oblong figure, supposed to take its name from its resemblance to a *billet of wood.*

Rules for Blazoning.

Rules. When a coat of arms is blazoned, the field is first mentioned, next the ordinary, last of all the charge. If the coat consists of two colours only, as the coat of Hatton, we may say, *azure a chevron between three garbs or,* which implies that both chevron and garbs are *or.* Or thus, *azure a chevron or between three garbs of the last.*

When the charges next to the field are mentioned, then proceed to those which lie more remote, as in the coat of Pratt, sable on a fess between three elephants heads erased argent as many mullets of the first. Here the mullets, being the most remote from the field, are last mentioned, and as both field and mullets are sable, the words *of the first* are used to avoid repetition.

When a field is divided by lines, they must always be mentioned before the colours, as in the coat of Waldegrave before mentioned *parté per pale argent and gules.* Aston, *parte per chevron sable and argent.* Boyle, *parte per bend crenellé argent and gules.*

N. B. Besides the above mentioned charges, there are other two, rejected indeed by our English heralds, but of common enough use among foreigners.

1. A shield is by them called *papilloné,* when it is covered with figures like the scales of fish.

2. "Diaspré, or diaperé, is said when the field is shadowed with flourishings and various turnings, by *purfels* of gold or silver, or tinctures after the fashion of flowers or leaves, like the weaver's diaper-napery." The Germans practise this most, as the French do the *papilloné.*

Concerning all the figures we have as yet observed, whether under the head of ordinaries, or under the present, heraldic writers are much at variance among themselves. Some arrange them all under the head of ordinaries, dividing them into honourable ordinaries, and subordinaries. Others, and among the rest Edmonstone, adopt that order which we have observed. Indeed, uniformity in this matter could by no means be expected among authors who differ from each other upon matters of so much greater importance in their art. Those figures which are by one set of writers affirmed to be altogether peculiar to heraldry, are by others considered as evident representations of objects the most familiar in nature or in art. As to those figures which we shall next take into consideration, they are all of one mind. Heraldry has, according to every authority, borrowed them from nature.

Of the Celestial Figures used in Armories.

Of celestials. 27. 1st, The *Sun.* When of the metal *or,* it is said to be proper; when of one of the colours of heraldry, it is called *ombre de soleil de gules,* &c.

2d, The *Moon.* When full, said to be *in* her complement. The half moon is styled *crescent, increscent, decrescent,* and, *crescent reversed,* according to her position in the shield; *crescent,* when the horns are towards the top of the escutcheon; *increscent,* when the horns are towards the right side of the shield; *decrescent,* when the horns are turned to the left; and *crescent reversed,* when they are pointed towards the base. The crescent is the cognisance of the Ottoman emperors. Aben Mahomet, the great Moorish prince who overran Spain, carried the *crescent reversed.* All over Spain, the crescent is a common bearing, in consequence of the achievements of particular families against the Moors.

3d, *Stars.* They are represented generally with five points. *Mollet* in French and Scottish heraldry means a figure of the same sort, of six points, and *pierced,* supposed to be the *revel* of a spur. But the English call stars of five points, mullets unpierced or *estoils* simply. When *pierced* they blazon them so—as, The name of Doughty in England. *Argent two bars between three mullets of six points pierced sable.*

Comets, spheres, and rainbows are also used in heraldry, as, *argent a rainbow,* by the family of Leiris in Languedoc in allusion to their name, *L'iris.*

Of Man and his Parts in Arms.

28. The use of these charges may be supposed to have arisen in a great measure from the practice of kings, and great men, particularly churchmen, having on their seals representations of themselves, their patrons, saints, &c. Thus the arms of the see of St Andrew's in Scotland were *azure, St Andrew carrying on his breast his proper cross (or saltier) argent.* Of man, &c.

When any part of the human body is represented as cleanly cut off as by a sword, it is said to be *couped,* if *torn off, erased;* in French *arraché,* in Latin *avulsum.*

Heads are frequently represented as surrounded with a wreath or bandage, and they are then said to be *banded or tortille.* Moors heads (always in profile) are common in Spanish coats as trophies.

Of Animals:—Lions, &c.

29. Lions standing upright with only one eye seen, are called *rampant;* if full faced, *rampant guardant;* and if they are looking behind them, then the word *regardant* is added to that which speaks the attitude, as *passant regardant, rampant regardant.* Lions, when represented as feeding, are called *rapin;* and when in an attitude of springing with both their hind legs together, they are termed *saliant;* as are also bears, wolves, unicorns, and all other beasts, except *griffins,* which are termed *segreant* instead of *rampant.* The tongues and claws of all beasts are in general represented in coat-armour as of a tincture different from that of their bodies, and are termed *langued* and *armed,* as, *argent, a lion rampant rampant regardant gules langued and armed azure.* Farther, it is a general rule, that when any beast is tinctured *azure,* the tongue and claws are *gules;* and *vice versa,* except when it is otherwise expressed. Of animals.

When any animal proceeds from the bottom of a chief, fess, &c. it is termed *issuant;* and when it proceeds from the fess or ordinary, it is termed *naissant.* A *demi-lion* is half a lion, so proceeding, *couchant, passant,* and the rest are sufficiently intelligible.

When any beast in a field has a fess, bend, &c. passing over him, he is said to be oppressed, depressed, or *debruised* with a fess, &c. When a beast is on a field, which is *per chevron,* it is said to be countercharged. Wherefore the cheveron line must continue its course through the beast, and the beast be painted of two colours of the field; for example, *Per cheveron argent et sable a lion rampant countercharged.* The upper part

Heraldry. of the lion, so far as to the cheveron line, is sable, the lower part, from the cheveron line to the base, argent. Again, if the field is *paly, of four or and azure,* and over all a lion rampant countercharged, some part of the lion must of consequence lie on each of the four pales, and therefore the lion must be painted of the different colour of each pale.

Lions, &c. may be borne of several pieces; as for example, *gules a lion barry wavy of eight argent and or,* by the name of Harrowden. *Gules a lion rampant cheque or and azure,* by the name of Cobham. *Gules a lion rampant barry of ten argent and azure,* by the name of Desney. *Gules a lion rampant vair crowned or,* the old bearing of Marmion. They may also be carried *dismembered* of head, feet, and tail. When a lion is said to be *dismembered,* the parts are put a little distant from each other, yet so as to preserve the form and shape of the lion. If dismembered of any particular part it should be mentioned; as dismembered of the head, if the head be cut off, &c.

If tongue or claws be cut off, he is said to be *disarmed.* If the parts cut off be not in the field, he is blazoned thus, *argent a lion sans tail gules,* &c.

Some call a lion rampant without tongue or claws a lion *mortue;* and the lion *sans tail* they call *defamed.* A lion rampant holding in his mouth a staff or batton, is said to be *baillonè.* One rampant, or sejant, (*i. e.* sitting) with his face to the sinister, is termed *Contourné.* If the eyes of lions are of a fiery colour, they are called allumés, or incensed; if their tails hang between their hind legs, they are termed *coward.*

When a whole fore-leg of a lion or other animal is borne in an armory, it is called *a jambe;* but if couped or erased near the middle joint, it is termed *a paw.*

As lions may be dismembered, so they may have additions made to them; as a lion with two or three heads, or one head with two or three bodies. Another bearing not uncommon is that of lions with two tails, which are moreover represented under various circumstances, as with *two tails erect, two tails forked and wreathed,* i. e. two tails twisted over one another, and having the two ends forked; and with two tails *nowed* or *notted.*

Palte ccxcii. Figs. 30—48. But as beasts of all sorts are blazoned in the same terms as the lion, we have given, in Plate CCXCII. representations of this animal in the principal attitudes in which heralds place him.

Fig. 30. Statant. 31. Passant. 32. Passant-gardant. 33. Passant-regardant. 34. Rampant. 35. Rampant-gardant. 36. Rampant-regardant. 37. Salient. 38. Sejant. 39. Coward. 40. Couchant. 41. Dormant. 42. Naissant. 43. Issuant. 44. Combattant. 45. Lions endorsed. 46. Lion demi-rampant erased. Lion's head coupé. 47. Lions jambe erased. 48. Lions tails erased.

Of the Tiger and Antelope.

The manner in which these two animals were anciently expressed in armories, is so dissimilar from the real figures of those well known animals, that it is not without difficulty we can recognise them. The heraldic tiger is drawn much in the shape of a wolf, with the tail of a lion, and thereon, as also on the inside of his hind legs, and on his chest, tufts of hair. On the back of his neck is a mane composed of separate tufts, similar to those *tusks* which are used in ornaments, and at the point of his nose is a tusk like that of a boar bending downwards. The imaginary antelope of former days is the same figure as this tiger in every respect, save that on his head he has two horns, whose edges are indented like a saw, and that he is hoofed like a buck. Heraldry

Besides those two creatures of heraldic fancy, the blazoners of old times invented a third, which they made of the same form, and tufted and maned exactly like their tiger and antelope, but with this variation, that he has two straight horns projecting from the head. This they term an *ibex.*

Of Birds, &c.

30. Birds painted of their natural colours are termed *proper,* and their claws, or talons and beaks, are called *arms;* thus *argent a falcon proper armed* OR, implies that he is taloned and beaked of gold. To distinguish the falcon from the eagle, the former bird is generally depicted with bells on his legs, and this is termed *belled;* but if the thongs of the leather by which these bells are attached, are flying off from the legs, then the falcon is said to be *jessed and belled.* Falcons, eagles, or hawks drawn feeding, are termed *preying.* When the wings, &c. are both behind the head, and back to back, they are termed, *expanded, expansed,* or *adossed;* and when the wings are on either side of the head, and the points are erect, they are termed *elevated.* An eagle with wings elevated and legs extended is termed a *displayed* or *spread eagle.* If the eagle has two heads, the blazon runs thus, *sable an eagle with two heads displayed* OR. Birds.

The eagle without legs, wings, tail, &c. is blazoned thus, *gules an eagle with two heads erased in the middle of the body, sans wings argent,* by the surname of Barlow. Parts only of eagles, &c. may be carried in coat-armour: wings by pairs are called *wings conjoined;* and if their points be downwards, *inverted* or *in lure,* as in the arms of Seymour. *Gules two wings conjoined in lure* OR. All birds, *not of prey,* having their beaks and legs of a different colour from their body, are called *membered;* as to claws and talons, *armed.*

When SMALL BIRDS are borne in armories, they are all represented after the same shape, of whatever tincture they be, and in our blazon are termed *birds* alone, in French "*alerons.*" *Martlets,* though principally used as a mark of distinction of houses, are nevertheless a bearing by no means uncommon. The English draw them as birds without legs. The French amputate them still more, and give them neither *beak,* legs, nor thighs.

COCKS are said *to be armed, crested,* and *jelloped; armed* signifies the beak and spurs, *crested* the comb, and *jelloped* the wattles or gills.

A SWAN, when he has a ducal coronet on his head, and a chain thrown over his back, is termed *a cygnet royal.* When a swan's head is borne, it is always blazoned *a swan's neck* couped, erased, &c.

Birds on wing are said to be *volant.*

FISH, when placed horizontally, are termed *naiant;* when placed perpendicularly, with the head in chief and tail in base, *haurient, i. e.* drawing in air; when bent, they are said to be *embowed,* (the dolphin is commonly represented thus.) When two fish are placed face to face, they are said to be *respecting each other;* if back to back, *endorsed.* Flowers of three leaves are called *trefoils,* of four *quatrefoils,* &c. When the human figure is borne clothed, it is termed *vested* or *habited.* Thus for a crest, *on a wreath, a dexter arm embowd, vested gules, cuffed argent, holding in the hand proper a rose of the last.* This implies the sleeve of the coat to be red turned up with white. Robes, vestments,

4

and habits of all sorts, crowns, sceptres, crosiers, cardinals hats, gloves, stockings, shoes, brogues, armour for man and horse, all military machines and engines, arms offensive and defensive, rings, jewels, and other ornaments, coins, dice, and chess-rooks, all articles of husbandry, all tools of trade, and in short almost every thing celestial or terrestrial, from the sun in the firmament to a carpenter's nail, have been represented in heraldry; and nothing more frequently than those creatures which have no existence except in the imagination of the poets and romancers: centaurs, unicorns, mermaids, wyverns, (*i. e.* adder-tailed dragons,) montegres, (*i. e.* monsters with the bodies of tygers and the heads of satyrs,) are abundantly to be met with. Nay, in the arms of the elder time, and more particularly in those of churchmen, we daily encounter such combinations of cherubim, seraphim, and angels, (*affrontés, volants, and with wings displayed,*) as to say the least of them, appear not a little indecorous. Astonishing, they certainly cannot be esteemed, if we take into our consideration that they are the works of the same men, who thought that the art of heraldry itself was one of the important secrets transmitted at once *viva voce* to Adam from his Maker, as being of two great depth and dignity ever to have been discovered by the mere unassisted intellect of man.

Of Marks of Cadency.

Cadency.

31. The several figures or marks of cadency, which have of later times been used for the differencing and distinction of houses, in order that their degrees of descent may be known, are for the first an Alabel; for the second a Crescent; for the third a Mullet; for the fourth a Martlet;* the fifth an Annulet; the sixth a fleur-de-lis; the seventh a rose; the eighth a cross moline; and for the ninth a double quatrefoil. See Plate CCXCII.

Plate CCXCII. Figs. 50—5.

These marks are said to have been invented by modern heralds, in order that coat-armour might descend to posterity with safety. Certain it is, however, that they are far from answering some at least of the purposes for which they were intended; for these marks, when painted on a shield of arms, are so small, complicated, and confused, that they are scarcely distinguishable. The ancient heralds adopted a better method. They made choice of more conspicuous brizures, and pitched on the border the bend, and armorial additions, as also changes of the tinctures, and of the position of the charges, as being more intelligible tokens of difference. Thus an old family of Salop, the Corbettes, bore *or a raven sable,* the second branch took *two ravens,* the third *three,* the fourth *four,* and a still younger branch bore their *ravens within a border.* It was the most usual method to have these borders of difference composed of the arms of the first marriage that had established the particular branch of the family which first assumed such border. The Manwarings of Salop bore *argent two bars gules.* The younger branches went on increasing the number of bars, till one took *ten bars.* The Warrens originally bore *cheque or and azure.* But the younger branch took *cheque or and azure on a canton gules a Lion rampant argent,* being the arms of the mother a Mowbray. Others took a part of the maternal coat, and added to their father's coat, to shew that it was a younger branch descended on the mother's side from such a particular family. At present the above mentioned marks of distinction, *label, mullet,* &c. are so combined with each other as to difference almost *ad infinitum.* The daughter of a house bears her father's mark of cadency, but not any to shew that she is his first, second, or third daughter.

Of Additions of Honour.

32. Certain ordinaries have been, from what cause it is difficult to say, selected as more proper than others for bearing and exhibiting heraldic additions of honour, and augmentations of arms. These are nine in number, viz. the *border,* the *quarter,* the *canton,* the *gyron,* the *pile,* the *flasque,* the *flanche,* the *voider,* and the *escutcheon of pretence.* These have all at various times been in vogue. In the days of King Henry VIII. the *pile* had the preference, and was by him granted to the Lady Jane Seymour, and to the Lady Catharine Parr. But of late years, the *quarter* and *canton* are most in use. Additions.

Abatements of Honour.

33. By *abatements of honour,* we are to understand "Such figures as heraldic authors affirm were, by judgments of the court military, to be added or annexed to coat armour, in order to denote some ungentlemanlike, dishonourable, or disloyal act, demeanour, quality stain, or vice in the bearer, and whereby the dignity of the said coat armour is greatly abased." These abatements of honour are in like manner nine in number, viz. Abatements of honour.

1st, *A delf* (or turf) *tenné,* for him who revokes or recedes from a challenge.

2d, *An escutcheon reversed sanguine occupying the middle point of the escutcheon of arms,* for him who deflowers a maid or widow, or flies from the banner of his prince.

3d, *A point dexter parted tenné,* for a braggadochio, or vain-glorious boaster of acts unperformed.

4th, *A point in point sanguine,* for a person guilty of cowardice.

5th, *A point champaine tenné,* for him who kills his prisoner after quarter demanded.

6th, *A plain point sanguine,* for him who lieth to his prince or general.

7th, *A gore sinister tenné,* for him who behaveth basely towards his enemy.

8th, *A gusset sanguine,* on the dexter side for an adulterer, on the sinister for a drunkard.

9th, *The whole coat turned upside down,* or *reversed,* for a traitor.

N. B. These figures are always given in the English systems, but are ridiculed by the Scotch writers, and by the Jesuit Menestrier termed "English fancies." The truth is, no instance is furnished in any of the books of such figures being actually borne for the purposes alleged. Certain it is, that many of these figures are frequently used as marks of honour.

Of Marshalling Coat-Armour.

34. "Arms," according to Nisbet, "are said to be marshalled, when ensigns of honour and dominion, or the entire arms of other families, are joined with the paternal arms of the bearer by partition lines, making Of Marshalling.

* This bird, represented in heraldry as ἄπους or *sive pedibus,* "is given," saith Bekenhawth, "for a difference to younger brethren to put them in mind to trust to their wings of vertue and merit to raise themselves, and not to their legs, *having little land to put their foot on,*"

distinct areas or compartments in one shield." Edmonstone defines marshalling of arms "an orderly disposing of sundry coats belonging to distinct families in their proper places within one shield, by impaling and quartering." Marshalling is moreover extended to the disposition of the appurtenances of such arms without the escutcheon.

Women, unless they are sovereign queens or princesses, by the rules of heraldry, bear their paternal arms in a lozenge or shield; and therefore, when they marry, it has been the custom to impale their arms with those of their husbands, in order to shew that alliance; which is called "*arms en baron et femme.*"

Plate CCXCIII. Fig. 1. Impaling has been practised in three different manners. First, by *dimidiation*, (Plate CCXCIII. Fig. 1.) that is, by halving or cutting the shields of both husband and wife into two equal parts, and joining the dexter half of the husband's to the sinister half of the wife's, so as to form one shield. In this mode (called in their tongue *accolée*) the French kings used to impale the arms of Navarre. The second mode is dimidiating the husband's arms, and impaling them with the full coat of his wife, (Fig. 2.) The third mode (Fig. 3.) and that now in use in England, is that of impaling the two full coats, except when one of them hath a border; for this can never be carried all round an impaled shield, but must stop at both ends where the two shields meet, (Fig. 4.)

Figs. 2, 3. Fig. 4.

Dimidiation of arms was much used long before entire impalements were in use. Margaret, sister to Philip IV. of France, and second wife to Edward I. of England, had on her seal, in the year 1299, the arms of England so dimidiated with those of France, and she was the first queen of England who had her arms so marshalled. The same method prevailed in France up to the time of the Revolution. But the reasons which have induced the English heralds to lay it aside are certainly very powerful; for were it practised as of old, no end could be put to the jumble and confusion which it must infallibly create. For example, dimidiate the arms of Clare, viz. *or three cheverons gules*, and impale them on the woman's side with any coat, and you will have *or three bends gules*. Again dimidiate the coat of Waldegrave, viz. *per pale argent and gules* for the man, and it will be only *a white field*; but do the same for the sister, and then it becomes *a red field*.

Besides this impaling by way of *baron and femme*, the husband in Scotland frequently quarters his wife's coat with his own, on account of her being an heiress, *i. e.* he divides a shield into four equal parts by coupe and party. In the first and fourth *areas* are the husband's arms; in the second and third those of the lady: (See Fig. 5.) But in England the husband of an heiress more commonly places his wife's arms on an inescutcheon in the centre of his coat, and this is termed *an escutcheon of pretence*. See Fig. 6.

Fig. 5. Fig. 6.

The other methods of accumulating many coats in one shield, which have been of common use in other European countries, have never much prevailed in Scotland. Of these the principal are, First, *that by tranchie and taille-lines*; thus a coat parted per saltier, is divided into four conal quarters or areas, &c. called in French *tranchée taillée*, as in the well-known arms of Sicily. *Quarterly per saltier, first and fourth, or four pallets gules* for Arragon; *second and third argent an eagle displayed sable, beaked and membered gules*, for Suabia. (Fig. 7.) Secondly, (as in Fig. 8.) by surmounting coats already quartered with inescutcheons, by the French termed *surletout*. When this inescutcheon is parted, couped, or quartered with diverse coats of arms, the French call the uppermost *le-tout-du-tout*. This mode was practised in the atchievement of the Princes of Orange, of the family of Nassau, before their late elevation to the kingly rank; thus, quarterly, 1st, *azure, semée of billets, a lion rampart or*, for Nassau. 2d, *Or a lion rampant guardant gules crowned, langued, and armed azure*, for the country of Catzellenbogen. 3d, *Gules a fess argent*, for the house of Vianden. 4th, *Gules two leopards or langued and armed azure*, for the country of Dietz. Over all an inescutcheon by way of *surtout*, quarterly. 1st and 4th, *Gules a bend or*, for Shallon. 2d and 3d, *Or a hunting horn azure virole and stringed gules*, for the principality of Orange: which inescutcheon is again surmounted by another by way of *le-tout-du-tout*, viz. *cheque or and azure of nine points* as a coat of pretence for the city of Geneva.

Figs. 7. Fig. 8.

Moreover, in foreign heraldry, the quarters are often divided by the *pale* or the *fess*, which ordinaries are then again charged with escutcheons. And the ordinary of the cross is often used in this very way by ourselves, as in the arms of the St Clairs, Earls of Caithness, who bear *quarterly*, 1st, *azure, a ship at anchor*, &c. for the earldom of Orkney. 2d and 3d, *Or a lion rampant gules*, for the name of Sparr. 4th, *azure a ship under sail*, for the title of Caithness; and, *over all dividing the coats a cross engrailed sable*, for Sinclair.

The third way (Fig 9.) is by *tiercing* and *engrafting*, (by the French called *Entée*), an instance of which is to be seen in the arms of the King of Great Britain, whose paternal escutcheon is, 1st, The arms of Brunswick, *gules two lions passent guardant or*, impaled with those of Lunenburg *or semée of hearts*. Gules a lion rampant azure armed and langued as the hearts, and *grafted by way of entee between the impaling in point*; the arms of Lower Saxony *gules a horse current argent*; or, more shortly, *Brunswick and Lunenburgh impaled with ancient Saxony entée en pointe*.

Plate CCXCIII. Fig. 9.

The fourth and last method proposed for marshalling of arms, is by dividing the shield into a plurality of areas or quarters by many partée and coupée lines, which when drawn appear like the areas of a chequer, divided by perpendicular and horizontal lines. (Fig. 10.) By this method any number of coats may be brought in; but it seems to be agreed by the best authors, that the number of *marshalled arms* in one shield should not exceed six or eight quarters at most, and these always charged on the warrantable grounds and reasons of the bearer having many territories or feus, or matching with heiresses, or as arms of alliance or pretension. The Germans, it is true, are in use to accumulate twenty or thirty coats in one shield; but this is always on account of their many territories or feus, to shew how many votes they have in the circles of the empire. The French also have many quarterings, though not so many as the Germans, their feus being neither so many nor so free, and the whole succession of these dignities belonging always to the eldest son. whereas in Germany the younger brothers share with the eldest in the dignity and titles of honour of the family. In Scotland, the prejudices of the heralds seem always to have run very strong against many quarterings, in so much that few have followed the example set them by Queen Mary of Lorraine, whose rich and loaded escutcheon is still to be seen in many parts of the kingdom, impaled with the simple bearing of her husband James V.; almost the only instances of the

Fig. 10.

sort being found in the arms of those Englishmen who were honoured with Scots titles after King James VI. succeeded to the crown of the sister kingdom.

The several ways whereby the quarterings to which a family may be collected and marshalled in one atchievement after the English method, are explained in the annexed scheme, to which the reader is referred.

No. I. Supposes the heir of the WILLOUGHBYS to have married the heiress of LATIMER, NEVIL, and BEAUCHAMP, which three coats the heir of Willoughby has an undoubted right to quarter with his own paternal coat.

No. II. Shews how WILLOUGHBY, in consequence of this marriage, may inherit the blood, and become entitled to quarter the arms of no less than fifty-six families: thus, as WILLOUGHBY by this marriage hath a right to quarter LATIMER, so LATIMER had before a right to quarter *Blyke*, who quartered *Brocton* and *Filylode*; *Astley*, who quartered *Fynes* and *Thynne*; *Darrel* and *Cheney*, who quartered *Boyle* and *Wilmot*. Secondly, TWENOE, who quartered before *Bulmer*, who quartered *Mallet* and *Beke*; and *Bruss*, who quartered *Fitchet* and *Dean*.

The like as to NEVIL and BEAUCHAMP, and the quarterings by them brought in.

No. III. Supposes THOMAS PYE to be the son and heir of Thomas Pye, and Elizabeth his wife, heiress of John Abbot, whereby he becomes entitled to quarter the arms of sixteen houses; eight by the father's side, and as many by the mother's.

No. IV. is formed upon a plan more extensive than either of the former, and shews how a person may in five descents be heir to thirteen families; so that we can no longer wonder at seeing two hundred coats borne in one achievement.

Schemes shewing how Quarterings may be Collected and Marshalled.

Edmonstone's schemes.

No. I. WILLOUGHBY marries the Heiress of . . . . LATIMER. / NEVIL. / BEAUCHAMP.

No. II. WILLOUGHBY
- LATIMER . . . .
  - Ledet . . . .
    - Blyke . . . Brocton. / Filylode.
    - Astley . . . Fynes. / Thynne.
    - Cheney . . Boyle. / Wilmot.
  - Thevenge . . . .
    - Bulmer . . Mallet. / Beke.
    - Bruss . . . Fitchet. / Dean.
- NEVIL . . . .
  - Clavering . . . .
    - Tilliot . . . Liff. / Fitz James.
    - Creke . . . Grenville. / Trivers.
  - Middleham . . . . Burley . . . Shirland.
  - Maldred . . . .
    - Morville . . Stafford.
    - Lovetot . . Wilby.
- BEAUCHAMP . . . . . .
  - Afflet . . . .
    - Engaine . . Orreby. / Rosceline.
    - Pembridge Abbot. / Howard.
  - Maudit . . . .
    - Gattacre . . Tillesworth. / Gypherwast.
    - Gresham . . Pointes.
    - Mallet . . . Arden. / Acton.
    - Strode . . . Audley. / Ferraby. / Hansard.

No. III. PYE'S PEDIGREE.

John Nevil = Alice, daughter and heiress of Maudit
Mary, D. and heiress = Thomas Moore
Joan, D. and heiress = John Scrope
Elizabeth, D. and heiress = Thomas Morley
Anne, D. and heiress = James Golding
Harriet, D. and heiress = John Croft
Margaret D. and heiress = Thomas Pye

Abr. Cranfield = Joan, heiress of Pool
Th. Tomkin = Harriet, D. and heiress.
Joseph Caldwell = Margaret, D. and heiress
B. Thornton = Amy, D. and heiress
T. Beauchamp = Anne, D. and heiress
John Finch = Elizabeth, D. and heiress
John Abbott = Mary, D. and heiress

Thomas Pye, only son and heir = Elizabeth, sole daughter and heiress

THOMAS PYE, only son and heir.

No. IV. WARREN'S PEDIGREE.

John Catline = Maud, heiress of Storey.
John Gray = Anne, heiress of Sloper.

John Warren = Anne, heiress
Thomas Owen = Ellen, heiress of Roper.
Thomas Pulford = Alice Etton.
Thomas Gray = Joan Ely.
Thomas Green = Maud, heiress of Pylewell.

John Warren = Alice, heiress.
Thomas Griffith = Joan, heiress of Thomson.
Thomas Pulford = Anne, heiress.
Thomas Green = Joan, heiress of Newton.

Thomas Warren, only son = Jane, heiress.
Tho. Pulford, only son = Jane, heiress.

John Warren, only son and heir = Alice, daughter and sole heiress.

JOHN WARREN, only son and heir.

The genealogical pennon.

The most approved method of marshalling arms in an achievement of this species is the following: "Begin with the arms of the first heiress who married into the family, and next to them place the several coats which she brought in; then proceed to the second heiress, and those which she brought in; and so on to the rest without any regard to the rank or station of any of these heiresses before their marriage." Nevertheless, when the royal arms are brought in by any match, it is usual to give that match the second quarter, next to the bearer's paternal coat. Nay, some place it in the first, and the paternal coat in the second quarter. The achievement composed in this way is most properly termed by Edmonstone, "The genealogical pennon."

Heraldry.

Of the External Ornaments of the Shield.

Origin of the external ornaments.

35. In the first part of this article, wherein we have attempted to trace the origin of armorial bearings to the tournaments of the middle ages, a passage is quoted from the treatise of King René of Anjou, in which the knights who propose to tilt at any tournament, are required to make display of their coats of arms some days before the lists are opened, with their helmets, crests, and other marks of their condition or dignity. In the MS. treatise of John Caxton, preserved in the Advocates Library of Edinburgh, it is said, that "no man shall wear his cognisaunce on a close basnet, except he has carried arms within the lists and barriers of military exercises." From these passages, and many others of a like nature in the old authors, it seems reasonable to conclude, that after the bearing of shields had begun to be common in Europe, the great nobility and gentry, entitled by their descent to partake in the courtly tournaments of the times, were willing to adopt some method of distinguishing themselves from the herd of those who bore coat-armour, and for this purpose introduced the practice of adorning their shields on seals, &c. with a representation of those helmets, crests, and other articles of apparel, which they were themselves accustomed to wear upon those solemn occasions, and to which those of humbler birth could, it was believed, make no pretension. In process of time the example of these military nobles was imitated by others, who thought themselves entitled to equal respect, although for different causes. Civil rulers adorned their shields with coronets, consular capes, batons, and such like signs of dignity; and the churchmen were not slow to make the same parade of the symbols of their office. The Papal tiara, the cardinal's hat, the patriarch's cross, the mitre, the crosier, and the keys of St Peter, were associated in strange union with the family emblems of worldly honour and advantage, such as a free feu, a feat of chivalry, or a wealthy marriage.

Of the Helmet.

36. This ornament in heraldic representations has many varieties of matter, form, and situation.

In Germany, by an imperial edict, helmets of gold belong to sovereign princes, of silver to the high nobility, and of steel to gentlemen.

The French heralds have settled every thing respecting helmets according to these rules.

The helmets of emperors and kings are all of gold damasked fronting, (*tarre de front*,) open without bars or vizor.

Dukes, marquisses, and counts, have silver helmets, damasked with gold, fronting with nine bars, *grille et mise de front.*

Viscounts, barons, and knights, have silver helmets, with gold edges in profile, with seven bars.

Esquires have helmets in profile, with five bars in the guard vizor.

Gentlemen of three descents, a helmet in profile, with three bars.

The English and Scots have their helmets somewhat different.

A gentleman, or esquire, has his in-profile close.

A knight has a full-faced steel helmet open.

Earls, viscounts, and barons, have profile steel helmets, with gold bars, &c.

Dukes and marquisses have the full-faced helmet of steel, with five bars of gold.

The king, and princes of the blood-royal, have the full-faced helmet, with six bars, all of gold damasked.

Of the Ornaments of the Helmet.

37. The MANTLING, LAMBREQUIN, HELM-DECKEN, or VOLET, is probably a representation of the hood or covering, intended for protecting the helmet in rain, &c. and its ragged form derived from the cuts which that integument must have sustained in battle. (See Plate CCXCIII. Fig. 11.) These ornaments are called *hachements*, from the Italian *azzimare*, (*caput ornare*,) or *ingemmare*. In the *patois* of Picardy, *achemer une epousee*, is still used for *to arrange the bride's head dress.* The *Lambrequin* seems, in old times, to have been ornamented with the bearings of the wearer, for King René speaks of it as "armoyé des armes de celui qui le portera;" even at present it is generally of the *tincture of the field*, in foreign heraldry. Behind the shield itself hangs the manteau, mantle, or cloak, in Latin *chlamys*. In this country the mantles of gentlemen and knights are red without and white within. Those of the nobles red, doubled up with rows of ermine, according to their degrees. The king's mantle is of gold, lined with ermine. Plate CCXCIII. Fig. 11.

Of the Wreath, &c.

38. Menestrier, speaking of this ornament, says, "that some hundred years ago the French nobility used garlands of twisted silk, with which they kept fast on their heads their hoods or capes, as may be seen in the pictures of the old Dukes of Burgundy," &c. These wreaths were commonly of the *colours of the lady** of the bearer. The wreath is now always of the colour of the shield. See Plate CCXCIII. Fig. 12.

Of the Crest or Cimier. (See Fig. 13.) Fig. 12.

39. This ornament of the helmet seems to have been very early in use among the Greeks or Romans. After its introduction among the moderns, the use of it was long restricted to sovereign princes and military commanders. But in imitation of King Edward III. (the first English prince who wore a crest,) the knights of the garter, and afterwards, by degrees, all the bearers of coat armour adopted crests. The crest is first seen on a seal of Philip Earl of Flanders in the year 1101.† Fig. 13

Though crests are hereditary, yet a greater latitude is allowed respecting them than any of the essential parts of armoury. They are looked upon somewhat in the nature of devices, and accordingly are varied by the caprice of individuals, so that the sons of the same family often wear different crests.

Of the Motto, Cry of War, and Device.

40. The *Motto* is a short sentence placed in a scroll above the crest, very often allusive to it, or to some part of the bearings. If it alludes to the crest, the two together form what is called *a complete device*; as in the case of Stewart, Earl of Galloway; the crest *a pelican vulnered feeding her young*; the motto "*virescit vulnere virtus.*" Kirkpatrick of Closeburn has for crest a hand

* Here take thy lover's token on thy pate. SPENSER, *Fairy Queen*, I. 6. 47.

† Had Mr Campbell been acquainted with Heraldry, he would never have written

But he, her loved-one, bore *in* FIELD
A meaner crest upon his SHIELD. O'Connor's CHILD.

Heraldry.

grasping a dagger; motto, "I'll make sicker," alluding to the remarkable feat of his ancestor, who slew the Red Cummin in the days of Bruce and Baliol. Often they have no such relation, and merely express some predominant passion of piety, love, or war, of the first who assumed them.

Camden tells us that the earliest instances of mottos painted on shields, which he had met with in this island, were those of William de Ferrariis, Earl of Derby, who carried round his escutcheon, *vair with a bordure of horse shoes*, "LEGE, LEGE;" and Sir Thomas Cavill, who bore for arms *a horse*, under which was written "THOMÆ CREDITE CUM CERNITIS EQUUM EJUS:" these are both of the age of Henry III. The more abundant use of mottos was, without question, owing to King Edward III. who having founded the order of the garter, and given it the motto "*Honi soit qui mal y pense*;" each of the original knights of that order took to himself a motto of his own choice, and put it under his arms. From that period the fashion grew more and more in vogue, as may be seen from the accounts which we have of the standards and pennons of the noblemen and gentlemen, both of England and Scotland, particularly during their French wars.

N. B. Women wear neither crests nor mottos.

The *cry of war* was the battle-shout of the house; and was also worn in a scroll, as the "Mountjoye St Denys" still is over the pavilion of the French king. Many families have, in consequence of the change of manners, retained these cries of war as mottos. Of old they consisted very often of the name of the noble, as "A HOME! A HOME!" "A DOUGLAS! A DOUGLAS!" &c.

Of Devices.

Personal devices.

41. The *Device Proper* is a badge or emblem independent of any part of the family bearing; the legitimate descendant of the emblems of the ancients. The device is always assumed by the bearer personally, and either may or may not be the same, or that of his ancestor, as he pleases. The roses, red and white, were the *devices* of York and Lancaster. The portcullis was a device belonging to the Beauforts (descended from John of Gaunt, fourth son of Edward III.) and carried as such by the Jameses of Scotland. The said John of Gaunt, when he pretended a right to the crown in the reign of Richard II. adopted for his device "an eagle standing on a padlock assaying to force open the same." This was a strictly personal device. From these *devices* of the kings, some of the English pursuivants derived their names, as *Portcullis, Falcon*, &c.

Of Supporters.

Opinions concerning the origin of supporters.

42. These likewise are exterior ornaments, being placed on the sides of the atchievement as matters of embellishment, and formally to timbre or support it. Menestrier assures us that they had their origin from tilts, tournaments, and justings. "On these occasions," says he, "it was usual for the knights to have those shields of their arms, (which we have already seen they were obliged publicly to display some days before the opening of the lists), guarded by their pages, armour-bearers, or other attendants, clothed in fancy dresses, sometimes making them appear as savages, Moors, Saracens, lions, &c. The business of these *supporters of the shield* was to take notice who, by touching the shield, accepted the challenge of their master." This custom was revived with perhaps greater magnificence than was ever before known, at a tournament in Paris before Louis XIV. in which the esquires who attended the nobles entering the lists, were drest in the most superb manner that art could invent representing Moors, Persians, Armenians, Turks, &c. &c. From these attendants thus disguised many heraldic writers bring the use of supporters, which, say they, every one who (being noble or gentle by father and mother's side) was admitted to tourney, had ever after a right to carry.

This doctrine is, however, strongly combated by many able writers, and particularly by the celebrated John Anstis, in his curious manuscript treatise entitled *Aspilogia*, (now in the Astle collection,) who has these observations.

"In these later ages, the nobility have been distinguished from persons of inferior rank, by having supporters and coronets cut on their seals; but, as far as I am able to observe, there was not anciently any particular mark in the seals of the nobility that differenced them from the knights. As to supporters, they were, I take it, the invention of the graver, who, in cutting on seals shields of arms which were in a triangular form, and placed on a circle, finding a vacant space at each side, and also at the top, thought it an ornament to fill up these spaces with vine-branches, garbs, trees, flowers, plants, ears of corn, feathers, fret-work, lions, wiverns, or some other animal, according to his fancy.

If supporters had been esteemed formerly, as at this time, the marks and ensigns of nobility, there could be no doubt but there would have been then, as now, particular supporters appropriated to each nobleman, exclusive of all others; whereas, in the seals of noblemen affixed to a paper addressed to the Pope, A. D. 1300, the shields of arms of twenty-seven of them are in the same manner supported (if that term may be used) on each side by a wivern, and seven of the others by lions. John de Hastings hath the same wivern on each side of his shield of arms, and also on the space over it, in the same manner as is the lion in the seals of *Hache, Beauchamp*, and *De Malolacu*. The seals of Despencer, Basset, and Badlesmere, pendent to the same instrument, have each two wiverns or dragons for supporters; and that of Gilbert de Clare three lions placed in the manner above mentioned. The promiscuous use of wiverns to fill up the blanks in seals, is obvious to all who are concerned in these matters.

But what is a stronger argument is, that the same sort of supporters are placed in the seals of divers persons never advanced to the peerage. Instances of this kind are often met with; nay, the engraver hath frequently indulged his fancy so far, as to insert such figures as do not seem proper, according to our present notions of supporters of arms; as *two swords* on each side the arms of Sir John de Harcla; and *St George fighting with the dragon* on one side, the *Virgin with our Saviour in her arms* on the other side of a seal affixed to a deed of the Lord Ferrers, whose arms on the impress of a seal pendent to a deed of the 17th May, 9 Henry VI. have not any supporters.

When supporters were assumed, if there were two on one seal, they were generally the same; but sometimes there was only one, and at other times three, as may be seen on various seals."

"After having considered the observations of Mr Anstis," says Edmonstone, "I am persuaded that not a doubt can remain of supporters having originated from the fancy of seal engravers. However this may be, it is certain, that in England supporters were of old worn by many persons of the commons. All those, particularly, who bore offices of dignity in the state, as the lord deputy of Ireland, the lord of the marches of Wales, the warden of the stannaries, &c. and even by families altogether in private life; as the Stevenings of Sussex, the Stawells of Somerset, the Wallops of Hants, Savage of Cheshire, &c.; and certainly the supporters still worn by the descendants of some of these families, rest on a much more honourable foundation than any modern grant of supporters that can be obtained from a college of arms."

Supporters of old very often changed.

It is worthy of remark, that supporters were formerly changed very frequently according to the choice of individuals, and by no means considered as fixed and unalterable marks of descent like the proper armorial bearings. From King Edward III. till James I. few of the English kings wore the same supporters as their predecessors. The lion, the falcon, the hart, the antelope, the swan, the leopard, the bull, the boar, the greyhound, the dragon, and the eagle, were all successively used by the monarchs of England; and one of them (Edward IV.) altered his no less than three times. Edward VI. was the first who bore the lion crowned with the imperial crown. This was retained by Mary and Elizabeth; and James also used it as his dexter supporter, placing the Scottish unicorn * on the left side; on which arrangement, no alteration has been made by any of his successors.

Henry VIII. was the first king of England who formally granted supporters to the peers of the realm. He gave the like ornaments to the knights of the garter and of the bath. The kings of arms in England are authorised to grant supporters to all persons not under the degree of a knight of the bath; and whoever of an inferior rank bears supporters in that kingdom, does so by an express grant from the crown.

Great abuses respecting the use of supporters in Scotland.

In Scotland, the right to bear supporters is commonly supposed to rest on somewhat a different footing. Some of the baronets of Nova Scotia have taken up the notion, that they are, by the terms of their patents, entitled to add supporters to their paternal coats, and they accordingly wear them in their armorial ensigns. But an impartial consideration of the clause in the patents will convince them of their mistake, more particularly as it is not pretended, that there ever was any other royal grant or warrant issued, whereon they can found a claim to any such privilege. In the patents previous to the year 1629, it is ordained, "that the baronets and their heirs-male shall, as an addition of honour to their armories, bear, either on a canton or inescutcheon, at their option, the ensign of Nova Scotia; being *Argent, a cross of St Andrew azure charged, with an inescutcheon of the royal arms of Scotland, supported on the dexter by the royal unicorn, and on the sinister by a salvage or wild man proper,*" &c.; all evidently referring to what is within the canton or inescutcheon, and not to any exterior ornaments of the baronet's own shield, of which the said canton or inescutcheon is henceforth to form a part. As for the patents posterior to the year 1629, the whole of the clause just quoted is omitted, and the patentee is not allowed to carry a canton or inescutcheon of honourable augmentation to his coat; but, in lieu thereof, "*around his neck an orange tanny silk ribbon, whereon shall be pendent in a scutcheon argent, a saltire azure, therein an inescutcheon of the arms of Scotland,*" &c. This alteration, in all probability, took place on account of the manifest impropriety of blazoning supporters, mottos, &c. on a canton or inescutcheon; an objection which could never have occurred, had the construction which has been put on the clause of gift been the proper one.

During the reign of Charles II. a letter was addressed to the Lyon-office, strictly prohibiting any grants of supporters to persons under the degree of nobility. But many of the old barons of Scotland, (and particularly *the chiefs of names,*) who had always been in use to sit in parliament in their own right, and who with justice considered themselves as inferior in degree indeed, but as members of the same order with the titled Lords of Parliament, protested with great zeal against being obliged to discontinue the use of those supporters which had been borne by their ancestors for several centuries, and originally retained either as the marks of their patriarchal superiority over their clans-men, or in consequence of some feat of skill or valour in tournament or in battle. The matter was not pressed, and these families have continued their supporters ever since without any objection being made. Of later years, however, a much more questionable extension has been given to the use of supporters. From whatever cause the laxity may have arisen, the fact is certain that we have seen supporters assumed by persons who, so far from having any claim to being descended from the old barons who had power of *pit* and *gallows*, and were in reality the nobles of Scotland, as much as either dukes, marquisses, or earls, are sprung from the very dregs of the people, and are in truth the very men to guard against whose presumption and insolence was one of the first great objects for which a college of heralds was instituted in this country. The utmost latitude which can be given to the interpretation of the law on this head, either as it is expressed in the King's own words, or as it has been modified by the practice of the heralds, is that those of the lesser barons, who can shew proofs, by old seals or otherwise, of their ancestors having borne supporters previous to the passing of the act 10th September 1672, are *excepted from the general rule*, and permitted to carry supporters. The letter above referred to was quoted by the Lord Lyon himself, as *his authority for refusing supporters* to persons of rank very different from most of those who have of late procured these ornaments by the good offices of his successors.

——At titulos Regina Pecunia *donat,*
Et genus, et proavos, sordesque parentis honestat.
Sectanus.

No women have a right to bear supporters, except those who are peeresses by descent or by patent. If they are peeresses by patent, they have in consequence a grant of supporters to themselves and their heirs-male; if by descent, they retain the ancient supporters of the barony, to which they have an indisputable right, in as much as they represent peers whose insignia and titles are all through them to descend to their posterity.

* The unicorn was originally, with great propriety, assumed by the Scottish kings, in allusion to the words of Scripture, Job xxxix.—"Canst thou bind the unicorn with his band? Will he be willing to serve or abide by thy crib?"

† Vide Fountainhall's *Decisions*, MS. (in the Advocates' Library) p. 217. This important document was pointed out by John Riddell, Esq. advocate, a gentleman whose attainments in every part of the antiquarian learning of his country are above all praise.

Of Crowns and Diadems.

Various uses of crowns in blazons.

43. Crowns or coronets may be used in armorial bearings in four different ways.

1st, As essential or internal parts of arms, that is, when they are the chief figures of the escutcheon, as the three crowns in the shield of Sweden. Many families throughout all the European kingdoms bear similar arms; and crowns so worn are no marks of sovereignty or dignity of whatever form they may be.

2dly, When they are used as additional charges, or ornaments within the shield, they are in like manner no marks of sovereignty or dignity.

3dly, When crowns are placed upon helmets, which *timbre* coats of arms, they are then marks of dignity, being commonly so placed by sovereign princes. Yet many gentlemen who have no pretensions to such rank bear crowns on this way in their helmets; a custom which, according to Menestrier, is derived from the tournaments, " especially those solemnized in Germany, where knights were allowed to adorn their helmets in that manner, in memory of their having been exercised in such disports." And though indeed there are many helmets placed over the German coats, according to the number of feus, whereby the bearers voted in the circles of the empire; yet we see but few of them adorned with crowns, which, according to our author, can only be explained by supposing that some of these feus are not privileged to carry a crown, the ancient possessors of them not having been present at the tournaments.

4thly, Crowns placed immediately above the top of the escutcheon, are ensigns of sovereignty or nobility, whereof the degrees are set forth by their shapes. The arched crowns topped with *monds* were first introduced by the Emperors, and from that circumstance are called imperial crowns, although now worn by all the kings in Europe, since Charles the Eighth of France assumed an imperial crown, in token probably of his pretensions to the empire of the East.

British coronets.

" The imperial crown of England is composed of four crosses pattee, and as many fleur-de-lys of gold placed on a rim or circlet of gold, embellished with precious stones. From these crosses arise four circular bars, ribs, or arches, which meet at the top in form of a cross; at the point of intersection whereof is a pedestal, whereon is a mound. On the top of the mound is a cross of gold, all embellished likewise with precious stones, and three very large oval pearls; one of them being fixed in the top, and two pendent at the transverse beams of the cross. The cap within this crown is of purple velvet, lined with white taffeta, turned up with ermine. See Plate CCXCIV. Fig. 1.

PLATE CCXCIV. Fig. 1.

The crown or coronet of the Prince of Wales resembles the king's crown, save only that it hath not four arches, but two only. See Fig. 2.

Fig. 2.

The younger sons of the king bear coronets, composed of crosses pattee and fleur-de-lys.

A duke (not of the blood-royal) has a circle of gold, with eight leaves of equal height above the rim, commonly called strawberry leaves, the whole richly chased; a crimson velvet cap, turned up with ermine of one row, and topped with a golden tassel. See Fig. 3.

Fig. 3.

A marquis has a circle of gold, with four leaves placed between four pearls, raised on points of equal height with the leaves. See Fig. 4.

Fig. 4.

An earl has eight pearls raised on as many points, between every two points a strawberry leaf lower down. See Fig. 5.

PLATE CCXCIV. Fig. 5.

A viscount has pearls to the number of twelve or sixteen, placed on the edge of the rim. See Fig. 6.

Fig. 6.

A baron has only six pearls, placed on the rim of his golden circle. See Fig. 7.

Fig. 7.

Of the Cap of State.

The cap.

44. This cap is of crimson velvet, faced with ermine, with two points turned to the back.

Of old, by the practice both of England and Scotland, this cap was borne by princes or dukes only, as an ensign of dignity, whether on the helmet itself, or timbering the whole atchievement. Mr Sandford, in his *Genealogical History of the Kings of England,* informs us that King Edward III. and his successors, as low down as Edward VI. had on their seals of arms this cap of state. For on one side is always to be seen the figure of the monarch on horseback and in armour, with this cap of state on his head, and the crest of England set thereon."

The cap was originally therefore granted to certain nobles, on account of pre-eminent dignity or merit, as we find in the case of Henry II. Duke of Lancaster in England, and Archibald Earl of Douglas, Duke of Tourraine, and Great Constable of France, whose seal, affixed to several charters still extant in Scotland, always represents the helmet as adorned with this cap. But now the cape of state hath lost all its former eminent dignity by the evil usage of certain heralds, and is now borne not only by all degrees of nobility, but by many of the inferior gentry, and indeed by some of the lowest extraction. See Fig. 8.

Fig. 8.

Of Ensigns belonging to Ecclesiastical Dignities.

Church ensigns.

45. The Pope carries his arms in an oval shield, or cartouche, which form has become common in Italy, in consequence of other ecclesiastics imitating their chief. This shield is adorned externally with the ensigns of his dignity, which are, 1st, *The Tiara.* This is an high cap, or mitre, of silk, environed with three crowns of gold, and topped with a mound and cross like the imperial crown. This triple crown (or as it is called by the Italians the *regno*) is the sign of his supremacy, and placed over the cartouche. See Fig. 9.

2dly, The keys, one of gold and one of silver, (symbols of the Pope's power of opening and shutting the gates of Paradise) are placed in saltire behind the cartouche.

3dly, The staves. The two angels which support the proper arms are placed in a sitting posture, one on each side of the cartouche; each with one hand upholding the *regno,* and with the other grasping a long staff, having three traverses near the top; which traverses end in trefoils, and are of the same metal with the keys.

The cardinal's external armorial mark of dignity is the *red hat,* with which they timbre their shields, having red strappings, with fifteen tassels hanging down at each side of the shield. Innocent III. charged the cardinals to discontinue all symbols of secular dignities; but this was never complied with except by the Italians.

Archbishops of the Roman church, primates, and legates, place a cross staff with two traverses in pale be-

Heraldry.

hind the shield, and above the same a green hat with ten tassels hanging down on each side.

Our modern archbishops in England place a mitre *affrontée* on the top of the shield, (Fig. 11.) issuing from a ducal coronet, and having two labels or pendants hanging from it, and behind the shield two crosiers in saltire. Bishops use the mitre alone, proceeding from a plain circlet of gold, without any other exterior ornaments.

Abbots of the Roman church use a mitre in profile, and a crosier in pale behind the shield; above both a black hat with a knotted cord, and six tassels on each side, as may be seen in many of our Scottish abbeys, such as Holyroodhouse, Paisley, &c. Priors, provosts, deans, and chanters of the church of Rome, are all distinguished by similar marks, such as palm-branches, pastoral staves, &c.

Ensigns of Civil and Military Offices.

Ensigns of offices.

46. In France and Germany it has always been the custom of the great civil officers to denote by some exterior ornament of the shield their station and dignity. In Scotland likewise this practice was common before the union; but in spite of the unceasing endeavours of the heralds of England, the great officers of that kingdom have never complied with the customs of their brethren in the other European states. The only established civil officer in England who is distinguished by any armorial ensign of his official dignity, is the Earl Marshall, who carries behind the shield of his arms *two batons in saltier sable, the ends gold.* When there is a deputy Earl-marshall, he is permitted to carry *one baton in bend dexter,* exactly as was used in Scotland.

The chancellor of Scotland bore behind his shield *two maces in saltire, ensigned with imperial crowns;* as also under the shield *a purse* with the strings open, *pendant, fretted, nowed,* buttoned, and tasselled gules, embroidered with the royal arms.

In addition to these, the chancellor of France has a proper cap of gold, (*mortier d'or*) turned up ermine on the helmet.

The presidents of the parliaments in France had in the same way their proper cap of black velvet edged with gold galloon.

The lord high chamberlain in Scotland had two keys disposed in saltire behind his shield, in the same manner as the *grand chambrier* of France.

The justice general of Scotland carried two naked swords in saltire behind his shield, the points being upward.

The lord high treasurer in Scotland carried a white staff ensigned on the top, with an imperial crown in pale behind his shield.

The office of cup-bearer being of old hereditary in the house of Southesk, these Earls carried a golden cup in their arms.

The king's foresters carried hunting horns; as Burnet in the northern forest, and Forester of that ilk, in the southern. So did the *grand veneur* of France.

The *grand pannetier* of France carries under his arms a rich cover and knife and fork in saltire.

The lord high constable of Scotland carries *on each side of the base part of his shield, an arm gauntletted jessanys, issuing out of a cloud, and grasping a sword erected in pale at the dexter and sinister sides of his shield, all proper hilted and pomelled* OR.

In France many other exterior marks of the same sort were in use, all sufficiently intelligible without previous description, as the grand master of artillery, who carried under his arms *two field pieces,* &c.

Buonaparte's heraldry.

But in no kingdom were either external or internal ensigns of dignity so extensively used, or so systematically arranged as in France, during the empire of Napoleon. Not only were princes, grand dignitaries, dukes, counts-senators, counts-archbishops, counts-military, barons-military, baron-bishops, and chevaliers, distinguished by mantles lined in different manners; but for each of these ranks of persons there was set apart some one of the honourable ordinaries, which, either by its charge, its colour, or its position, immediately denoted that order in the state to which the bearer belonged: Thus the princes grand dignitaries had a chief of azure charged with bees of gold; dukes, a chief of azure charged with stars of silver; counts-senators, a canton dexter azure, charged with a mirror in pale *or,* in which a serpent wreathed argent regards itself; counts-archbishops, on a canton dexter azure a cross patee *or;* counts-military, on a canton-dexter azure, a sword erect in pale *argent* mounted *or,* &c. The canton dexter always denoted a count, the canton sinister a baron. Chevaliers of the legion of honour placed the cross of their order on any one of the nine honourable ordinaries which they preferred. In this heraldry supporters are entirely laid aside, and the nobility, under the rank of princes, are distinguished by the number of feathers in the plume of the bonnet with which the shield is timbred. See Plate CCXCIV. Fig. 12. shewing the *Arms of a Duke* under Napoleon. Plate CCXCIV. Fig. 12.

Of Ensigns of Chivalry or Knighthood.

Badges of knighthood.

47. Knights of the different sovereign orders in Europe are in use, to surround their shields with the collars of their orders; and if any one has more orders than one, the collar of the most ancient order ought of right to be placed nearest the shield. In Britain, however, it has become the practice for knights of the garter to place their shields within the garter itself, not the collar of the order, and always to give this most dignified order the preference over every other, by assigning to its ensign the place of honour nearest to the escutcheon. For a particular account of the several orders now so much in vogue among the sovereigns of Europe, see the article KNIGHTHOOD.

Of the Compartment.

Compartment.

48. The compartment is that figure, on which the shield and supporters usually rest. When the bearer has more mottos than one, if one of them relate to the supporters or figures of the shield, it should be placed in the compartment; if one relate to the crest, it should be in an escrole thereupon. Heralds agree, that the compartment is in general intended to represent the lands or feu of the person below whose shield it lies, although it be sometimes granted or assumed in memory of some remarkable action. An instance of the compartment thus applied, is to be found, says Nisbet, "in that of the Earls of Douglas, who obtained the right of having their supporters placed within a *pale of wood wreathed,* because the Lord James, in King Robert Bruce's time, defeated the English in the forest of Jedburgh, and, that they might not escape, caused wreath and impale that part of the wood, by which he conjectured they might make their escape." The territorial compartment may, in like manner, be illustrated from the same family. William, first Earl of Douglas and Mar, has

"a compartment like to a rising ground, with a tree growing out of it, and semée of hearts, mullets, and cross crosslets, the armorial figures of this Earl's escutcheon, to shew that the compartment was meant to represent his lands and feus." Others seem to have assumed a compartment from more fanciful motives; as the old Earls of Perth, who had a green hill semée of galtraps, which, with their motto "Gang warrily," forms a complete device.

Of the Pavilion.

Pavilion.

49. After treating of these external marks of honour common to the nobles of the European kingdoms, it remains to take notice of one entirely confined to sovereign princes, although not assumed by all of them, viz. the pavilion. This is a tent or tabernacle, with a canopy roof, under which the arms of the emperors, of the kings of France, and of some other princes, are usually represented. Menestrier is of opinion, that the first who invented this use of the pavilion was Philip Moreau, and that from its having made its first appearance on the coins of Philip of Valois, it derived the name by which we know it. As a specimen of the mode of blazoning arms, we have inserted the royal atchievement of Scotland, in Plate CCXCIV. in which the blazon, according to Mr Nisbet, runs thus: "The sovereign ensign armorial of the kingdom of Scotland—*or* a lion rampant *gueules*, armed and langued *azure*, within a double tressure counter flowered with flower de lysses of the second; timbred with a helmet affrontée with bars *or*, adorned with lambrequins *or*, doubled ermine, and ensigned with the imperial crown of Scotland; and thereon for crest a lion sejant full-faced *gules*, crowned *or*, holding in his right paw a naked sword proper, and in the sinister a scepter *or*, both erected; and above, in an escrole, the motto "IN DEFENSE." The shield is encircled with the colour of the most noble order of the thistle, with its badge thereto appended of gold, enamelled azure, having the image of St Andrew surmounted of his cross argent; and supported by two unicorns argent, crowned with imperial and gorged with open crowns, to the last chains affixed passing between their forelegs and reflected over their backs *or*; he on the dexter bearing up a banner *or*, charged with the red lion of Scotland; he on the sinister, a banner azure charged with the white cross of St Andrew, both standing on a compartment cheque or and azure like a pavement, on the first the lion of Scotland, and on the second St Andrew's cross. All within a royal pavilion of cloth of gold, semée of thistles slipped proper, doubled ermine, the comble or canopy rayonnée, and adorned with precious stones, and topped with the crown of Scotland, over all on an escrole the device of Scotland, (alluding to the thistle,) "NEMO ME IMPUNE LACESSET."

Full blazon of Scotland.

PLATE CCXCIV. Fig. 13.

Of Funeral Escutcheons, &c. in Scotland.

Funeral atchievement.

50. Although our code calls no man noble under the degree of a baron, yet there is an old and well-known distinction between *nobiles majores* and *nobiles minores*: the first comprehending all titled nobles from the prince to the baron; the second, all between the baron and the gentleman inclusive.

A gentleman is one descended of three descents of nobles (viz. of name and arms) by both father and mother, for gentility is not perfect in the person who first obtains arms among us, or letters patent of noblesse on the continent; as, among the Romans, though the father was free born, and of the equestrian census, yet it was requisite that the grandfather should be so also, otherwise the son could not obtain the *annulus*, or symbol of the equestrian rank. Gentility, then, begins in the grandfather, increases in the father, and is perfect in the son.

The proofs of this nobility are the armorial ensigns or gentilitial tesseras of these ancestors, arranged in due order on the sides of the escutcheon, (and therefore fitly here treated of among the external ornaments of the shield), not indeed commonly, but on particular occasions, as on that of the funeral of the bearer. The arrangement of these tesseræ is the same, to whatever number they amount. If the nobility be of four descents or lineages, the mode of arrangement is as follows:

Arms of the Father.		Mother.
Father's Mother.	Arms of the Great-Grandson, noble by four descents on both Father and Mother's side.	Mother's Mother.
Grandfather's Mother.		Grandfather's Mother.
Grandmother's Mother.		Grandmother's Mother.

The full funeral escutcheon of the Duke of Athole is represented in Plate CCXCIV. Fig. 14.

PLATE CCXCIV. Fig. 14.

In England, the place of this genealogical escutcheon is supplied by the genealogical pennon before described, in p. 730.

Of Precedency.

English precedency.

51. It is, as was formerly observed, the part of the *heralds* to settle the order or precedency of all those assembled in public meetings. The rules by which the precedency of individuals is ascertained, seem to be more fixed and determinate in England, than with us of Scotland. Sir William Blackstone, in his *Commentaries on the Law of England*, book i. chap. 12, gives a Table of Precedence, which is here copied as the most safe authority.

TABLE OF PRECEDENCE.

Table of precedency.

The King.
The King's Children and Grand-children.
———— Brethren.
———— Uncles.
———— Nephews.
The Archbishop of Canterbury.
Lord Chancellor or Keeper, if a Baron.
Archbishop of York.

Heraldry. Table of precedence.

Lord Treasurer.
Lord President of the Council. } If Barons.
Lord Privy Seal.
Lord Great Chamberlain.
Lord High Constable.
Lord Marshall.
Lord Admiral. } Above all peers of their own degree.
Lord Steward of the Houschold.
Lord Chamberlain of do.
Dukes.
Marquisses.
Dukes eldest sons.
Earls.
Marquisses eldest sons.
Dukes younger sons.
Viscounts.
Earls eldest sons.
Marquisses younger sons.
Secretary of State, if a Bishop.
Bishop of London.
———— Durham.
———— Winchester.
Bishops.
Secretary of State, if a Baron.
Barons.
Speaker of the House of Commons.
Lords Commissioners of the Great Seal.
Viscounts eldest sons.
Earls younger do.
Barons eldest do.
Knights of the Garter.
Privy Counsellors.
Chancellor of the Exchequer.
Chancellor of the Duchy.
Chief Justice of the King's Bench.
Master of the Rolls.
Chief Justice Common Pleas.
Chief Baron of the Exchequer.
Judges and Barons of the Coif.
Knights Bannerets Royal.
Viscounts younger sons.
Barons do. do.
Baronets.
Knights Bannerets.
Knights of the Bath.
Knights Bachelors.
Baronets eldest sons.
Knights do. do.
Baronets younger do.
Knights younger sons.
Colonels.
Serjeants at law.
Doctors (of Divinity, Law, Medicine.)
Esquires.
Gentlemen.
Yeomen.
Tradesmen.
Artificers.
Labourers.

N. B. Married women and widows have the same rank among each other as their husbands would have among themselves, except such rank be merely professional or official. And unmarried women to the same rank as their eldest brothers would bear among men during the lives of their fathers."

Father Menestrier has expressed the principal rules of heraldry in a very few verses, which may easily be retained in the memory.

" Le Blazon composé de differens emaux
N'a que quatre couleurs, deux panes, deux metaux.
Et les marques d'honneur qui suivent la naissance
Distinguent le noblesse, et font sa recompense.
Or, argent, sable, azure, gueules, sinople, vair,
Hermine au naturel, et la couleur de chair,
Chef, pal, bande, sautoir, fasce, barre, et bordure,
Cheveron, pairle, orle, et croix de diverse figure,
Et plusieurs autres corps nous peignent la valeur
Sans metal sur metal, ni couleur sur couleur.
Support, cimier, bourlet, cri de guerre, et devise,
Colliers, manteaux, honneurs et marques de l'Eglise,
Sont de l'art du blazon les pompeux ornements;
Dont les corps sont tirés de tous les elements
Les astres, les rochers, fruits, fleurs, arbrès, et plantes.
Et tous les animaux en leur formes differentes,
Servent a distinguer les fiefs et les maisons,
Et de communautés composent les blazons.
—De leur termes precis enoncer les figures
Selon qu'ils auront de diverses postures.
Le *blason plein* echoit en partage a l'aisné;
Tout cadet doit briser comme il est ordonnê."

Abrege, p. 62.

See the works of Menestrier, de la Colombiere, Palliot, Henniker, Upton *de Militari Studio;* Johannes de Bado Aureo *de Armis;* Spelman *Aspilogia;* Morgan's *Sphere of Gentry*; Spenerus *de Heraldica;* Favin *Theatre d'Honneur*; Guillim's *English Heraldry*; Edmonstone's *English Heraldry;* Dallaway's *English Heraldry*; Nisbet's *Scots Heraldry*; Leigh (Hearne's *Eminent Antiquaries*), Carter, Camden (*Remains*); Sir George Mackenzie's *Treatise;* Bartolus *de jure Armorum;* Ducange, &c.

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Herat.

HERAT is a city of Persia, and formerly the capital of Khorassin. It is the ancient *Aria* or *Artacoana*, the capital of Ariana. Herat is situated in a spacious and highly cultivated plain, encircled by lofty mountains, and traversed by the river Herirood, which runs into the Caspian Sea near Zaweh. The city, which covers an area of four square miles, is surrounded with a lofty wall and a wet ditch, and is defended by a citadel in the western face, which is a small square castle, built upon a mound with burnt brick, and flanked with towers at the angles. On each face of the city is a gate, and two in the northern face, and from each gate a spacious and well supplied bazar leads to the centre of the town. The street which leads from the southern gate to the cattle-market, opposite to the citadel, is covered with a vaulted roof. Independent of the public fountains on either side of the Bazars, almost every house has a separate fountain of water. The principal public buildings are the residence of the prince, and the chief mosque. The former is a mean building, with a common gateway. In the front of the building is an open square, with the gallows in the centre. The mosque, which is called the Mesghed Jama, was formerly a magnificent building, and covered a space of eight hundred square yards. It is now, however, falling rapidly into decay.

Herat, Herault.

Herat carries on a very extensive trade, and has therefore received the appellation of *Bunder* or *Port*. It is the emporium of the commerce carried on between Cabul, Cashmere, Bukhara, Hindostan, and Persia. Cabul supplies the inhabitants of Herat with shawls and raw sugar, chintz, muslin, leather, and Tartary skins, which they export to Meshed, Yezd, Kerman, Ispahan, and Tehraun, and receive in return dollars, tea, china-ware, broad cloth, copper, pepper, and sugar-candy. Kerman furnishes dates and shawls, and they receive carpets from Ghaen. The staple commodities of Herat, are silks, saffron, and assafœtida, which are exported to Hindostan. The gardens are filled with mulberry trees for the use of the silk worms, and the assafœtida is produced on the plains and hills near the city. The trade is principally carried on by the Hindoos, who alone possess capital and credit, and who are highly distinguished by the government, in consequence of their great commercial concerns.

The severity which sometimes characterises the winter at Herat, is often injurious to the crops; but nothing can surpass the fertility of the plain, which produces the most abundant crops of wheat, barley, and every kind of fruit known in Persia. The roses in the vicinity of the town are so plentiful, that it has obtained the name of *Sargultzar*, or the city of roses. The cattle are small, and by no means numerous, but the broad tailed sheep are abundant. The revenue of the town is estimated at 4½ lacks of rupees. It is raised by a tax on caravanseras, shops, and gardens, and a duty on exports and imports. The town is governed by Prince Hadjy Firooze, son of the late king of Cabul, who pays an annual tribute of 50,000 rupees to Persia. The population of Herat is 100,000, of whom 10,000 are Patans, 600 Hindoos, and the remainder Afghans, with a few Jews. East Long. 63° 14′, North Lat. 34° 12′. See Macdonald Kinneir's *Geographical Memoir of the Persian Empire*, p. 181—183.

HERAULT is the name of one of the departments of France, formed out of the dioceses of St Flour, Lodeve, Montpellier, Bezieres, and Agde in Lower Languedoc. It is bounded on the north by the departments of the Gard and the Aveyron, on the west by those of the Tarn and the Aude, on the south by that of the Aude and the sea, and on the east by the Gard. Its principal rivers are the Herault and the Orbe; the Herault passes by Pezenas, and runs into the sea at Agde. The Orbe waters Bezieres. This department consists of hills, vallies, and plains of different soils. It produces all sorts of grain, wines, brandy, olives, chesnuts, fruits, silk, verdigris, and salt. The trade of the department is greatly facilitated by the canal of the South, which begins at Cette, passes within 12 myriameters of Montpellier, coasts along the Mediterranean, and after passing before Agde, it reascends to Bezieres, and from this, after crossing the Orbe, it goes on to Narbonne. The woods in this department are very fine, but not numerous. They occupy only from 28 to 29 hectares, or from 54 or 55 acres, one half of which belongs to the nation. The contributions in 1803 were 334,317 francs. The principal towns are

Montpellier, the capital	33913
Bezieres, ...	14211
Lodeve, ...	7843
St Pons	4506

The population of the department is 291,957

See France, vol. ix. p. 676. col. 2.

Herculaneum.

HERCULANEUM, is an ancient city of Italy, situated on the Bay of Naples, and supposed to have been either founded by Hercules, or in honour of him, 1250 years before the Christian era. About 957 years later, the Romans seem to have taken possession of the city, and to have retained it ever after. In the year 63, it suffered severely from an earthquake, which, according to Seneca, occasioned the total ruin of part of it, and left the remainder in a tottering state. But in the year 79, an eruption of Vesuvius for the first time exhibiting volcanic fires to the existing generation, buried the whole many feet deep, under repeated showers of stones and ashes; while other cities were overwhelmed by torrents of liquid lava, or swallowed up by the earthquakes which accompanied them.

Cuncta jacent flammis et tristi mersa favilla. Martial.

All memorials of the devoted cities were lost; and discussions on the places they had once occupied, were excited only by some obscure passages in the classical authors. Six successive eruptions contributed to lay them still deeper under the surface. But after sixteen centuries had elapsed, a peasant, in digging a well beside his cottage in 1711, obtained some fragments of coloured marble, which attracted attention. Regular excavations were made, under the superintendance of Stendardo, a Neapolitan architect; and a statue of Hercules of Greek workmanship, and also a mutilated one of Cleopatra, were withdrawn from what proved to be a temple in the centre of the ancient Herculaneum.

Twenty or thirty years afterwards, the king of the two Sicilies, with a laudable love of science, directed a complete search to be made among the remains of the subterraneous city, and all the antiquities to be preserved. This was long and ardently prosecuted; and the entrance is now gained by a narrow passage, descending gradually to more than 70 feet from the surface, where it branches into numerous alleys leading to different streets and buildings. Neither the precise extent or population of Herculaneum can be ascertained, though it is probable that both were considerable; and we know that it was a city of the second order. All the streets run in straight lines; they are paved with blocks of lava, which indicates the vicinity of more ancient volcanic eruptions; and there is, for the most part, an elevated foot-path along their sides, for the convenience of pedestrians. The houses, whose exterior does not seem to have been ornamental or regular, consisted only of one story, built of brick. The walls of many are thrown out of the perpendicular, and some are covered with coloured stucco, upon which are executed paintings in fresco. From the general appearance exhibited by the different edifices, we may safely conjecture that the volcanic matter consisted of very fine dust, or ashes, which fell in repeated showers, and perhaps in a humid state, until the city was totally buried under it. Indeed it was so fine, that the most perfect impressions of the objects thus covered were imprinted there, and, on their being now removed, the cavity may serve for a plaster or metallic cast. By this means innumerable articles were preserved entire, and scarcely displaced from their original position, for the incumbent load received gradual accessions unaccompanied by any extraordinary degree of heat or violence.

Ancient temples.

The remains of several public buildings have been discovered, which have possibly suffered from subsequent convulsions. Among these are two temples, one of them 150 feet by 60, in which was found a statue of

Herculaneum.

Jupiter. A more extensive edifice stood opposite to these, forming a rectangle of 228 feet by 132, supposed to have been appropriated for the courts of justice. The arches of a portico surrounding it were supported by columns; within it was paved with marble; the walls were painted in fresco; and bronze statues stood between 42 columns under the roof.

Theatre.

Before the year 1738, the theatre was discovered; the size of which has afforded some conjectures regarding the population of Herculaneum. The building was nearly entire; very little had been displaced; and we see in it one of the best specimens extant of the architecture of the ancients. It seems to have had two principal gates, with inscriptions over the architraves of each, besides seven entrances, called *vomitoria*, communicating with the benches. Many columns and pilasters, with laboured entablatures, appeared in the *Proscenium*, and some supported bronze or marble statues. The walls were covered with paintings in the arabesque, and the floor paved with marble; that of the orchestra, consisting of the finest yellow antique, is preserved nearly entire; and similar decorations adorned the various apartments connected with the theatre. Twenty-five rows of high and wide marble benches accommodated the audience; which, rising gradually above each other, gave a full and distinct view of the arena below. The greatest diameter of the theatre, taken at the highest benches, is 234 feet; whence it has been computed, that it could contain 10,000 persons, which proves the great population of the city. This theatre was rich in antiquities, independent of that ornamental part to which we have already alluded. Statues, occupying niches, represented the muses; scenic masks were imitated on the entablatures; and inscriptions were engraven on different places. Analogous to the last were several large alphabetical Roman characters in bronze, and a number of smaller size, which had probably been connected in some conspicuous situation. A metallic car was found with four bronze horses attached to it, nearly of the natural size; but all in such a state of decay, that only one, and the spokes of the wheels, also of metal, could be preserved. A beautiful white marble statue of Venus, only 18 inches high, in the same attitude as the famous Venus de Medicis, was recovered; and either here, or in the immediate vicinity, was found a colossal bronze statue of Vespasian, filled with lead, which twelve men were unable to move; besides many objects entire, there were numerous fragments of others, extremely interesting, which had been originally impaired, or were injured by attempts to obtain them. The Herculaneans are said to have had a particular taste for theatrical entertainments; and some authors have maintained, that, disregarding the danger which menaced them, they remained so intent on the performance, that both here, and at Pompeii, they were surprised by the eruption of Vesuvius, and buried under it. But we may reasonably conclude, that, with regard to Herculaneum, the theatre did not suffer materially from the earthquake, and that it was not attended with the destruction of the spectators. Remarkably few skeletons have been found in this city, though many occur in the streets of Pompeii; but one appears under the threshhold of a door, with a bag of money in its hand, as if in the attitude of escaping, leaving its impression in the surrounding volcanic matter. Nevertheless, it might be here, as we are told of a different city, where the Emperor Nero appearing on the stage, was surprised by a sudden earthquake; but the audience had time to escape, and the theatre fell without doing any injury. A similar incident occurred within these few years at Naples where the decorations of the theatre were in visible motion before the terrified spectators, but the strength of its parts resisted the shock.

The exfodiation was prosecuted along the walls of the buildings, turning the corners, and entering by the doors and windows as they occurred. Two marble equestrian statues of the finest workmanship, which had been erected in honour of the two consuls Balbi and son, were found opposite to the theatre: and in prosecuting the researches into the public edifices and private houses, or even through the streets, the workmen met with many things worthy of observation. A well now containing good water, was seen surrounded by a parapet, and covered by an arch which had excluded the ashes. A capacious bath of a circular form was penetrated, and also repositories of the dead, still more ancient than the overthrow of Herculaneum. Fragments of columns of various coloured marble, beautiful mosaic pavements entire, and mutilated statues, were abundantly disseminated among the ruins. Some of the pavement, representing figures, has been taken up and again disposed in its original order in a spacious museum prepared for the reception of the antiquities. The public edifices afforded a copious collection corresponding to their different uses; but many were utterly destroyed, such as the statues in the building containing forty-two columns. Numerous sacrificial implements, however, such as pateræ, tripods, cups, and vases, were recovered in excellent preservation, and even some of the knives with which the victims are conjectured to have been slaughtered. Numerous domestic utensils employed in the exercise of the arts, and contributing to the amusements of the existing generation, were all preserved.

Mosaic pavement.

Sacrificial implements.

When we reflect that 1600 years have elapsed since the destruction of this city, an interval which has been marked by numerous revolutions both in the political and mental state of Europe, a high degree of interest must be experienced in contemplating the venerable remains of antiquity recovered from the subterraneous city of Herculaneum. Pliny the Younger, in his letters, brings the Romans, their occupations, manners, and customs, before us. He pictures in feeling terms the death of his uncle, who perished in the same eruption as the city we now describe: and that event is brought to our immediate notice by those very things which it was the means of preserving. Among these we see the various articles which administered to the necessities and the pleasures of the inhabitants, the emblems of their religious sentiments, and the very manners and customs of domestic life.

State in which the timber was found.

Articles in vast variety were obtained from the houses, wherein the beams appeared as if converted to charcoal; but it is to be observed, that all the remains of wood exhibit the same aspect to the very heart. They are not consumed or turned to ashes, owing probably to the exclusion of the external air by the showers of volcanic matter. It is singular, that while wood, which has remained during ages buried in the earth, or immersed in water, acquires additional consistence, this has entirely lost what it possessed. Pieces of thin and delicate texture have preserved their shape, but blocks of a large size are converted throughout to charcoal.

Statues.

If the subjects recovered from Herculaneum be classed according to their value, the statues should be enumerated first, both as being of the finest workmanship, and of the most difficult execution. Some are colossal, some of the natural size, and some in miniature; and the materials of their formation are either clay, marble, or

Herculaneum.

Statues.

bronze. They represent all different objects, divinities, heroes, or distinguished persons; and in the same substances, especially bronze, there are the figures of many animals. Sculpture in its various branches, had attained a high degree of perfection among the ancients; their religious prejudices and manners greatly contributed to the perfection of the art; and we have ocular demonstration, that the reputation of their celebrated artists was not overrated. Paintings are interesting, but the small portion of the object represented, renders them far less so than statues which afford complete imitations, and are thence to be ranked as the most precious relics of antiquity. Here there are two statues seven feet high of Jupiter, and a woman, in clay; and two of gladiators, in bronze, about to combat, are much admired. The same may be said of Nero in bronze, naked and armed as a Jupiter *tonans*, with a thunderbolt in his hand. A Venus *pudica* of white marble in miniature, is extremely beautiful, and also the statue of a female leaving the bath. In the year 1758, a fine bronze statue of a naked Mercury, supposed to have been the work of a Greek artist, was discovered: and in the course of the excavations extending beyond the confines of the city, a Silenus, with a tiger, sometimes his attribute, was found, which had formerly adorned a fountain. Several fauns or other sylvans, with vases on their shoulders, were obtained in the vicinity of Silenus, which are of bronze; and it is singular to observe, that the younger figures have silver eyes, a disagreeable deformity sometimes adopted in marble statues. The figure and attitude of a drunken faun, stretched on a lion's skin, and supported by one full of liquor, presents all that vacuity of thought and sensation of animal pleasure which accompany ebriety: another faun asleep, as large as life, presents a state of absolute repose. We have named two fine equestrian statues of full size. There is also a bronze equestrian statue of an armed Amazon, only 16 inches high. There are many elegant statues of the goddesses and graces only 8 or 10 inches in height: and we likewise see some of the monstrous Egyptian divinities with which the Herculaneans were acquainted. Several fine busts or simple heads of the ancient philosophers, as Zeno or Epicurus, stood in the houses; the name being inscribed below, or on a pedestal. Bas-reliefs likewise occurred, but few coins or medals. Gold coins of Augustus were found, and silver medallions, two or three inches in diameter, bearing uncertain devices.

Pictures.

The ancient pictures of Herculaneum are of the utmost interest, not only from the freshness and vividness of colour, but from the nature of the subjects they represent. All are executed in fresco; they are exclusively on the walls, and generally on a black or red ground. It has been supposed, from passages in the classics, that the ancients used only four colours, white, black, yellow, and red; but here are added blue and green.* Some are of animated beings, large as life, but the majority are in miniature. Every different subject of antiquity is depicted here: deities, human figures, animals, landscapes foreign and domestic, and a variety of grotesque beings. Sports and pastimes, theatrical performances, sacrifices, all enter the catalogue. Having occasion afterwards to speak cursorily of some of these subjects, we shall content ourselves with observing that they are more remarkable for variety than for their intrinsic quality. One of larger size found in a temple, and the most celebrated, represents Theseus vanquishing the Minotaur, which lies stretched at his feet, with the head of a bull and the body of a man. A female, supposed to be Ariadne, and three children, form part of the group. This, along with a picture, composed of several figures as large as life, of which Flora is the most conspicuous, adorned a temple of Hercules; each is six or seven feet high and five broad. Another represents Chiron teaching Achilles the lyre; and female centaurs are seen suckling their young. The interior of a shoemaker's shop is exposed on a smaller scale; a feast, baskets of fruit, a grasshopper driving a parrot yoked to a car, a cupid guiding swans in the same manner, and many allegorical subjects are represented. It is impossible within these limited bounds to enumerate their varieties, but we shall immediately refer the reader to a specific work upon the subject, from which much entertainment will be derived. The king, desirous of preserving these pictures, directed them to be sawed out of the walls, a work of great labour and perseverance, after which they were put in shallow frames and kept in the museum.

Paintings.

Triremis.

It is said that a triremis or vessel, with three banks of oars, was discovered with the iron or copper tackle, and wood work complete, and that a drawing was taken of it; but the more material parts immediately fell to dust. A sea piece with vessels is among the paintings.

State in which different fruits were found.

It is extraordinary, that numbers of perishable substances should have resisted the corrosions of time. Many almonds in the shell, imprinted with all the lines and furrows characterising their ligneous envelope, were dug out of the ruins of Herculaneum; figs and some kinds of wild apples were in preservation; and a sort of pine cone yet growing in the woods of Italy, the seeds of which are now ate, or used for culinary purposes. Grain, such as barley, and also beans and pease, remained entire, of a black colour, and offering resistance to pressure. The stones of peaches and apricots are common; thus denoting the frequency of two trees, reputed indigenous in Armenia and Persia. But what is still more singular, a loaf, stamped with the baker's name in Roman characters, or the quality of the wheat, was taken from an oven and was apparently converted to charcoal. Different parts of plants prepared for pharmacy, were obtained from the dwellings of those who had been apothecaries.

State of liquids.

After such an amazing lapse of time, liquids have been found approaching to a fluid state—an instance of which cannot be sufficiently admired in a phial of oil conceived to be that of olives. It is white, greasy to the touch, and emits the smell of rancid oil. An earthen vase was found in the cellars containing wine, which now resembles a lump of porous dark violet coloured glass. We acknowledge, however, that there is great difficulty in comprehending how this change should have taken place. The ancients speak of very thick wines, requiring dilution previous to use, which would keep 200 years, and would then acquire the consistence of honey. Eggs are also said to have been found whole and empty. Solid pitch was found at the bottom of a vessel, wherein it had probably melted, as it afterwards did from heat in the museum at Portici, which stands near the entrance to the subterraneous city.

Kitchen utensils.

An entire set of kitchen furniture has been collected, which displays several utensils exactly similar to our own. The copper pans, instead of being tinned, are internally coated with silver; probably a better precau-

* See Sir Humphry Davy's interesting paper on the colours used by the ancients, in the *Phil. Trans.* for 1815.—Ed.

Herculaneum.

Kitchen utensils.

tion, as more of the poisonous metals are expelled from the latter. These have not been attacked by verdigrease, whence the ancients perhaps understood some branches of metallurgy as well as the moderns. Here is a large brass cauldron, three feet in diameter, and fourteen inches deep, an urn or boiler for hot water similar to those on our tables, and also having a cylinder in the centre for a heater. There are pestles and mortars, and all kinds of implements for cutting out and figuring pastry; and, in short, a complete culinary apparatus. Utensils of finer quality were likewise collected which had been employed at tables, as silver goblets, and vases, silver spoons, and the remnants of knives. But from the absence of forks, both among the other remains and in pictures, it is doubtful how far they were known to the ancients. It is probable, indeed, that their invention and common use are to be dated several centuries later.

Articles of dress and ornament.

Several articles belonging to personal ornament and decoration occurred: We shall not speak of the colours still in a condition fit for painting, because it is questioned whether they were such as it is known the ladies of that generation were accustomed to use for more ordinary purposes. Besides, they are red, blue, and yellow. Those with which females heightened their complexion were prepared both from minerals and vegetables, the latter being chiefly marine plants. Two silver bodkins, with which they pinned up their hair, eight inches in length, are preserved; the end of one appropriately sculptured with a Venus adjusting her tresses before a looking-glass held by Cupid. Gold armlets, bracelets, necklaces with pieces of plate gold suspended to them as a locket, are preserved. Small nets also with fine meshes, which, some have supposed, the ladies employed to tie up their hair; and others of coarser texture, which must have been used for other purposes. Pieces of cloth, coloured red on one side, and black on the other, were found on the breast of a skeleton; the texture of which, whether silk, woollen, linen, or cotton, antiquaries have not been able to decide. Very few jewels are discovered, which favours the idea of the inhabitants having had time to escape. There was a wooden comb, with teeth on both sides, closer on one of them than on the opposite; and portions of gold lace fabricated from the pure metal. Sandals of laced cords are seen, though it is more commonly believed that leather was in general use among the Italians; and a folding parasol, absolutely similar to what we esteem a modern invention, was likewise discovered.

Surgeons instruments.

There is kept in the museum a case of surgeon's instruments, complete, with pincers, spatulæ, and probes; also a box supposed to have contained unguents; and pieces of marble, employed in braying pharmaceutical substances. A variety of carpenters and masons tools, as chissels, compasses, and trowels, were found, resembling our own; and bolts and nails all of bronze.

Carpenters and masons tools.

Weights and measures.

The weights and measures of the ancients have excited considerable discussion, which those preserved in Herculaneum may elucidate: Different balances appear, of which the most common is analogous to the Roman steelyard: but those with flats for scales, though wanting the needle, are likewise seen. The weights are either of marble or metal, of all gradations up to thirty pounds; and from the marks exhibited by a set, well made of black marble, in a spherical shape, it is supposed the pound was divided into eight parts. A weight is inscribed *eme* on one side, and *habebis* on the other. There are pocket long measures, folding up like our common foot rule, which may throw some light on the length of the Roman foot. Neat copper vases are supposed to have been measures for grain; the capacity of one is 191 cubic inches.

The various implements for writing repeatedly occurred; and among the pictures is a female apparently listening to dictation. That the ancients were perfectly acquainted with the art of making glass is proved by the varieties discovered in these exfodiations. Considerable numbers of phials and bottles, chiefly of an elongated shape, are preserved; they are of unequal thickness, much heavier than glass of ordinary manufacture, and of a green colour. Vessels of cut white glass have been found, and also white plate glass, which antiquaries suppose was used in lining chambers called *cameræ vitreæ*. Coloured glass, or artificial gems, engraved, frequently occur: and the paintings exhibit crystal vessels. We may remark in this place, that any one who studies the antiquities of Herculaneum, will find his researches greatly facilitated by frequent reference to the epigrams of Martial, whom nothing used in ordinary life seems to have escaped.

Articles of glass.

Artificial gems.

Vases.

The beauty and variety of the vases have attracted particular notice, and they serve as excellent models for the moderns; for all the skill of the ancient artists seems to have been exhausted in their execution. There is one preserved four feet in diameter of fine white marble; others are of earthen-ware or silver, and the majority of bronze or copper. Some are low, wide, and flat; others tall and narrow, plain, fluted, or sculptured. Sacrificial vases were supported on tripods, whose construction seems to have been attended with equal care. Some of the latter are richly sculptured with real and imaginary figures of men and animals. One is ornamented with three lions heads, and is supported by as many paws: another rests on three Priapeian satyrs of elegant workmanship, or on the feet of eagles. The god of the gardens seems to have been treated with peculiar regard by the Herculaneans. He appears with all his attributes, of every possible variety, figure, and dimensions, in tripods, lamps, and household utensils. The articles on this subject are so common as to constitute a large branch of curious antiques, concerning the emblematic use of which we can only entertain conjectures. Several tripods are very ingeniously constructed, so that the feet may be closed or expanded by double sets of hinges. Endless diversity and infinite elegance are displayed in the lamps and candelabra, which are now affording models for the works of the moderns; but we do not know whether chandeliers have been discovered, at least they are so rare, that we may doubt whether the inhabitants often resorted to lights from wax or resinous substances. Sometimes a lamp appears as a shell, sometimes as a bird; then a human figure, or resembling a quadruped. The vases, lamps, and tripods were particularly used in sacrifices, several of which are represented in the pictures; and among others, are sacrifices to the Egyptian deities. There were many funereal urns and sepulchral lamps, such as those regarding which vague ideas have been entertained as formed for containing perpetual fire.

Tripods.

Candelabra.

Lamps.

Urns.

Dice and dice-boxes.

In regard to sports and pastimes, numerous remains render us familiar with those of the ancients. Here we find dice, with the same disposal of points on a cube; and dice-boxes of bone or ivory, like those now used, besides some of a flattish shape. Several are false, being loaded on one side: and the manner of throwing the dice

Musical instruments.

appears on a picture. No musical instruments were found but the sistrum, which we imperfectly understand, cymbals, and flutes of bone or ivory are yet obtained. However, a concert is represented on a picture 16 inches square, containing a lyrist, a player on a double flute, probably by a mouth piece, and a female apparently singing from a leaf of music; besides other two figures. Several theatrical masks, of different fashions, were found in clay and metal, along with moulds for their formation. Their use in dramatic representations, regarding which the reader may consult a work by *Ficoroni*, is well known, and is the subject of many of the pictures. The theatre, we repeat, was a favourite resort of the ancients; and some ivory tickets of admission, with the author's name, and that of the piece, are preserved from Herculaneum. Rope-dancing is exhibited on the pictures, wherein all the modern dexterity of playing on musical instruments, pouring out liquids into cups, and other feats of address are shewn. The most elegant and graceful of the Herculaneum pictures are perhaps female dancers suspended as it were among the clouds.

It is to be observed in general, with regard to the numerous articles relative to this brief detail, that the quality of the statues infinitely surpasses that of the pictures; and that the vases, tripods, lamps, and candelabra, are frequently of the finest workmanship. Of many once complete, only fragments at this day remain; and while gold, silver, bronze, or clay remain entire, iron has altogether wasted away.

After a vast collection of antiquities had been made, the king resolved on publishing a laborious and expensive work, containing engravings of those which appeared most curious. In the course of thirty-eight years, from 1754 to 1792, this was accomplished in nine folio volumes, including the pictures, bronzes, lamps, and candelabra: The first is devoted to a catalogue, five to pictures, two to the bronzes, and one to the *lucerne*. No less than 738 pictures are named in the catalogue, and the other articles are proportionally numerous. The work was, with royal munificence, presented to the principal public libraries in Europe; but, owing to the succession of the king of the Sicilies to the crown of Spain, it is seldom to be seen complete. At the same time, it has been affirmed, that some of the engravings of the pictures appear with a perfection and delicacy which do not belong to the originals, although their general character be not lost.

Discovery of ancient manuscripts.

In penetrating an apartment of a villa in the neighbourhood of Herculaneum, a number of supposed pieces of charcoal were carried off, which, by accidental fracture, exposed the remains of letters, and proved so many ancient manuscripts. Here Camillo Paderni, the keeper of the museum, buried himself during twelve days, and succeeded in carrying away 337 manuscripts; and, by subsequent careful research, the total number recovered now exceeds 1800. They were in various stages of decay; some so much disfigured and obliterated, that nothing could be determined regarding their nature from the beginning. However, the king instituted a society for investigating them completely. High expectations were formed by the European literati, of the knowledge which would be acquired respecting the history, the manners, and the customs of antiquity; more especially as the materials themselves indubitably remounted to a period of more than 1600 years. The manuscripts consisted of rolls, scarcely a span in length, and two or three inches in thickness, formed of pieces of Egyptian papyrus glued together. Some had a label in front, at one end of the roll, exposing the name of the work, or the author, as it occupied its place in the library. But the substance of the involutions was so crushed together, the ink or pigment employed for the character had faded to such a degree, that, united to the general injury which they had received from time, and the heat to which they had been exposed, the opening of them seemed at first sight to be impracticable. Accordingly, some snapped asunder like burnt wood, others flew into fragments, or they exposed nothing. The assistance of Piaggi, a monk, was obtained from the Vatican, who invented an ingenious method of unfolding the manuscripts without destruction, by means of a mechanical apparatus. The process was slow, but tolerably certain; and the first manuscript put on the machine, being unrolled in the year 1754, proved to be a treatise in Greek capitals, written by Philodemus, an Epicurean philosopher, against music, with his name twice inscribed at the end, or interior of the roll. Similar means were adopted with other manuscripts, and they were partly successful. Almost the whole manuscripts are in Greek, very few having hitherto been found in Latin; and some of the rolls are forty or fifty feet in length. The entire surface of the roll is divided into successive columns, resembling our ordinary pages, each containing from forty to seventy lines in different manuscripts, this being dependent on the size of the roll; but each line is only about two inches long, and the column is no broader. In the original state, therefore, the reader held the roll before his eyes with one hand, while he unwound it with the other, as is represented by some of the Herculanean pictures. Uncommon difficulties were experienced, from the decay of the substance, from frequent blanks and obliterations within, and from the absence of punctuation. Four volumes, all by Philodemus, were successively unrolled; and, in 1760, Piaggi reached a fifth by another author, on botany. But the king was induced to order it to be withdrawn, and a sixth volume was put on the machine, where it remained thirty-six years. After twenty years preparation, the work on music was published, with illustrations by Mazzocchi, a learned Italian, under the title *Herculanensium voluminum quæ supersunt, tomus* 1. Napoli, 1793. It must have been anxiety for publication, not the desire of enlightening the world, that led to the selection of this volume, reputed a dull and controversial performance, which the most ingenious commentary is incapable of enlivening. Cicero, notwithstanding, has called the author *optimum et doctissimum*; Piso, the supposed owner of the manuscripts, derived his philosophy from him, and he was well skilled in the polite literature of the period. In the course of forty years from the discovery of the manuscripts, which were gradually withdrawn, only eighteen were unfolded. The accession of Charles, indeed, to the crown of Spain, and the death of Mazzocchi, had enervated the Herculanean Society, which was renewed in 1787 by the Marquis Caracioli, and the secretary of state thenceforward placed at its head. Yet the work advanced very tardily; few persons were employed, either from the difficulty or want of interest in its prosecution; and it was perhaps totally interrupted by the political events which disturbed the peace of Europe. Mean time, six of the manuscripts were presented, along with other Herculaneum curiosities, to Bonaparte in 1802, by the sovereign of the Sicilies, in whose reign, indeed, we believe that both Philodemus and the volume of Lucerne were published; and ten volumes are said to

State of the ancient manuscripts.

Process of unfolding them.

Herculaneum.

Unrolling of the manuscripts.

have been sent, on some occasion, to the Prince of Wales.

At length a proposal was made on the part of this country, to co-operate with the Neapolitan government on a subject so important to the diffusion of literature as that of elucidating the Herculaneum manuscripts; and Mr Hayter, chaplain to the Prince of Wales, was appointed with a regular commission to superintend their subsequent developement. A parliamentary grant of £1200 was next obtained to aid its prosecution; and Mr Hayter having commenced his operations under the most favourable auspices in 1802, employed thirteen persons in unrolling, deciphering, and transcribing. Some improvements seem to have been attempted in the evolution of the manuscripts by a chemical process; but of those subjected to it, we are told that "the greatest part of each mass flew under this trial into useless atoms; besides, not a character was to be discovered upon any single piece: the dreadful odour drove us all from the museum." Mr Hayter continued his operations from 1802 to 1806, during which time he affirms, that more than 200 papyri had been opened wholly or in part, and he calculated that the remainder would have been unrolled and copied within six years farther at latest. But as to the precise nature and description of these manuscripts, the accessions which literature has gained or would gain by the work, we are only informed that certain fac similes of some books of Epicurus were engraved.

It cannot but be considered particularly unfortunate that the public expectation, so repeatedly excited regarding what are to appearance among the most interesting memorials of antiquity, should be as often disappointed. Admitting every possible difficulty, and all the opposition which might have been experienced, unquestionably there were sufficient materials to make a specific report regarding the state and description of the manuscripts, towards the developement of which the public had so liberally contributed.

In 1806, during Mr Hayter's operations, it became necessary to evacuate Naples; but the existing government acquainted him, that the king had prohibited the removal of the manuscripts; and in the flight of the court, every thing was abandoned to the French, who seem to have continued the assistants in unrolling and deciphering as before. From the opposition which Mr Hayter experienced, he could do nothing more than retire with some of the fac similes to Palermo, where it appears he superintended engravings of them. Yet misunderstandings with the secretary of state prevented him from procuring a complete copy of the whole, until the British ambassador interfered.

Ninety-four fac simile copies were then obtained, partly engraved it would seem, and partly in manuscript. These were carried to England by Mr Hayter on his final recal in 1809, and presented by the Prince Regent to the university of Oxford. However, a very confused and indistinct account of the whole of this matter has reached the public, which compels us to be thus brief regarding the history of the Herculaneum manuscripts.

Perhaps it may ultimately be found that they are less worthy of notice than was anticipated, particularly if we are entitled to form any judgment regarding the rest, from the inconsiderable portions that have already been published. See *Antichita d'Ercolano*, 9 vols. in folio; Bayardi *Prodromo delle Antichita d'Ercolano;—Notizie, del Scoprimento dell' Antichita citta d'Ercolano;* Venuti *Descrizione delle prime scoperte dell' Anticha citta d'Ercolano;* Murr *de Papyris Herculanensibus;* Drummond and Walpole *Herculanensia*; Hayter, *Letter and Report on the Herculaneum Manuscripts; Philosophical Transactions* for 1751, 1753, 1754, 1755, 1756; and Sir W. Hamilton *Campi Phlegræi*, p. 58. (c)

Hercules.

HERCULES, one of the most illustrious heroes of antiquity, and the first of the *Dii Minorum Gentium*, or demi-gods. He was descended from the kings of Argos; but in the Pagan mythology, he is said to have been the son of Jupiter by Alcmena, the wife of Amphitryon, king of Thebes. The period of his birth is uncertain: Herodotus places it about the year 1282, before the commencement of the Christian æra; and in Blair's *Chronological Tables*, his death is placed in the year 1222 B. C.

The history of this celebrated personage consists of a tissue of prodigies. His first, or what may be called his infantine, exploits, were his strangling two serpents, which were sent to destroy him in his cradle; and his killing a large lion, near his native city, Thebes. Next come those adventures, which are commonly known by the name of his twelve labours, undertaken by order of Eurystheus, and of a decree of the Delphian oracle, as it is said, by way of expiation for the crime of killing the three children which he had by his wife Megara, and in order to acquire immortality. The first of these was his combat and victory over the Cleonæan lion, in the forest of Nemæa; the second, his conquest of the hydra, by which he is said to have cleared the fens of Lerna near Argos, of the serpents that infested them, and which seemed to multiply as fast as they were destroyed; the third, his destruction of the Erymanthian boar; the fourth, his slaying the brazen-footed stag on Mount Menalus; the fifth, his shooting the harpies, or stymphalides; the sixth, his cleansing the stables of Augeas; the seventh and eighth, his destroying the Cretan bull, and Diomede, the barbarous tyrant of Thrace, with his horses or mares who were fed on human flesh; the ninth, his combat with Geryon, who is generally represented with three bodies; the tenth, his conquest of the Amazons; the eleventh, his dragging Cerberus up from the infernal regions; and the last, his killing the serpent, or dragon, and carrying off the golden fruit from the garden of the Hesperides. The remainder of his exploits were those which he undertook voluntarily; such as his slaying the giant Antæus, and Cacus, the notorious robber of Italy, fixing pillars in the *Tretum Gaditanum*, or Straits of Gibraltar, &c. It would appear, that this redoubted champion was by no means insensible to the influence of the tender passion, or proof against the allurements of vicious pleasure. The principal scene of his effeminacies was in Asia, whilst he lived with Omphale, queen of Lydia; and he at length fell a sacrifice to the jealousy of his wife, Deganira, who, dreading the influence of his passion for Iole, the daughter of Eurytus, king of Æchalia, poisoned his robe, so that he died in great agonies on Mount Oëta. Ovid represents him as preparing his own funeral pile, and laying himself upon it with great composure.

Such is the substance of the traditional histories of this celebrated hero of antiquity, whose adventures have afforded ample materials to the sculptor and the poet. These traditions seem to contain a mixture of truth and fable. It appears from ancient authors, that there were several individuals of the name of Hercules, whose heroic actions were probably exaggerated, and ascribed to one man; and to him, as his fame increased and spread abroad, was likewise transferred the credit of all great and valorous enterprises, the authors of

Hereford, Herefordshire.

which were unknown. Thus the Theban Hercules became, as it were, the representative of heroism and manly virtue, according to the notions of antiquity. Accordingly it has been observed, that none even of the twelve great pagan deities have so many monuments relating to them, as Hercules. The famous statue, called the Farnese Hercules, is well known. The hero is there represented as resting after the last of his twelve labours, leaning on his club, and holding in his hand the apples of the Hesperides. In this, and in all the other figures of him, he is formed, by the breadth of his shoulders, the spaciousness of his chest, the largeness of his size, and the firmness of his muscles, to express prodigious strength, and a capacity of enduring great fatigue. His other attributes are his lion's skin, his club and his bow. See Plate CCXXXIV. Fig. 2.

Hercules was peculiarly honoured among the Greeks, by the epithet of *Musagetes*, the conductor of the Muses; and among the Romans, by that of *Hercules Musarum*. In reference to these titles, he is represented, on medals, with a lyre in his hand; and the reverse is marked with the figures of the nine Muses, with their appropriate symbols. (*z*)

HEREFORD is a town of England, in the hundred of Grimsworth, 135½ miles W. N. W. from London. It is situated on the left bank of the river Wye, over which it has a stone bridge of six arches, constructed in the 15th century. The streets are in general wide: the inns are particularly good, one or two of them being equal to any in the kingdom. The public buildings particularly worthy of notice, are the cathedral, bishop's palace, college, county gaol, and theatre. The general plan of the cathedral is that of a cross. The interior is very interesting, though not nearly so much so as it was before the removal of the sepulchral memorials, painted glass, &c. The see of Hereford comprehends Herefordshire, and part of Shropshire. It is rated in the king's books at £768: its real value is supposed to be about £3000. The civil government of the city is vested in a mayor, six aldermen, a common council consisting of 31 members, an high steward, and a recorder. It returns two members to Parliament, the right of election being vested in the citizens and freemen, to the number of about 1200. The situation of this city, on the banks of the Wye, would be extremely favourable to its trade, if the navigation of that river were less precarious. The principal manufacture carried on is gloves. Cyder, grain, and oak bark, are conveyed in considerable quantities down the river to Bristol and other places; and by means of the same navigation, the city is supplied with coals from the forest of Dean. This city suffered much during the wars between the houses of York and Lancaster, and also during the wars between Charles and his parliament. In 1803, its population was 6828; in 1811, it amounted to 7306. See Duncombe's *Agriculture of Hereford*; *Beauties of England and Wales*, vol. v.; and Marshall's *Rural Economy of Gloucestershire*, &c. vol. ii. p. 221, &c. (w. s.)

HEREFORDSHIRE is an inland county in the west of England, and on the borders of Wales. It is situated between 51° 53′ 7″, and 52° 29′ 43″ North Latitude, and 2° 28′ 30″ and 3° 19′ 32″ West Longitude from London. It is bounded on the north by Shropshire; on the west by the counties of Radnor and Brecon, from the latter of which it is separated by the Hatterel Hills, or Black Mountains; on the south by Monmouthshire and Gloucestershire, being separated from the former by the river Wye, and from the latter, partly by the river Munnow; and on the east it is bounded by Worcestershire. Its outline forms nearly a circle, but its circumference is made irregular by many windings and indentations. The extent, from Ludford on the north, to the opposite border, near Monmouth on the south, is 38 miles; and from Clifford on the West, to Cradley on the east, 35 miles. Some detached parts are situated beyond the general outline; the parish of Farlow being wholly insulated by Shropshire—that of Rochford by Worcestershire; Lytton hill by Radnorshire; and a considerable tract of land, called the Futhog, by Monmouthshire. According to the original report to the Board of Agriculture, the gross number of acres is 781,440; but in Mr Duncombe's report they are stated to be only 600,000. In the returns to Parliament respecting the poor rates, they are stated at 621,440; while Mr Marshall estimates them so high as 800,000. On the supposition that there are 600,000 acres, which is the most probable, it is computed that 30,000 are the sites of towns, roads, water, &c. and 50,000 waste lands and woods; hence there are about 520,000 acres of cultivated ground; a much larger proportion than most of the other counties of England contain.

Situation and boundaries.

Extent.

Herefordshire is divided into eleven hundreds, viz. Broxash, which contains 26 parishes; Ewias Lacey, which contains seven parishes; Greytree, which contains 17 parishes; Grimsworth, which contains 23 parishes; Huntingdon, which contains eight parishes; Radlow, which contains 24 parishes; Stretford, which contains 15 parishes; Webtree, which contains 27 parishes; Wigmore, which contains 14 parishes; Wolphey, which contains 24 parishes; and Wormelow, which contains 30 parishes; making in all 215 parishes, besides six parishes in the city of Hereford. Besides this city, which is also the county town, there are in Herefordshire two borough towns, Weobley and Leominster; and five other market-towns, Ross, Ledbury, Kington, Bromyard, and Pembridge. It returns eight members to parliament, viz. two for the county, two for the city, two for Leominster, and two for Weobly. It is in the province of Canterbury, and diocese of Hereford, and in the Oxford circuits.

Divisions.

The general aspect of this county is extremely beautiful; its surface is finely diversified, and broken by swelling heights in such a manner as to resemble the more central parts of Kent; no wide open vale, nor any extensive range of hills, appear in the north-western quarter; some separated links of the Welch mountains rise above the hillocks and minor hills which are scattered over the rest of the county. In short, Herefordshire may be said, without exaggeration, to be altogether beautiful. From many of the elevations, the prospects are uncommonly fine; rather rich and luxuriant, however, than grand, or even picturesque. The forest prospects are from the Malvern hills on the east, and the Hatterel, or Black Mountains, on the west.

Face of the country.

It is equally favoured in respect to soil, which is everywhere fertile; no watery bottoms, nor thin-soiled barren hills, except perhaps in the northern and western outskirts; every other part is uniformly productive. The eastern side of the county is mostly a stiff clay, of great strength and tenacity; for the most part red, but in some places of the ordinary colour. The western side is lighter, but still a productive soil. The county is clothed in almost perpetual verdure: on every side luxuriance of vegetation is exhibited, in widely extended corn fields, rich orchards, expansive meadows, and flourishing plantations. The subsoil, as well as the soil, contributes to this wonderful and almost

Soil.

Herefordshire.

unrivalled fertility. It is mostly limestone of different qualities. In some parts, particularly near Snodhill castle, it assumes the appearance and properties of marble, being beautifully variegated with red and white veins. Deep beds of gravel are occasionally met with in the vicinity of the city of Hereford, and the subsoil of several of the hills is of siliceous grit. Fullers earth is sometimes dug near Stoke; and red and yellow ochres, with tobacco pipe-clay, are found in small quantities in various parts of the county. Iron ore has been met with on the borders of Gloucestershire, but none has been dug for many years.

Rivers. The principal rivers in Herefordshire are the Wye, the Lugg, the Munnow, the Arrow, the Frome, the Teme, and the Leddon. Wye, The Wye, so highly and deservedly celebrated for its picturesque beauties, enters Herefordshire near Clifford. Between Whitney and Hereford, its general character is mild and pleasing, consisting of delightful reaches, with the most agreeable landscapes and luxuriant scenery on both sides. From Hereford to Ross its features occasionally assume greater boldness; but, at the latter town, it resumes the brightness and rapidity of its primitive character, and forms the admired bending seen from the church-yard of Ross. Beneath the arches of Welton bridge it flows through a charming succession of meadows: the peninsula of Symond's rock succeeds, round which the river flows in a circuit of seven miles, though the opposite points of the isthmus are only a mile apart. New and pleasing objects now rapidly succeed one another; and the romantic village of Whitchurch, stupendous hills, and hanging rocks, exhibit a rare union of what is grand, beautiful, and picturesque. Shortly afterwards, the Wye quits the county and enters Monmouthshire. This river is navigable to Hereford in barges from 18 to 40 tons; but either a large or small supply of water is fatal to the navigation. Lugg. The Lugg, which rises in Radnorshire, enters Herefordshire on the north-west side: near Stapleton castle, below Leominster, it is joined by the Arrow and the Frome. Soon after its junction with the latter, it falls into the Wye. The Munnow rises on the Herefordshire side of the Hatterel mountains; and, after many windings, forms the boundary between the county and Monmouthshire, till it quits the former. Teme. The Teme enters Herefordshire a short distance north-west from Brampton Bryan, but it soon enters Shropshire; thence again it enters Herefordshire, but soon leaves it for Worcestershire, where, having made a considerable circuit, it once more flows on the borders of this county, after which it falls into the Severn. Leddon. The Leddon rises on the east side of Herefordshire, and after running south, and giving name to the town of Ledbury, it flows into Gloucestershire, and unites with the Severn. Arrow. The Arrow enters Herefordshire from Radnorshire, and, flowing to the east, falls into the Lugg near Leominster.

Canals. The inland navigation of this county is very imperfect. The Hereford and Gloucester canal, which was begun in 1791, is not yet completed. It begins at Hereford, and is to fall into the Severn near Gloucester. Its total length is to be 35 miles 5 furlongs. At the beginning of it is a tunnel of 440 yards, and another about the middle of the summit 1320 yards long. The Kingston and Leominster canal begins at the former place, crosses the Lugg, and afterwards the Teme, and is to unite with the Severn near Stourport in Worcestershire. The total length is to be 45 miles: on it there are two tunnels, one of 1250, and the other of 3850 yards.

State of property. The greatest estates in this county, belong to Guy's Hospital, the Duke of Norfolk, the Earls of Oxford and Essex, Sir George Comerall, R. P. Knight, Esq. &c. In that part of the hundred of Wormelow, called Irchenfield, the tenure of gaval-kind prevails, by which, in cases of persons dying intestate, landed property descends in equal divisions to all the sons. In the manor of Hampton-Bishop, which belongs to the see of Hereford, the tenure of borough-english prevails, by which the youngest son succeeds to the exclusion of his brothers. Copyhold property is not so common in this as in many other counties of England. Leasehold estates are more common. They are for the most part held under the dean and chapter of Hereford, the corporation of that city, &c. It is estimated, that two-thirds of the whole county is freehold, and the remaining third under the other tenures. The size of farms varies from 200 to 400 acres.

Produce. The produce of Herefordshire is uncommonly various. In a general view, however, it may be regarded as a corn county. The bottoms nevertheless furnish great quantities of grass; and the sides of the hills produce in great abundance, and of excellent quality, most kinds of woods, especially oak. The immediate banks of the vallies, and the skirts of the higher hills, are covered with orchards. The objects of husbandry are principally cattle, sheep, swine, corn, hops, and fruit liquor; but two products render Herefordshire particularly famous, its cyder and its wool.

Wheat, &c. The principal cultivated lands are under tillage. The wheat grown in the vales, in the vicinity of Hereford, and thence through the clays towards Ledbury, is of a remarkably fine quality. The lighter lands produce excellent barley. Ross is the centre of the principal barley district. Oats are grown in most abundance on the borders of Wales, and on the eastern confines of the county. Neither turnips, nor artificial grasses, are sufficiently attended to.

Meadows. The most fertile meadows lie on the banks of the Wye, Frome, and Lugg. For fattening cattle, they cannot be exceeded; but Herefordshire has no pretensions to rank among the dairy counties. Mr Knight has proved by experiments, that equal quantities of milk in Herefordshire and Cheshire will produce unequal quantities of curd, highly to the advantage of the latter county.

Hops. Considerable quantities of hops are grown in this county, particularly about Bromyard, in that part of Herefordshire, bordering on what may be called the hop district of Worcestershire. They are of two kinds, the white and the red; but the former are the most delicate, and are preferred by the buyers.

Orchards and fruit-liquor. Plantations of fruit trees are found in every aspect, and on every soil; but the most approved site is that which is open to the south-east, and sheltered in other points, but particularly in the opposite direction. The period when the orchards of this county acquired the high character which they still retain, seems to have been the reign of Charles I. when, according to Evelyn in his *Pomona*, by the noble exertions of Lord Scudamore of Holm Lacey, and other gentlemen, Herefordshire became in a manner "one entire orchard." Of the apples that are cultivated, there are various kinds, yielding liquors of different quality and strength. The Styre cyder is remarkable for a strength and body unusual to this liquor, and keeps very well. The pears most in estimation are the Squash, so called from the tenderness of its pulp; the sack pear, the red pear, and the Longland. Every pear tree when nearly fully

Herefordshire.

grown, will afford an annual average produce of 20 gallons of liquor. Many single trees in this county have produced a hogshead in one season; and an extraordinary tree growing on the glebe land in the parish of Holm Lacey, has more than once filled 15 hogsheads in one year. In other respects, this is a most extraordinary tree; for its branches becoming long and heavy, their ends fell to the ground, where they took root, each branch becoming as it were a new tree, and in its turn producing others in the same way. Nearly half an acre of land is covered with this tree.

The produce of an acre planted with apple trees, will generally be found nearly one-third less than the produce of pear trees on the same space; but the former begin to bear at an earlier age. As an object of sight, the pear tree is far superior. The orchards are of various sizes, from 4 or 5 to 30 or 40 acres. The principal markets for the fruit liquors of Herefordshire, are London and Bristol. From the latter, great quantities are sent to Ireland, to the East and West Indies, and to foreign countries, in bottles. The principal part of the liquor is bought immediately from the press by the county dealers. They prefer it in that state, in order that the fermentation and subsequent management may take place under their own direction.

Cattle.

In the opinion of Mr Marshall, the Herefordshire breed of cattle, taking it all in all, may, without risk, be deemed the first breed of cattle in the island. Those of Devonshire and Sussex approach nearest to them in general appearance; but they are of a larger size, and an athletic form. The prevailing colour is reddish brown, with white faces. As beasts of draught, their form is nearly complete; and the females at least fat kindly at an early age. In Herefordshire, working oxen are the principal object of breeding. Half the plough teams are of oxen, and they are also used frequently in carriages. They are bred chiefly in the north-western quarter of the county; but more or less in every other quarter, except the Ryeland. The most valuable collection of cattle to be seen out of Smithfield, are often met with at the Hereford Michaelmas fair.

Sheep.

This county has long been celebrated for a peculiar breed of sheep, called the Ryeland breed, from an indeterminate district in the southern quarter of the county which goes by the name of Ryeland, on which this breed of sheep are principally reared. These sheep are remarkable for the sweetness of their mutton, but still more so for the fineness of their wool: they are a small white-faced, hornless breed, their form being extremely beautiful. In the management of the store flocks of this breed, what is provincially termed a *cot* is used: this is a building in which they are shut up during the night, instead of being folded in the open field. The Merino has been crossed with this breed to great advantage. Leominster is the principal wool market in the county, hence Leominster wool has long been famous.

Roads.

The roads in Herefordshire, even so late as 1788, when Mr Marshall visited the county, were very bad, indeed proverbially bad; but since that time they have been much improved.

Manufactures.

There are no manufactures of any extent or consequence in the county; for the manufactures of gloves and flannel in Hereford, and of cloth at Ledbury, are by no means so important as to deserve particular notice.

Poor's rates.

The returns made under the act of the 26 George III. report the net expences for maintaining the poor throughout the county, in the year 1776, to have been £10,393. The average of the years 1783, 1784, and 1785, as returned under the same authority, was stated at £16,727. In the year 1805, Mr Duncombe estimated them at £20,000. By a return made to the House of Commons in February 1806, containing an account of all money raised by poor's rates or other rate or rates, in the several counties of England and Wales, in the year ending 25th of March 1815, it appears that 243 parishes, and places in Herefordshire, paid under these rates the sum of £81,182: sixteen parishes or places had made no return.

History.

The earliest inhabitants of this county of whom we have any notice, were the Silures; after a long and strenuous opposition to the Romans, they were subdued in the 73d year of the Christian era. Under the heptarchy, Herefordshire formed part of the kingdom of Mercia, and was the last which submitted to the Saxon authority.

Population.

According to the act of 43 George III. for taking an account of the population of Great Britain, the number of inhabitants in the year 1801 amounted to 89,191. The following is the result of the population returns in 1811:

Houses inhabited	18,572
Families inhabiting them	20,081
Houses building	154
Houses uninhabited	724
Families employed in agriculture	12,599
Ditto in trade	5,044
Ditto in other lines	2,438
Males	46,404
Females	47,669
Total inhabitants	94,073

(W. S.)

Heresy.

HERESY, (Lat. *Hæresis*, Gr. *αιρεσις*, from *αιρεω*, *I chuse*,) signifies an error in some essential point of Christian faith, publicly avowed, and obstinately maintained; or, according to the legal definition, *Sententia rerum divinarum humano sensu excogitata, palam docta, et pertinaciter defensa*. Particular modes of belief or unbelief, therefore, which have no tendency to overturn Christianity itself, or to sap the foundations of morality, cannot be held as falling within the above definition. It is properly the obstinacy, and not the error, that is considered as constituting the character of heresy. When a man embraces any opinion, however erroneous, but is at the same time humble and ingenuous, ready and desirous of receiving farther light and instruction, and of giving its due weight to every argument that is urged against him, he is not guilty of heresy. *Errare possum, hæreticus esse nolo*, is a celebrated maxim of St Augustine.

Among the ancients, the word *heresy* appears to have had nothing of that odious signification, which has been attached to it by ecclesiastical writers in later times. It only signified a peculiar opinion, dogma, or sect, without conveying any reproach; being indifferently used, either of a party approved, or of one disapproved, by the writer. In this sense, they spoke of the heresy of the Stoics, of the Peripatetics, Epicureans, &c. meaning the sect, or peculiar system, of these philosophers. In the historical part of the New Testament, the word seems to bear very nearly the same signification, being employed indiscriminately to denote a sect or party, whether good or bad. Thus we read of the sect or heresy of the Sadducees, of the Pharisees, of the Nazarenes, &c. See *Acts* v. 17, ch. xv. 5. ch. xxiv. 5. ch. xxvi. 5. ch. xxviii. 22. In the two former of these passages the term *heresy* seems to be adopted by the sacred historian merely for the sake of distinction, without the least appearance of any intention to convey either praise or blame. In *Acts* xxvi. 4, 5, Paul, in defending himself before king Agrippa, uses the same term, when it was manifestly his design to exalt the party to which he had belonged, and to give their system the preference over every other system of Judaism, both with regard to soundness of doctrine, and purity of morals.

It has been suggested, that the acceptation of the word αἱρεσις, in the Epistles, is different from what it has been observed to be in the historical books of the New Testament. In order to account for this difference, it may be observed, that the word *sect* has always something relative in it; and therefore, although the general import of the term be the same, it will convey a favourable or an unfavourable idea, according to the particular relation which it bears in the application. When it is used along with the proper name, by way of distinguishing one party from another, it conveys neither praise nor reproach. If any thing reprehensible or commendable be meant, it is suggested, not by the word αἱρεσις itself, but by the words with which it stands connected in construction. Thus we may speak of a strict sect, or a lax sect; or of a good sect, or a bad sect. Again, the term may be applied to a party formed in a community, when considered in reference to the whole. If the community be of such a nature as not to admit of such a subdivision, without impairing and corrupting its constitution, a charge of splitting into sects, or forming parties, is equivalent to a charge of corruption in that which is most essential to the existence and welfare of the society. Hence arises the whole difference in the word, as it is used in the historical part of the New Testament, and in the Epistles of St Peter and St Paul; for these are the only apostles who employ it. In the history, the reference is always of the first kind; in the Epistles, it is always of the second. In these last, the apostles address themselves only to Christians, and either reprehend them for, or warn them against, forming sects among themselves, to the prejudice of charity, to the production of much mischief within their community, and of great scandal to the unconverted world without. In both applications, however, the radical import of the word is the same; and even in the latter, it has no necessary reference to doctrine, true or false.

During the early ages of Christianity, the term *heresy* gradually lost the innocence of its original meaning, and came to be applied, in a reproachful sense, to any corruption of what was considered as the orthodox creed, or even to any departure from the established rites and ceremonies of the church. In the present article, we do not intend to enter into a minute history of the various heresies, which have at different times disturbed the repose of the church, and given occasion to persecutions, which are revolting to the milder genius of modern times. All that we propose, is to give a short view of the progressive doctrines of the law upon this subject.

In our definition of the word *heresy*, we have marked the essential character of the offence, as it falls under the view of the law. In the law of England, however, it seems difficult to determine precisely what errors amount to heresy, and what do not. By our ancient constitution, this was left generally to the determination of the ecclesiastical judge, who, in this respect, had a most arbitrary latitude allowed him. For the general definition of an heretic given by Lyndewode, (*cap. de Hæreticis,*) extends to the slightest deviations from the doctrines of the holy church: *hæreticus est qui dubitat de fide Catholica, et qui negligit servare ea, quæ Romana ecclesia statuit, seu servare decreverat.* Or, as the statute, 2 Hen. IV. c. 15, expresses it in English; "Teachers of erroneous opinions, contrary to the faith and blessed determinations of the holy church." Very contrary this to the usage of the first general councils, which defined all heretical doctrines with the utmost precision and exactness. And the uncertainty of the crime, which ought to have alleviated the punishment, seems to have enhanced it in those days of blind zeal and pious cruelty. It is true, that the sanctimonious hypocrisy of the Canonists, went at first no farther than to enjoin penance, excommunication, and ecclesiastical deprivation, for heresy; though afterwards they proceeded boldly to imprisonment by the ordinary, and confiscation of goods *in pios usus.* But, in the mean time, they had prevailed upon the weakness of bigotted princes, to render the civil power subservient to their purposes, by making heresy not only a temporal but even a capital offence; the Romish ecclesiastics determining, without appeal, whatever they pleased to be heresy, and shifting off to the secular arm the odium and drudgery of executions, with which they themselves were too tender and delicate to intermeddle. Nay, they even pretended to intercede and pray, on behalf of the convicted heretic, *ut citra mortis periculum sententia circa eum moderetur*; (*Decret.* l. 5. t. 40. c. 27.) well knowing at the same time, that they were delivering the unhappy victim to certain death. Hence the capital punishments inflicted on the ancient Donatists and Manichæans, by the emperors Theodosius and Justinian, (*Cod.* l. 1. tit. 5.); hence also the constitution of the emperor Frederic, mentioned by Lyndewode, (*cap. de Hæreticis,*) adjudging all persons, without distinction, to be burnt with fire, who were convicted of heresy by the ecclesiastical judge. The same emperor, in another constitution, ordained that if any temporal lord, when admonished by the church, should neglect to clear his territories of heretics within a year, it should be lawful for good Catholics to seize and occupy the lands, and utterly to exterminate the heretical possessors. And upon this foundation was built that arbitrary power, so long claimed, and so fatally exerted by the Pope, of disposing even of the kingdoms of refractory princes to more dutiful sons of the church, which formed a fruitful source of contention and animosity during the dark ages of Europe.

While Christianity was thus deformed by the demon of persecution upon the continent, it was not to be expected that our own island should be left entirely free from the same scourge. Accordingly, we find among our ancient precedents a writ *de hæretico comburendo,* which is thought by some to be as ancient as the common law itself. It appears from thence, however, that the conviction of heresy by the common law, was not in any petty ecclesiastical court, but before the archbishop himself in a provincial synod; and that the delinquent was delivered over to the king, to do as he should please with him; so that the crown had a controul over the spiritual power, and might pardon the convict, by issuing no process against him; the writ *de hæretico comburendo* being not a writ of course, but issuing only by the special direction of the king in council.

But in the reign of Henry IV. when the eyes of the Christian world began to open, and the seeds of the Protestant religion (under the opprobrious name of

Lollardy) took root in this kingdom, the clergy, availing themselves of the king's dubious title to demand an increase of their own power, obtained an act of parliament, (2 Hen. IV. c. 15.) which sharpened the edge of persecution to its utmost keenness. By that statute, the diocesan alone, without the intervention of a synod, might convict of heretical tenets; and unless the convict abjured his opinions, or if after abjuration he relapsed, the sheriff was bound *ex officio*, if required by the bishop, to commit the unhappy victim to the flames, without waiting for the consent of the crown. Another and subsequent statute (2 Hen. V. c. 7.) made Lollardy also a temporal offence, and indictable in the king's courts; which did not thereby gain an exclusive, but only a concurrent jurisdiction with the bishop's consistory. When the final reformation of religion began to advance, the power of the ecclesiastics became somewhat moderated; for although what heresy *is*, was not then precisely defined, yet we are told, in some points, what it *is not*. Thus the statute 25 Hen. VIII. c. 14. declares, that offences against the see of Rome are not heresy; and the ordinary is thereby restrained from proceeding in any case upon mere suspicion; that is, unless the party be accused by two credible witnesses, or an indictment of heresy be first previously found in the king's courts of common law. Yet the spirit of persecution was not then abated, but only diverted into a lay channel. For in six years afterwards, the bloody law of the Six Articles was introduced by the statute 31 Hen. VIII. c. 14. which established the six most contested points of Popery, viz. transubstantiation, communion in one kind, the celibacy of the clergy, monastic vows, the sacrifice of the mass, and auricular confession. These points, it seems, were "determined and resolved by the most godly study, pain and travail of his Majesty; for which his most humble and obedient subjects, the lords spiritual and temporal, and the commons, in parliament assembled, did not only render and give unto his highness their most high and hearty thanks," but did also enact and declare all oppugners of the first to be heretics, and to be burnt with fire; and of the five last to be felons, and to suffer death. The same statute established a new and mixed jurisdiction of clergy and laity, for the trial and conviction of heretics; the reigning monarch being then equally intent in destroying the supremacy of the bishops of Rome, and confirming all the other corruptions of the Christian religion.

Passing over the detail of the various repeals and revivals of these sanguinary laws in the two succeeding reigns, we shall proceed directly to the period of the final establishment of the Reformation in the reign of Queen Elizabeth. By statute 1 Eliz. c. 1. all former statutes relating to heresy are repealed, which leaves the jurisdiction of heresy as it stood at common law: viz. As to the infliction of common censures in the ecclesiastical courts; and, in case of burning the heretic, in the provincial synod only; or, according to Sir Matthew Hale, in the diocesan also. But, in either case, it is agreed, that the writ *de hæretico comburendo* was not demandable of common right, but grantable or otherwise merely at the king's discretion. 1 Hal. P. C. 405. The principal point, however, was now gained; for by this statute a boundary is, for the first time, set to what shall be accounted heresy, which is restricted, for the future, to such tenets only which have been heretofore so declared by the words of the canonical scriptures, or by one of the first four general councils, or by such other councils as have only used the words of the Holy Scriptures, or which shall hereafter be so declared by the parliament, with the assent of the clergy in convocation. For the writ *de hæretico comburendo* remained still in force; and there are instances of its being put in execution upon two Anabaptists in the seventeenth of Elizabeth, and upon two Arians in the ninth of James I. But this odious writ was at length totally abolished, and heresy again subjected only to ecclesiastical correction, *pro salute animæ*, by virtue of the statute 29 Car. II. c. 9. The matter, therefore, is now brought into its proper situation, with respect to the spiritual cognizance and spiritual punishment of heresy, unless, perhaps, that the crime itself ought to be more strictly defined, and no prosecution permitted, even in the ecclesiastical courts, until the tenets in question are, by proper authority, previously declared to be heretical. Under these restrictions, it seems necessary for the support of the national religion, that the officers of the church should have power to censure heretics, yet not to harass them with temporal penalties, much less to exterminate or destroy them.

The fury of persecution, indeed, has been greatly allayed, both by the prudence and the humanity of modern times; and the gradual repeal of the savage laws enacted against heretics, as well as the mitigation of cruelty in the legal punishments which were devised by barbarous ages, must be considered as a natural consequence of the advancement of civilization. With regard to one species of heresy indeed, the legislature still thought it proper for a long while, that the authority of the civil magistrate should be interposed. For by the statute 9 and 10 W. III. c. 32. it was enacted, that if any person educated in the Christian religion, or professing the same, should by writing, printing, teaching, or advised speaking, deny the Christian religion to be true, or the Holy Scriptures to be of divine authority, or deny any one of the persons in the Holy Trinity to be God, or maintain that there are more gods than one, he should, upon the first conviction of professing his peculiar doctrines, be rendered incapable of enjoying any office or place of trust, civil or military, as well as ecclesiastical; and upon a second conviction, he should be disqualified from bringing any action, or from being guardian of any child, executor, legatee, or purchaser of lands, and besides suffer imprisonment for three years without bail. But if, within four months after the first conviction, the delinquent should, in open court, publicly renounce his error, he was to be discharged at once from all disabilities. But even this comparatively mild law could not well be executed in an enlightened age, and seemed to be retained merely *in terrorem*, until it was at length repealed in the year 1813. And it is the wish of many in this land of free inquiry, of knowledge, and liberal sentiment, that our statute books may be entirely rescued from the opprobrium of penal laws in the province of religion, and that the rights of conscience may be for ever confirmed, as not controlable by human laws, nor amenable to human tribunals. See Campbell's *Prelim. Dissert. to the Four Gospels, &c.*; Suicer's *Thes.* vol. i. p. 120, 124; Lardner's *Works*, vol. ix. p. 223, &c.; Blackstone's *Comment.* b. iv. ch. 4; Furneaux *Letters to Judge Blackstone*, p. 30; *Popular Reflections on the Progress of the Principles of Toleration*, &c. Newcastle, 1814; and *Edinburgh Review*, No. 51, p. 51, *et seq.* (z)

HERITIER, Charles Louis L' de Brutelle, an eminent French botanist, was born at Paris in 1746. In the year 1772, he was appointed Superintendant of the Waters and Forests of the Generalité of Paris; and, Hermanstadt.

with the view of acquiring a knowledge of forest trees, he applied himself with diligence to the study of botany. The first work of L'Heritier was entitled *Stirpes Novæ*. The first fasciculus, with eleven finely engraved plates, appeared in 1784. It was completed in six fasciculi, containing in all eighty-four plates, with their descriptions, which were dated in 1784 and 1785, though they did not appear till some years afterwards. This circumstance gave rise to a controversy between the Abbe Cavanilles of Madrid and L'Heritier. In order to secure some of his own discoveries, L'Heritier published them in the form of monographs, with one or two plates. The subjects were *Louichea, Bucholzia Michauxia, Hymeno-pappus,* and *Virgilia;* and twelve of each only were printed.

After the Herbarium of Dombey had been put into the hands of L'Heritier in 1787, with orders to publish its contents, the influence of the court of Spain induced the French government to give orders that the Herbarium should be withdrawn; but L'Heritier having received notice of the measure, carried it over to London, where he remained for fifteen months, chiefly under the hospitable roof of Sir Joseph Banks. The state of his country, however, compelled him to return to Paris; and at this time the MSS. of his *Peruvian Flora* was complete, sixty drawings were finished, and many of the plates engraven. During his stay in England, he had collected the materials of his *Sertum Anglicum,* an unfinished work, of which he published several fasciculi, on the same plan as his *Stirpes Novæ*.

In the year 1775, L'Heritier married Madamoiselle Doré, who brought him five children, and died in the year 1794. In the year 1775, he became a *Conseiller a la cour des aides,* and was a long time the dean of that court. After the death of his wife, L'Heritier devoted himself to the education of his children; but his hopes were frustrated by the unprincipled conduct of his son. When he was one evening returning from a meeting of the National Institute, in August 1800, he was murdered, and his body was found next morning, with his money and other articles of value untouched. No discovery was ever made respecting this barbarous event; but suspicions of the most unnatural kind were confidently entertained. See Rees' *Cyclopedia*.

HERMANSTADT, HERMENSTADT, or SZEBENY, the *Cibinium* and *Hermanopolis* of the ancients, is a town of Hungary, and the capital of the province of Transylvania. It is situated in a champaign country, near the river Cibin, or Szeben, from which it derived the name of *Cibinium* and Szebeny. The principal public buildings are three monasteries for men, and one convent for women. One of the monasteries is for Ex-Jesuits, another for Catholics of the Franciscan order, and another for Greek monks of the order of St Basil. There is also a theatre, which is open during summer, a cassino, a public school for Protestants, and another for Greeks. In the great square there is a statue. The town is fortified with a double wall and deep moat. The museum of Baron Bruckenthal, a venerable nobleman, contains one of the finest collections in Europe of pictures, antiquities, and natural history. Dr Clarke has given a very minute description of it. The soap works of this town have been long celebrated; and the tallow candles manufactured here are so white, that there is a great demand for them at Vienna. The chateau of Freck, in the vicinity of the town, is worthy of being visited. The town was founded by Hermannus, a Greek emperor. It is well built, large, and populous, and contains from 15,000 to 16,000 inhabitants. The climate is said to be insalubrious. See Clarke's *Travels,* part ii. sect. iii. Supplement, p. 603, &c.; and *Hermannstadter Handlungs, gewerbs-und Reise-Kalender,* by M. Hochmeister, 1790.

Hermaphrodite.

HERMAPHRODITE, is a living being possessing the organs of generation belonging to both sexes.

On surveying the origin, the progress, and decay of the animal creation, there is sufficient reason to infer, that nature is infinitely more solicitous about preserving the different genera and species than the individuals of the race. Thus where their continuation is required by mutual concourse, as among the larger and more perfect creatures of the earth, it is necessary that the sexual organs of each should be reserved distinct and entire. Though accidental monstrosities ensue in other parts, the animal functions can be carried on, and sometimes with little injury; but imperfections in that portion of the frame appropriated for procreation, is for the most part an impediment to the laws which regulate the reproduction of living beings.

Nevertheless, the sexual organs, like other parts of animated matter, are liable to exhibit malformation, or monstrosities; and hence an idea has originated, that in man and different animals, the qualities of a perfect male and female may be united in the same individual. The fables of the ancients have perhaps conspired to give probability to these opinions. According to their allegories, a son of Mercury and Venus, who had been fostered by the Naiads of Ida, became enamoured of the nymph Salmacis, who fled from his embraces. But he joined her in a fountain where she could escape no longer, and besought the gods that their bodies might be united in one. His prayers were heard.

> " Vota suos habuere deos: nam mista duorum
> Corpora junguntur, faciesque inducitur illis
> Una . . . .
> Nec duo sunt et forma duplex nec femina dici
> Nec puer ut possint: neutrumque et utrumque videntur."
> OVID *Metam.* lib. iv. cap. 9.

This androgynous being was thenceforth called Hermaphroditus, (whence the derivation of hermaphrodite,) and affords a subject for many beautiful sculptures from the hands of the ancients, which are still preserved.

No question has been more keenly agitated than the existence of human hermaphrodites; and the difficulty of the subject has been greatly increased, by that anxiety with which mankind conceal their nakedness; and, by an unjust abhorrence entertained against whatever seems beyond the standard of ordinary configuration. The Jews, for example, have a long catalogue of denunciations against persons labouring under disease or infirmity, natural or accidental; and even in the islands which we ourselves inhabit, monstrous productions of animals are almost invariably destroyed, as also those of mankind, where it can be effected with safety. But the vehemence of civil institutions seems to have been more conspicuously directed against those unfortunate beings known to labour under malformation of the sexual organs. At an early period of Roman history, a law was enacted, that every child of this description should be shut up in a chest and thrown into the sea; and Livy gives an instance where, on some difficulty with respect to the sex of an infant, it was directed to be thrown into the sea, *tanquam fœdum et turpe prodigium*. Nay, such a visitation seems to have been considered a mark of divine vengeance, for the execution was always followed by religious rites. The Jewish law is extremely solicitous regarding the disposal of hermaphrodites: the civil and canon law contain numerous hypotheses and enactments concerning them, and their succession is provided for by the laws of England.

The general scope of these laws tends to form regulations which shall apply according to the apparent predominance of sex; for the ancient legislators, though sufficiently aware of this distinction, do not seem to have admitted hermaphrodites as possessing a complete duplication of the generative organs. Being undoubtedly founded on experience, they cannot be considered void of interest. The numerous and diversified ordinances of the Talmud divide hermaphrodites into four classes; under which aspect they are to be treated partly as male, partly as female; next, as both male and female; and, lastly, as neither male nor female. First, they are like men, in being obliged to dress in male attire, and marry their brothers widows. Secondly, they are like women, because they may not converse with the male sex alone in private; they may walk among the dead; and are prohibited from bearing testimony: also, because they may shave their heads after a particular fashion, and pluck out their beards. Thirdly, they are to be esteemed both men and women, from having their share of the paternal and maternal inheritance, and such other succession, which they may claim as of either sex: they may retire to a sanctuary in case of accidental slaughter, and remain there as if it had been of either a man or woman; and if it be murder, they shall be put to death as for killing either a man or woman. Fourthly, hermaprodites are to be considered neither man nor woman, by the law of Moses, in striking or calumniating another, but the judge shall ordain reparation; nor in making vows to the Deity, or in withdrawing from the world to devote themselves to his service. Many other partitions are made under these divisions. The canon and civil law displays all that uncertainty which is the natural offspring of prejudice, and the want of knowledge. Doubts and questions are started, useless to society, and oppressive to those affected by them; and in general they are, as in the Jewish law, to be solved according to the predominance of sex. Notwithstanding the numerous and absurd restraints put upon supposed hermaphrodites, it does not appear that they are precluded from marrying; on the contrary, if the two sexes in themselves be equal, a choice of the object is left, while other cases of marriage are regulated by the sexual predominance. However, should the question be regarding an oath, the ordinances of the church seem to declare, that under the same equality of organization the testimony must be rejected. Hermaphrodites may not be promoted to holy orders, on account of deformity or monstrosity; nor can they be appointed judges, "because they are ranked among infamous persons, to whom the gates of dignity should not be opened." These are but a few of the prohibitions levelled against them. Many are cruel and unnecessary; and of so singular a kind, that a learned and humane physician exclaims, "would not any one conceive, that these supposed androgyni, instead of being of the same nature with us, however marked and deformed their parts of generation might be, were rather another race of animals, *sui generis*, than what they really are, when a string of laws, compiled with so much accuracy, and in such a formal manner, has been exhibited and increased in all ages?" Yet rational enactments, founded on experience, are by no means void of utility; for observance of the law may prevent contention in all the mazes of doubt. Thus M. Ferrein, a modern physician, acquaints us, that he was consulted by the relatives of a young nobleman, labouring under a dubious conformation, who, if a male, as was commonly believed by them, would inherit a considerable estate, to which he could have no right if belonging to the other sex. Having afterwards occasion to illustrate the case, we shall not here anticipate the result. The subject of succession is doubtless fit for regulation, and consequently must frequently be determined by the predominance of sex. Happily the absurd penal laws, directed against this portion of our fellow creatures, are obsolete among us.

We shall now proceed to the opinions of recent philosophers and naturalists, which afford more copious sources of knowledge and entertainment. These are widely different from what were received of old, and most of the moderns incline to a different opinion: they doubt whether there is any well authenticated instance of a person having been seen with the organs of both sexes complete.

The origin of sex is in itself a dark and mysterious subject. That of no living animal can be distinctly recognised at an early period of existence; and some naturalists affirm, that there is reason to believe that the organization is such as to admit the evolution of the parts of the embryo, distinguishing either male or female; and that this evolution takes place during some period of gestation. Thus Ackermann adopts the principle, that *in omni individuo latent utriusque sexus genitalia, a modo dictis dependet circumstantiis an hæc an illa evolvi et increscere debeant.* The cause of evolution, however, if we rightly understand the author, will scarcely be admitted by naturalists; for he seems to ascribe it to matter of which the presence can only be presumed; *Discrimen quod a sexu est non absolutum sed ad ceteras partes respectivum dici debet. Sicut fœtus vel ex materiei plasticæ excessu vel ex oxygenii abundantia, coaluit, et prout in prima uterinæ vita epocha in fœtus incrementum vires agunt extraneæ, ita jam vir jam femina nascitur.* Sir Everard Home also appears to consider "the ovum, previous to impregnation, to have no distinction of sex, but to be so formed as to be equally fitted to become a male or female fœtus." On descending to the insect tribes, we find an intermediate kind between the two sexes, in those called neuters, incapable of generation. But certain naturalists have shewn, by ingenious experiments, that among bees, where this distinction is most prominent, the imperfection may be removed by a particular sort of food early supplied, and the sexual organs of females amply unfolded.

Intermixture of the sexual organs.

Leaving the subject of proper hermaphrodites, or those with the combined sexual organs entire and capable of performing the generative functions, we shall now give some account of the three classes into which hermaphrodites may be divided. First, individuals exhibiting a mixture of the sexual organs, neither being complete; secondly, men labouring under a malformation of the parts; and, thirdly, females with analogous imperfections, by enlargement or defect. Examples of the first are extremely rare. Such perhaps is a case mentioned in Dr Baillie's *Morbid Anatomy*, where the person was 24 years of age, and examined as a patient of Nottingham hospital; and such perhaps was an androgynous child, which is the subject of discussion by Ackermann. Another instance is related in the *Journal de Medicine*, of a person who was long considered a woman, treated as such in society, and who was either married or lived in concubinage with a man. At the same time, others may consider all these as more strictly belonging to the class of males with malformation. The androgynous child of which we speak was born at Mentz in June 1803. Its singularity of structure was supposed indicative of the masculine gender by those present, and it was baptised as such. Having died at the age of five or six weeks, Ackermann, who had previously inspected the external configuration, obtained an opportunity of dissection, though the organs had declined along with the decay of the body during sickness. He found an intermixture of the sexual distinctions, removing the infant from a perfect male or female; the glans imperforate, scrotal labia, an uterine sac, and other doubtful indications, of which he has given an ample detail, illustrated by engravings; and at the same time he expresses his conviction of the androgynous nature of the subject.

A remarkable case came under the notice of some of the most learned continental physicians in the preceding century, respecting Michael Ann Drouart, a native of Paris, born about the year 1734. This individual was baptized, treated, and dressed as a girl, but having attained the age of 16, a report was circulated of her being a hermaphrodite, which led to a minute inspection by M. Moraud, who has presented us both with the result in detail, and several engravings. He found the external configuration partly masculine, partly feminine, but the former predominated. It corresponded to the age of the person, whereas the female characteristics belonged to a period of childhood, or early adolescence. An organ denoting virility appeared, but the urethra was absent; neither could he determine the exact point of a deep fissure, occupying the scite of the scrotum, into which the urine was discharged; and other medical men were equally unsuccessful. The breast was quite flat, and it always remained so; the person had the gesture, step, and voice of a youth, some rudiments of a beard on the upper lip, and a decided propensity for females." Yet, says M. Moraud, "there was a strange intermixture of the sexes in all respects; for the bason was more enlarged; and in comparing the two thighs together, one resembled that of a male, and the other that of a female." From these and concomitant circumstances, he formed an opinion that the subject was a male. Michel having left Paris some time after, underwent another inspection by M. Cruger, principal surgeon to the King of Denmark, who was induced, on the other hand, to consider the female character predominant; but he concludes on the whole, that in strict definition the subject was neither male nor female. At the age of 21, some Genevese physicians had an opportunity of making their observations. The principal organ now exceeded the ordinary human dimensions in every respect; a thin black beard, nearly such as a young man of that age should have, appeared; and the breast and stature were completely those of the same sex. But now the propensities for males were supplanted by those formerly entertained; for at the age of 17, those evacuations characterising females of the human species had commenced, but experienced many irregularities and interruptions; and in 1761, had ceased for nearly three quarters of a year. Cotemporary observers were then inclined to depart from M. Moraud's sentiments, and to believe that there was a predominance of the female sex. However, some of the most recent authors, and those who have studied the subject most profoundly, seem to rank Michel Anne Drouart with hermaphrodites, exhibiting an intermixture of the sexual organs. M. Ferrein found the appearances in the more youthful subject above alluded to, completely the same as in the preceding individual in the essential parts.. The whole external mien, intimately resembled that of girls at twelve years of age; the breast was quite flat, and the voice rather masculine. The external sexual organ, which would have indicated a male, was much smaller, though of the same structure as before; those of the female were somewhat misplaced, but the position of the urethra could be easily ascertained. Enough was disclosed, to induce M. Ferrein to declare, that this young nobleman was in fact a female, and would consequently be deprived of the expected inheritance. If his opinion be correct, the present case should be removed to the third class of persons designed hermaphrodites, though, from the doubts of the learned respecting the former, we are induced still to retain it here. It is not the structure of the sexual parts which is alone to be taken into view, but the total organization combined. The personal configuration, the habit of the body, the presence of a beard, the quality of the voice, propensities and dispositions, and other characteristics, added to any uncommon structure of these parts, shew that some of the male and female properties are confounded together. At an early period of gestation, human females are frequently mistaken for males; and hence an erroneous opinion has prevailed, of abortions at certain stages being more commonly of males. Many such fœtuses have been exhibited by Dr Parsons and others in illustration of the fact: and Mr Ferrein concludes his observations on the preceding case, with words of the following purport: "If to constitute a hermaphrodite, wherein the sexes are combined, it is necessary to have the distinctive character of the male united to the female parts, there never was any woman who has not been a male during several months of her existence. In the earlier stages of pregnancy, that distinctive organ is prominent, and fashioned very nearly after the manner of males, so that those unskilful in anatomy, may suppose the embryo a male, though truly a female; nor on narrow inspection is the difference easily ascertained." The possibility of a complete duplication of the male and female organs is questioned, from there being no place in the human body which they could occupy, or wherein they could be contained. The same difficulty does not occur to us, and perhaps it can only be admitted where all the other parts, independent of them, are meant to be exactly of the natural structure and proportions. If so intimate a resemblance prevails in the sexual parts of the male and female embryo, something of an intermediate kind may be produced, should the position and developement of either be deranged; and thus exhibit an intermixture of sex: or, as we have sometimes witnessed a complete duplication of some essential organ, as the head, hands, or feet, the like may happen to other parts. Among animals, very extraordinary instances have occurred of some decidedly males, to external appearance, nevertheless possessing female properties, such as the power of secreting milk. This faculty, indeed, is said in rare examples to reside in the nipples on the breast of men, the use of which is yet unknown by anatomists. A bull, which is reported to have generated five calves, had a small udder and small teats, which afforded a quantity of milk that on one occasion is said to have amounted to an English pint. In the *Philosophical Transactions* also, there is preserved an account of two wedders giving suck to lambs. Yet we cannot be too scrupulous in admitting such wonderful deviations from the course of nature. At the same time it must be recollected, that

Hermaphrodite.

the rudiments of the mammæ exist in all the males of mankind and quadrupeds; and that before the age of puberty in the former, and when the powers of procreation cease, there is a more intimate resemblance between the sexes than at other periods. Nor is it to be omitted, that emasculation produces a decided approximation to the feminine character.—But, in prosecuting the intermixture of sexes in animals, an example is generally given in the free martin, on which the late celebrated Mr John Hunter observes—"When a cow brings forth two calves, and one of them a bull calf and the other to appearance a cow, the cow calf is unfit for propagation, but the bull calf becomes a very proper bull. This cow calf is called in this country a *free martin*." Mr Hunter, on dissection, found such an intermixture of organization, that the animal always partakes of the nature of both sexes, though that of the one is sometimes more predominant than that of the other. Its external aspect is also different from the appearance of each, and it never betrays any sexual propensities. The muscular texture and the voice are peculiar, and the size is considerably larger than that of either bull or cow. Apparently there is much analogy between the free martin and an emasculated animal. Mr Hunter observes, that he has frequently seen hermaphrodite horses; that he dissected a hermaphrodite ass; and that sheep of this description are also to be found. The dissection of a hermaphrodite dog is given by Sir Everard Home in the *Philosophical Transactions* for 1799, where there was only one characteristic of the female decidedly present. However, there appear several reasons to conclude, that some of the animals quoted as undoubted hermaphrodites, ought rather to be classed with females labouring under vicious conformation. The intermixture of the masculine organs is not sufficiently prominent.

It has been observed, that among wild pheasants, a hen sometimes appears with the feathers of a cock; yet, on dissection, the female organs are found complete. Mr Hunter conceives, that this is a change which ensues at a certain age, and subsequent to the cessation of the procreative faculties; and he traces the history of three, where the alteration took place. But on descending still lower among the animal tribes, we find a multitude of beings apparently possessing the absolute character of hermaphrodism. Many of the mollusca contain individually the perfect organs belonging to either sex, not by accidental admixture or malformation, but by regular, natural arrangement. A sexual union takes place; all impregnate, and are impregnated; and this ensues by a singular and interesting distribution of the parts. Such is the case with many of the mollusca, or soft bodied animals with external organs, and those in general included under the order Helminthology. There can be no generation, however, without their mutual concourse; but in the animalcula infusoria, some seem perfect hermaphrodites, in so far as they propagate in an isolated state, while in others the sexual union seems requisite. In the numerous genus of polypi, the young animal protrudes from the side of the mother, and in its turn becomes a parent in the same way, while no union with another sex follows; or, as in the actinia, the young are formed within, and then discharged by the mouth. The subject of hermaphrodism may be still farther illustrated by a series of experiments which have recently been made on an extraordinary race of animals bearing some analogy to the leech and snail, called *planariæ*. In one species, the sexual union takes place, and the result is eggs including young. In another, this union is never observed, but a portion of the tail separates by spontaneous division. It remains a shapeless mass, and absolutely quiescent, until the evolution of wanting organs enables it to perform all the functions of the parent. Having remained a certain time complete, this new animal loses a fragment of the tail to become another perfect being; and thus their race is carried on. These creatures, therefore, seem to possess such structure as to enable each individual to reproduce its like.

Instances of mixed organs are of very rare occurrence in the human race. The most uncommon kind of configurations, indeed, are those which pass by the name of hermaphrodism. The older authors, nevertheless, on finding any monstrosities or imperfections in the sexual parts, immediately pronounced the individual a hermaphrodite; but as they were constantly in search of the marvellous, we must repose the less confidence in their observations. Nay, the moderns have, in some cases, too hastily bestowed this character; and we are told of an instance where "the fore parts of the unhappy object were entirely wanting; even the bladder was not entire. It had the appearance as if the external parts of generation, and the anterior part of the bladder, had been cut off. Yet this unhappy object was vulgarly called a hermaphrodite."

Masculine malformation.

The malformations of men are more frequently seen and constitute the second class of hermaphrodites. Mr Brand relates, that being consulted in 1779, on occasion of some complaint in the groin of a child seven years of age, he found a vicious structure of the sexual organs, consisting of the unnatural presence of an integument confining the parts. This child had been baptized and brought up as a girl: but it was evident to him erroneously, for the male organs were present. By a slight incision of the integument, he liberated the restricted parts, and proved, to the great admiration of the parents, that they had mistaken a boy for a girl. The operator narrates these facts in a pamphlet, accompanied by three engravings as large as life, of the appearances before and after the operation. Wrisberg, a German anatomist, in discussing a case of malformation, quotes an instance of a child probably labouring under a similar restriction. The parents, who were Jews, entertained so much doubt regarding the sex of their offspring, that they had deferred the accustomed rite of circumcision until it should be determined whether it was actually a boy or a girl. But it died at the age of eight months. The same author mentions, that he removed a lesser restriction in a young man; and speaks of another person aged 46, reputed a hermaphrodite, who would not consent to undergo an operation, which, perhaps, would easily have determined his sex. His wife, to whom he had been married five years, then obtained a divorce against him, on account of impotency. An example of a mistake in sex under more doubtful circumstances, is given by Abraham Kaau Boerhaave, a member of the Petersburgh Academy of Sciences. The child of a trumpeter was baptized Charlotte, and for some time brought up and treated as a girl. But the parents afterwards entertained some doubts regarding its real sex, and at the age of seven resorted to skilful persons to establish the truth. Instead of being a girl, as had been supposed, it was declared to be a boy. Sex, however, is much more doubtful, though the predominance of organization indicates the male, where the scrotum is

Hermaphrodite.

absent, with a fissure in the perinæum, or a misdirection of the urethra. In the Transactions of the Academy of Siena, a person named Augustine Broli, is described as being reputed a hermaphrodite, and having so little of the male configuration, that he doubted whether he ought to marry. On consulting Dr Caluri, however, he was assured he might do so with safety. If the description be correct, procreation was impossible. Persons have been mistakenly educated and employed as of a sex to which they did not belong. This was the case with a young man who was brought up and dressed as a woman, yet after he died he was found to be essentially a man. Caspar Bauhin, likewise, speaks of a servant hired by a peasant, who being viewed with remarkable favour by his wife, led to an unexpected discovery of sex, under a malformation. An instance of doubtful sex, though more probably referable to the third class, is quoted by Ackermann, in the case of Dorothea Derrier. Here opposite opinions were entertained by three medical men, Hufeland, Mursinna, and Stark, from the sexual formation conjoined with the general character of the whole body. The malformation of the male seems to be much more uncommon in animals, or perhaps it has attracted less attention.

Feminine malformation.

But the third class into which beings with a preternatural sexual structure may be divided, namely, females with malformations, is the most comprehensive of the whole. Nay, there are reputable authors who include all the rest under it, maintaining, that among the human race especially, the issue of every questionable case is, proving the subject a woman. Many examples are collected by Dr Parsons, to whose *Mechanical and Critical Enquiry into the Nature of Hermaphrodites*, we shall refer for the detail. The females of this class are sometimes designed the *macroclitorideæ*, from the preternatural enlargement they exhibit, and which is frequently such as to assume the appearance of virility, even in an adult. In the warmer climates, this being more usual, though probably not to a great extent, but attended with other circumstances, the operation of excision, concerning which the reader may consult the eastern travellers Niebuhr, Bruce, and Browne, is resorted to. Yet this malformation generally has other concomitants, either in corresponding restrictions in the rest of the sexual organization, flatness of the breast, woolliness on the chin, or a hoarser voice than belongs to females. De Graaf, a celebrated anatomist, mentions a female child which, from a preternatural enlargement, had been taken for a male, and baptized as such. It died, and he, along with several physicians and surgeons, having obtained an opportunity of dissecting the body, first had a drawing made of the external appearance; and then proceeding to a more strict examination, pronounced the organs those of a female only. An account has been given of a hermaphrodite in France, which merits particular attention, either in establishing the fact of hermaphrodism, or in illustrating how the learned may be deceived. Towards the year 1686, a maid-servant, named Margaret Mauluse, born near Tolouse, was brought to the hospital of that city. She was about 21 years of age, with a feminine mien and appearance, a handsome face, and agreeable expression, her bosom well formed, but she presented the male sexual organization, intermixed with the female structure. The evacuations peculiar to the sex were regular and abundant, as was testified by the attending physician; and, according to what he understood, the secretions denoting virility were proportionally copious. These facts being known to several physicians, the vicars general were consulted on the subject, and the result was to compel the hermaphrodite to adopt the apparel of a man, under the name of Arnaud Mauluse, and to learn some profession. We are further told, that those concerned had no difficulty on the point, because "the hermaphrodite was sufficiently capable of the functions of a man, but of none belonging to a woman." Notwithstanding the necessity of compliance, however, this individual seems to have been dissatisfied with such a compulsory change of sex, and not finding it congenial to her nature, she afterwards solicited the king's permission to resume female attire. Some persons have supposed, that she merely exhibited a *prolapsus uteri* of an unusual form. Even within these few years, a woman was shewn as a hermaphrodite in London, pretending to the capacities of a male, who suffered under the same disease. The deception was detected, but not until a large sum had been realized by her, when she changed her abode. However, the enlargement exciting the idea of the presence of virility, is beyond dispute in adult females. Realdus Columbus says, a gipsey, whom he conceived to be a hermaphrodite, requested him to perform an amputation of the superfluous organization, which he declined from apprehensions of danger. Between 1730 and 1740, an African slave being brought from Angola to Bristol, and carried from thence to London, was exhibited as a hermaphrodite. She was about 26 years of age, presented nothing masculine in voice or appearance, but exhibited the like enlargement as before, attended with some other slight malformations. Dr Douglas made drawings of the whole; and Mr Parsons having also seen the individual, concluded that she was absolutely a female. In the year 1750, a French woman, aged 18 years, was shewn also in London as a hermaphrodite, with what was called, "an inordinate enlargement" of the organ, and corresponding restrictions of a preternatural appearance. Sir Everard Home speaks of a Mandingo woman, carried from Africa to the East Indies, with flat breasts, a rough voice, and masculine countenance; who exhibited, besides, all the appearance of virility in enlargement, while the rest of the sexual organization seemed in the natural state.

It is exceedingly probable that almost the whole animals vulgarly esteemed hermaphrodites are of this class, females with malformations; because whatever uncertainties prevail, there is always a decided predominance of the latter sex, though the masculine nature be very obscure. From these and similar uncertainties, a change of sex is said to have sometimes ensued in mankind. Nor is it improbable that this was firmly credited, since a diseased female may, to cursory inspection, manifest the semblance of virility. This imaginary change is most usually of women into men, and rarely of men into women. However Caspar Bauhin relates, that a child was baptised as a boy, became a soldier, and married a woman, with whom he lived seven years. But the supposed husband himself becoming pregnant, was most unexpectedly delivered of a daughter; and upon an investigation by the magistrates of the place of his residence, it appeared there was a malformation, never disclosed by the wife, and that the husband had on some occasion cohabited with a Spaniard. Thus the person supposed to be a male, proved in fact to be a female. Another instance, which seems to have been first related by Dr Douglas, an eminent anatomist, happened in London, where one of two waiters living in a tavern

Reputed change of sex.

in like manner became pregnant by the other, to the great astonishment of the neighbourhood, at the reputed change of sex; and her dress was thenceforward changed to that of a female. The examples above given, shew that it is possible to mistake the sex of an infant from preternatural organization, but that the real nature of the individuals may be disclosed with the evolution, if we may so call it, of the sexual propensities.

The masculine and feminine character is deeply influenced by the state and condition of those organs which nature has appropriated for the perpetuation of the species. Thus the analogy between the sexes, hardly separable in the embryo, is infinitely greater during childhood, before the complete developement of the generative faculties, and after the procreative powers have ceased, than in the intermediate period. A corresponding analogy is produced by the destruction of the essential parts, or by their vitiated expansion. The eunuch is weak and timid, the beard is wanting, the voice shrill, and he seldom possesses a vigorous intellect. His whole personal configuration and mental disposition are approximated to those of females. On the other hand, where the essential organization of women is injured, there is some tendency by nature to remove them from their original sex. Cases of this kind can seldom occur, but such was the effect in the necessary extirpation of an ovary on account of disease; and also in another instance where the full developement of the ovaries had not ensued. It is impossible to admit the last class of hermaphrodites, females with preternatural enlargements, accompanied by a hoarse voice, indications of a beard, flat breasts, and masculine propensities, along with women exhibiting none of these peculiarities. They are somewhat removed from females, as men whose person and mind are of a corresponding description, are somewhat removed from the entire and vigorous sex. The difference arises from sexual organization. It has also been conjectured by some learned authors, as Wrisberg, that women of masculine manner and appearance, and men exhibiting an extraordinary degree of effeminacy, may be divided into two distinct classes, the former characterised by ten, the latter by six peculiarities, among which sterility is common to both. These he supposes to be dependent on sexual organization; and it is worthy of remark, that weakness of intellect is almost invariably concomitant on the imperfect expansion of the generative parts, whether this is prevented by natural infirmity, or by violence in childhood.

Perhaps all the varieties of configuration which we have thus endeavoured to reduce to three classes, may be ranked in general under monstrosities. Nothing can be more interesting than to investigate the elements of sexual distinction. In whatever manner the expansion of these elements may be deranged, the result is monstrosity, as in other cases, by excess or defect, or some unnatural combination of what would constitute a male or female imperfectly developed. This vicious configuration, though for the most part the lot of some solitary individual, as other monstrosities, prevails in families where there are also perfect beings. One instance is given by Kauu Boerhaave in two young Siberians, and another by Sir Everard Home, in two children born in Devonshire. The latter were males with malformations: They were idiots, and they were of an uncommon size. The parents had an intermediate child, who was a perfect girl. See Ackermann *Infantis Androgyni Historia.* Haller *Commentatio ap. Gottingen Transact.* tom. i. *Novi Comment. Academ. Petropolit.* tom. i. and xvi. *Memoires de l'Academie Royale*, 1720—1725, and 1750, 1756, 1767. *Philosophical Transactions*, 1751, 1799, 1805. Parson's *Enquiry*. Brand's *Case of a Boy who had been mistaken for a Girl.* Hunter *On the Animal Economy*, p. 45. *Phenomena of Planariæ.* (c)

HERMOPOLIS. See Civil Architecture, vol. vi. p. 573, col. 2.

HERNIA. See Surgery.

HEROD, King of Judea, surnamed the Great, on account of his power and talents, as it frequently happens, rather than of his virtues, was the second son of Antipater the Idumæan, and was born at Ascalon in Judea, about seventy years before the Christian æra. At the age of twenty-five, he was appointed by his father to the government of Galilee, where he distinguished himself by the suppression of a band of robbers, and the execution of their leader Hezekiah, with several of his comrades. Having performed this service of his own authority, and executed the culprits without even the form of trial, he was summoned to answer for his conduct before the Sanhedrim; but he escaped both punishment and censure, through the strength of his party, the zeal of his friends, and his own abilities and dexterity.

In the civil wars of Rome, Herod at first embraced the party of Brutus and Cassius, and was, in consequence, made governor of Cælesyria; and, after their death, when Mark Antony arrived victorious in Syria, he and his brother contrived to ingratiate themselves with him, and were appointed tetrarchs in Judea. But in a short time afterwards, in consequence of an invasion by Antigonus, who was assisted by the Jews, Herod was compelled to make his escape from Jerusalem, and to retire, first to Idumæa, and then to Egypt. He at length arrived at Rome, and upon occasion of a disputed succession to the crown of Judea, between the two branches of the Asmodean family, he found means, through his own intrigues, and the influence and powerful recommendations of Mark Antony, to obtain a decree of the senate, conferring that kingdom upon himself. Immediately thereafter he repaired to Judea, and in the course of about three years, succeeded in getting possession of the whole country. But this success was not obtained without bloodshed. The throne was at that time in the possession of Antigonus; and although aided by the Roman army, Herod was obliged to lay siege to Jerusalem, which held out for six months, when it was at length carried by assault, and a great slaughter made of the inhabitants. Antigonus was taken prisoner and put to death. The attention of Herod, upon assuming the government, was first directed towards the replenishing of his treasury, and repressing the Asmodean faction, by whom he was regarded as an usurper. In the pursuit of these objects, he was guilty of many oppressive acts of extortion and cruelty. Soon after this, an accusation was lodged against him before Mark Antony by Cleopatra, who, it is said, was influenced, upon this occasion, by his mother-in-law, Alexandra. Having been summoned to appear before the triumvir, to answer to the charges exhibited against him, he contrived, by great pecuniary sacrifices, to make his peace with Antony, and returned in high credit to his kingdom. It was upon this occasion that he displayed that conflict of passions, which for ever embittered his domestic life. Being distractedly fond of his wife Mariamne, and unable to endure the thoug't of her falling into the hands of another, he exacted a solemn promise from Joseph, whom he appointed to govern in his absence, that if the accusation should prove fatal to him, he would put the queen to death. Joseph disclosed the secret to Mariamne, who, indignant at this savage proof of his affection for her, conceived from that moment a deep and settled aversion to her husband. Upon his return, some hints were thrown out respecting Joseph's familiarity with Mariamne during his absence. These suspicions he communicated to his wife, who immediately recriminated, and upbraided him with his cruel order concerning her. His fury then became unbounded. He put Joseph to death for betraying the secret confided to him, and threw his mother-in-law Alexandra, into prison. About this time he received a visit from Cleopatra, who is said to have entertained amorous inclinations towards him. These, however, Herod did not gratify, but endeavoured to glut her avarice with profuse donations.

In the war which broke out between Antony and Octavius, Herod levied an army for the support of the former; but was obliged first to encounter Malchus, king of Arabia, whom he defeated and compelled to sue for peace. After the decisive battle of Actium, his great object was to make terms with the conqueror; and, as a preliminary step, he put to death Hyrcan, the only surviving male of the Asmodean family. Having taken this precaution to secure himself, he embarked for Rhodes, and appeared before Augustus in all the ornaments of royalty excepting his diadem. With all the appearance of noble and ingenuous confidence, he related the faithful services he had performed for his benefactor Antony, and hinted that he was ready to transfer his gratitude and allegiance to a new patron, from whom he should hold his crown and kingdom. Augustus was struck with the apparent magnanimity of this defence of his former conduct, and replaced the diadem on the head of Herod, who continued to be the most favoured of his tributary sovereigns.

But the good fortune which Herod experienced, as a prince, was poisoned by domestic broils, and particularly by the insuperable aversion of his wife Mariamne, whom at length he brought to trial, convicted, and executed. She submitted to her fate with all the intrepidity of conscious innocence, and was sufficiently avenged by the dreadful remorse of her husband, whose peace of mind was for ever afterwards destroyed. In vain did he endeavour to banish her memory by scenes of dissipation and cruelty: the charms of his beloved Mariamne haunted him wherever he went; and he would frequently call aloud upon her name, as if willing to forget that she was no longer among the living. At times he would fly from the sight of men; and on his return from solitude, which was ill suited to a mind stricken with the consciousness of guilt, he became more brutal and ferocious than ever, and in his fits of phrenzy spared neither friends nor foes. Alexandra, who had always exhibited the utmost malignity towards her daughter, fell the unpitied victim of his rage. At length he appears to have recovered some portion of self-possession, and employed himself in projects of regal magnificence. He built at Jerusalem a magnificent theatre and amphitheatre; in which he caused games to be celebrated in honour of Augustus; to the great displeasure of the zealous Jews, who discovered Gentile profanation in the theatrical ornaments and spectacles. These, and other offensive acts, excited a most serious conspiracy against him, which he, fortunately for himself, discovered, and exercised the most brutal revenge on all the parties concerned in it. He next built Samaria, which he named Sebaste, and adorned with the most sumptuous edifices; and for his security, he erected several fortresses throughout the whole of Judea, of which the principal was called Cæsarea, in honour of the emperor. At the dedication of this last new city, he displayed such profuse magnificence, that Augustus said, "his soul was too great for his kingdom." The same taste for sumptuous magnificence was exhibited in his palaces, on which he lavished the most costly materials and workmanship. To supply the place of his lost Mariamne, he married another wife of the same name, the beautiful daughter of a priest, whom he raised to the high rank of the supreme pontificate. His two sons by the first Mariamne he sent to be educated at Rome, and so ingratiated himself with Augustus and his ministers, that he was appointed imperial procurator for Syria.

With the view of acquiring popularity among the Jews, and of exhibiting an attachment to their religion, he undertook the vast enterprize of rebuilding the temple of Jerusalem, which he completed in the course of about a year and a half, in a noble style of magnificence. During the progress of this work he visited Rome, and brought back his sons, who had grown up to manhood. These, however, at length conspired against their father's person and government; and were tried, convicted, and executed. It was in reference to this transaction that Augustus is reported to have said, that "it was better to be Herod's hog than his son."

In the thirty-third year of his reign, occurred the memorable event of the birth of our Saviour; upon which occasion, according to the Gospel of St Matthew, the jealousy of Herod was so highly excited by the prophetic intimations of the future greatness of the Messiah, that he slaughtered all the infants in Bethlehem, in hopes of destroying him among the number. About this time Antipater returning from Rome, was arrested by his father's orders, and accused of treasonable practices. He was found guilty of conspiring against the life of the king. This and other calamities, combined with a guilty conscience preying upon a broken constitution, threw the wretched monarch into a loathsome and mortal disease, which has been represented by historians as a just judgment of heaven for the many foul enormities and impieties of which he had been guilty. In truth, his cruelty appeared to increase as he approached the termination of his career. A premature report of his death caused a tumult in Jerusalem; and those who had been imprudently concerned in it, were immediately seized, and put to death, by order of the dying king. He also caused his son Antipater to be slain in prison, and his remains to be treated with every species of insult and ignominy. Even on his death-bed, he had planned a scene of more atrocious cruelty than he had ever devised or attempted at any former period of his life. He summoned the most considerable persons among the Jews to Jericho, and caused them to be shut up in the hippodrome, or circus, and gave strict orders to have them all massacred, as soon as he should have expired. "This," said he, "will provide for my funeral all over the land, and make every family in the kingdom lament my death." Fortunately, however, this savage order was not executed by those to whom it was entrusted

Herod expired in the sixty-eighth year of his age, and the thirty-fourth of his reign. He bequeathed his kingdom to his son Archelaus, and left tetrarchies to his two other sons. The character of this monarch exhibits a combination of great talents and great vices. The success which attended his enterprizes, and which shed a false though dazzling lustre around his government, has given him an eminent rank in the list of sovereigns; while the savage disposition, which appears to have taken delight in the most revolting and horrible acts of cruelty, has consigned his memory to merited detestation. He was the first, it may be remarked, who shook the foundations of the Jewish government. He appointed the high priests and removed them at his pleasure, without any regard to the laws of succession; and he entirely destroyed the authority of the national council. In short, his reign was similar to that of most able tyrants; splendid and glorious to outward appearance, but, in reality, destructive of the prosperity of the kingdom over which he presided. See Josephus, Prideaux, Lardner; *Univers. Hist.*; and *Gen. Biog. Dict.* (z)

HERODOTUS, the most ancient of the Greek historians whose works are extant, and thence called by Cicero the Father of History, was born at Halicarnassus in Caria, in the first year of the 74th Olympiad, or about 484 years B.C. The name of his father was Lyxes; that of his mother Dryo The city of Halicarnassus being at that time oppressed by the tyranny of Lygdamis, grandson of Artemisia, Queen of Caria, Herodotus quitted his country, and retired to Samos; from whence he travelled over Egypt, Greece, Italy, &c. collecting every where all the information he could procure concerning the origin and history of nations. He then began to digest the materials he had thus collected, and composed that history which has preserved his name and reputation even to our times. He is generally supposed to have written it in the island of Samos, where he studied the Ionic dialect, in which his history is composed; his native dialect being the Doric. He afterwards revisited his native place, and is said to have greatly displeased and irritated his countrymen, in consequence of having contributed, by his influence, to the overthrow of the government, and the expulsion of the tyrant Lygdamis, which obliged him again to go into exile. When he had attained his thirty-ninth year, he was induced, by the desire of fame, to recite his history to the people assembled at the Olympic games. It was received with universal applause, and procured him a general and permanent celebrity throughout all the states of Greece. The place and period of his death are uncertain; but it is probable that he died in exile in a town of *Magna Græcia.*

The history of Herodotus embraces a period of about 240 years, from the time of Cyrus the Great, to Xerxes; and contains, besides the transactions between Persia and Greece, a sketch of the affairs of other nations, as of the Lydians, Ionians, Lycians, Egyptians and Macedonians. The work is divided into nine books, which are called after the nine muses, not by the historian himself, but, as it is thought, by the Greeks at the Olympic games, when they were first recited, as a compliment to the author.

As an historian, Herodotus has been generally censured for betraying too great a partiality for the marvellous. But it may be remarked in his justification, 1*mo*, That the truth of many of the physical phenomena which he relates, and which were considered as incredible prodigies by the ancient writers, has been abundantly confirmed by modern discoveries; and, 2*do*, That Herodotus compiled a great part of his history from popular traditions, and expressly cautions his readers against an implicit belief of many of the wonderful things he relates upon the authority of mere hearsay. And it is an argument much in favour of this ancient writer, that his chronology requires less correction, according to Newton's Canons, than that of any of the subsequent Greek historians. With respect to those great transactions which took place in Greece after his own birth, he is generally thought to be worthy of credit; and the publication of his work, at a general assembly of the nation, may be considered as a voucher for his veracity. He has, nevertheless, been suspected of partiality in particular instances; and Plutarch, the most formidable of his critics, wrote a small treatise *On the Malignity of Herodotus*, in which he expressly taxes him with injustice towards the Thebans and Corinthians, and, indeed, towards the Greeks in general. His history, however, is still accounted one of the most precious relics of antiquity. The greatest inconvenience attending the perusal of this historian, results from his method and arrangement, which are extremely awkward, irregular, and discursive; some entire histories being introduced, by way of parenthesis, in the bodies of others. His style is easy, graceful, flowing, and copious even to exuberance. Its chief excellence lies in narrative, as it seems to want force and conciseness for sentiment and remark, in which he is surpassed by Thucydides. Herodotus is esteemed the model of the Ionic, and Thucydides of the Attic dialect.

Besides this work, Herodotus is supposed to have written an history of Assyria; which, if it was ever published, (which seems doubtful,) is now lost. The Life of Homer, which is usually printed at the end of his works, has also been ascribed to Herodotus; but the best critics are of opinion that it is the production of a different author.

The two best editions of Herodotus are that of Wesseling, fol. Amsterdam, 1763; and that of Glasgow, in 9 vols. 12mo. 1761. A very excellent edition of Herodotus, in Greek and Latin, was published in Edinburgh by Mr Laing, in 7 vols. 12mo, in the year 1806, corrected by Professor Porson and Professor Dunbar. The *editio princeps* is that of Aldus, Venet. fol. 1502. There are two English translations of this historian; the one by Littlebury, in 2 vols. 8vo. and the other by Mr Beloe, in 4 vols. 8vo. with many useful and entertaining remarks and annotations. There is also an excellent French translation, with very learned notes, by M. Larcher. The geography of Herodotus has been examined and explained by the ingenious Major Rennell, in one volume 4to, 1800. (z)