



ELEMENTS

Joseph Ball OF *November 27th 1799*

PHYSIOLOGY.

IN TWO VOLUMES.

Wm. L. Anderson
Oct 27/50

THE UNIVERSITY OF CHICAGO

PHILOSOPHY DEPARTMENT

PHILOSOPHY 101

LECTURE NOTES

BY [Name]

DATE [Date]

CHAPTER 1

Introduction

1.1 The Philosophy of Language

1.2 The Philosophy of Mind

1.3 The Philosophy of Action

1.4 The Philosophy of Law

1.5 The Philosophy of Science

1.6 The Philosophy of Religion

1.7 The Philosophy of Art

1.8 The Philosophy of Education

1.9 The Philosophy of Politics

Elements of Physiology;
Joseph BY *Ball.* 1799.

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GOETTINGEN, AND OF SEVERAL OTHER SOCIETIES IN
DIFFERENT PARTS OF EUROPE.

Translated from the Original Latin,

AND

INTERSPERSED WITH OCCASIONAL NOTES.

BY CHARLES CALDWELL.

TO WHICH IS SUBJOINED, BY THE TRANSLATOR,

An APPENDIX,

EXHIBITING A BRIEF AND COMPENDIOUS VIEW
OF THE EXISTING DISCOVERIES

Relative to the Subject of

ANIMAL ELECTRICITY.

VOLUME I.

PHILADELPHIA,

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TO

THE PROFESSORS

OF THE

VARIOUS BRANCHES OF MEDICAL SCIENCE
IN THE UNIVERSITY OF PENNSYLVANIA.

GENTLEMEN,

LONG have you been my *fathers* and long my attentive *preceptors*, in the interesting science of medicine. You justly hold on me, therefore, a twofold claim for the twofold duty of a pupil and a son. In respectful acknowledgement of this undeniable claim, I now step forward and thus publicly solicit your acceptance of the *first fruits* of that medical education, which you yourselves were pleased
to

to patronize and direct with such ability and care.

Avowedly to solicit an extension of your immediate patronage and protection to the following translation, would be to offer you an indignity little short of actual insult. Such a solicitation would falsely represent you as men unwilling to become the spontaneous guardians and friends of silent, unassuming truth and merit, but standing with open arms for the reception even of intrusive error itself, when ushered to your notice by a brazen front and a blandidious tongue.

The original work of Professor Blumenbach has been already sanctioned

tioned by the applauding voice of the learned and the ingenious in almost every part of the globe to which physical science has hitherto found its way. On the solitary basis of its own intrinsic merit let my *translation* also stand; or if, indeed, it be destitute of such basis, with disgrace let it sink into that sea of oblivion which so justly awaits its final reception.

From you, Gentlemen, it is secure of at least, a patient, and, I flatter myself, an impartial examination. Should the execution of the work fortunately meet with your approbation and applause, you will be its auspicious announcers to the medical public: but should it appear to you faulty and
even

even wholly unworthy of further attention or regard, you will not, I am sure, lose sight of that favourite maxim of the humane and generous bosom, “*primum peccatum veniandum est.*”

Impressed with the most profound sentiments of esteem and gratitude for your favours of a public nature, as well as for your attentive acts of private friendship, I have the honour to be,

Your sincere Friend,

And Pupil,

THE TRANSLATOR.

PHILADELPHIA, }
February 11, 1795. }

Preface by the Translator.

WHAT a fashionable letter of introduction is to its bearer, a fashionable preface is to the literary performance which it openly announces to the world. The former procures, for the most part, admission, and, at least, a dinner ; the latter most commonly an attentive perusal. For their future continuance, however, in favour and esteem, both the visitant and the volume must depend on something more substantial, and of more unequivocal utility, than either the light etiquette of a letter, or the specious proposals of a recommendatory preface.

The

The reader is requested to view the present prefatory address as a mere peace-offering, made by the translator to ancient and inveterate custom, and not as a solemn appeal to the public designed to enhance either the *merit* of the following *performance*, or the *uprightness* of the *motives* which led to its execution. For with regard to the *merit* of the work, I flatter myself that no character of literature and talents will ever resign his right of judging for himself; and as to the *motives* by which I was induced to engage in its translation, they are indeed at present nothing better than absolute non-entities, and will in no way effect its utility to man.

The want of a new and complete system of physiology has been long and very sensibly experienced and regretted by all medical students on this side the Atlantic. As to myself, I am sure I was led most devoutly to
regret

regret such a want, throughout every stage of my medical studies. In order to acquire a knowledge of the improvements which had lately taken place in this important branch of physical science, I was obliged to range with an infinitude of labour and attention, through daily accumulating volumes, which it was sometimes extremely difficult to procure. This difficulty was augmented even to impossibility itself with those unfortunately living out of the sphere of public libraries.

The mutilated abridgment of Haller's physiology, published in the English language, is (to use a common mode of expression) certainly nothing more than a *bare apology* for a system. It is imperfect, erroneous, and, in many places, to me wholly unintelligible. In some parts, therefore, it no doubt inculcates truth, in others implants the

the

the seeds of error, and in other places again leaves the young mind at liberty to indulge itself in all the wildness and revelry of conjecture.

For these deficiencies and faults, I am sure that at least some compensation is made, and some degree of remedy provided in the following sheets, which I am about to usher forth to the world. But on this subject let decision be awarded, and judgment pronounced, by the candid and intelligent reader, and not by

His obedient humble Servant,

THE TRANSLATOR.

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E L E M E N T S
OF
P H Y S I O L O G Y .

SECTION I.
OF THE LIVING HUMAN BODY IN GENERAL.

§ 1.

IN the living human body, the healthy functions of which constitute the exclusive object of the science of Physiology, there occur three things worthy of our immediate attention and regard*; namely,

The *Solids*, or parts containing;

* In an ancient volume commonly ranked among the writings of Hippocrates, *Epidemic*. VI. Sect. 8. § 19, we find the following remarkable clause: “*Quæ continent corpora, aut intus continentur, aut in nobis cum impetu moventur contemplanda sunt.*” This celebrated clause furnished Abr. Kaaui Boerhaave with the first hints and suggestions

The *Fluids*, or parts contained within the solids ;

And lastly, the *Vital Energies*, which in the consideration of the science of physiology, constitute the most interesting and important object of our regard. It is in consequence of these energies that the solids are rendered alive to the impulse of the fluids, endued with a power to propel the same, and also to perform a variety of other motions. It must however be observed, that these energies are not incommunicably excluded even from some of the fluids themselves : on the whole, they appear to constitute the essence or supreme characteristic of an organised body.

§ 2.

But although these three *objects* have been with propriety considered as distinct from each other, and may therefore be separately enumerated on the present occasion, they are notwithstanding in the living body, which is alone the exclusive subject of physiology, so intimately connected together, that it is scarcely possible to form even a conception of one without at the same time embracing the others.

on the subject of his inestimable work entitled, “ *Impetum faciens dictum Hippocrati per corpus consentiens.*” L. B. 1745-8.

The most pure and limpid fluids of our body abound with animal earth: on the other hand, though our solids may appear to us completely destitute of liquid matter, yet, besides the circumstance of their originating from the fluids as their *matrix* or primary source, they contain in their composition an evident quantity of moisture: lastly, if we be not deceived, it is certainly true that there exists scarcely a fibril in the living body which does not possess, in a higher or lower degree, a vital energy inherent in itself.

§ 3.

We now proceed to treat of each of those three objects separately and in order: and first of the fluids; as constituting by far the *greatest*, and what may be emphatically called the *first-born* part of our bodies.

 SECT. II.

OF THE FLUIDS OF THE HUMAN BODY IN GENERAL,
AND OF THE BLOOD IN PARTICULAR.

§ 4.

ALL the different fluids of our body, may with propriety be thrown into three leading classes.

A 2

These }

These are, I. The *Crude* or unassimilised fluid, consisting chiefly of the chyle contained in the primæ viæ, and destined for conversion into blood; to which may also be added, *that fluid* received by absorption from the external superficies of the body, and conveyed to the same receptacle with the former.

II. The blood itself;

And Lastly, the *secreted fluid*, or that formed from the volume of blood by the animal process, called secretion: the fluids prepared by this process are destined, some of them, to be retained in our body, to serve further purposes in the animal economy; and others, to be eliminated from our system, as wholly excrementitious.

§ 5.

Of the first and third of those classes we will speak on a future occasion, when we come to treat of chylification, and of secretion, together with the other functions to which those fluids are respectively related. Let us now proceed to the consideration of the blood, that most important, that primary, and truly vital liquid, which may with the greatest propriety be called, the living fountain of all the other fluids; as being that *into* which the crude fluid is converted; and *from* which all
the

the secreted fluids derive their origin ; and which (a few parts of the body excepted. such as the epidermis, the *tunica arachnoidea*, the amnion, the vitreous substance, or enamel, of the teeth, &c.) flows uniformly through every even the most minute and fine spun parts of the inexplicable texture of our system.

§ 6.

The blood is a liquid *sui generis*, of a well known colour, more or less intense : it is glutinous and warm to the touch : the formation of this liquid has hitherto been ranked among the *arcana* of nature, as it has never been successfully imitated by any process of art.

§ 7.

This vital liquid when recently drawn from a living subject, and received into a vessel, exhibits in a very obvious manner the following remarkable phenomena :

In the first place, while it is yet warm, a subtle halitus ascends from it, which being collected in a receiver, forms small pellucid globules, similar in appearance to drops of dew ; it is of an aqueous nature, resembling not a little common fountain water, except that it emits a peculiar nidorous smell, (still more considerable in the blood of car-

nivorous animals) and which may be aptly called the *animal odour*; such, for example, as arises from fresh urine, or from the thoracic and abdominal cavities of a dead subject recently opened. Of this aqueous liquor a considerable quantity remains in a state of mixture with the other constituent parts of the blood, which shall be hereafter mentioned.

§ 8.

In the mean while, as the blood contained in the vessel suffers a gradual reduction of temperature, it begins to separate into two parts. A coagulum is first formed, from the superficies and sides of which, there presently exudes a liquor of an intermediate shade between pale yellow, and evanescent red, which they call the *serum* of the blood; in proportion as this liquor accumulates by exudation, a corresponding diminution is observable in the volume of the coagulum itself; the coagulum thus reduced in size has been distinguished by the name of *crassamentum*, as also by those of the *liver*, and *placenta* of the blood, from a resemblance, in point of colour and fragility of texture, supposed to exist between it and these two bodies; it has been likewise called *the island*, from the circumstance of its being held in a natant or floating state in the surrounding serum.

§ 9.

This crassamentum itself, by a delicate treatment, such as gentle agitation or frequent ablutions in water, may be again separated into two constituent parts, viz. the *cruor*, which imparts the red colour to the whole mass of blood, and which by ablution is carried off from the *lymph*, the other and more substantial part, and which, therefore, is called the basis of the crassamentum; that the *cruor* retains for this basis a much stronger affinity than the serum possesses, is sufficiently obvious from this circumstance, that the *cruor* and basis cannot be disparted unless by the interposition of a certain degree of force. The *lymph* itself being robbed of the *cruor*, becomes more and more pale until it finally assumes the appearance of a white and considerably tenaceous coagulum.

§ 10.

Such then appears to be the four principal constituent parts of the blood,—viz. the watery *halitus*; the *serum*; the *cruor*, or red globules; and the coagulable *lymph*; which several parts, as long as they retain their native degree of vital temperature, continue in a state of the most equable mixture, constituting an uniform and homogeneous fluid.

It will now be proper to enter into a more minute consideration of those three portions of the blood which stand last in the above enumeration : As to the aqueous exhalation which we have mentioned, it does not appear of sufficient importance to claim any further attention ; indeed as it is also discovered in other parts of the body, it cannot be considered as proper to the blood alone, any more than the air which this vital fluid contains, and on which we will state a few observations in a subsequent part of this section.

§ II.

The serum is a liquid of such a gelatinous nature as to impart to the whole mass of the blood the chief part of its viscosity or gluey consistence : it very much resembles, in all its properties, the albumen or white of eggs ; when subjected to the action of a temperature equal to the 150th degree on the scale of Fahrenheit's thermometer, it passes into a coagulum, white and easily broken down, analogous to the white of eggs in a boiled state ; it also suffers a similar change, according to the experiments of the celebrated Moscati, if it be mixed with a quantity of quick lime, though in this case the coagulation proceeds much more slowly, and is not completed till after the twentieth hour. But if the serum be dried with a gentle heat, and left wholly undisturbed, it is converted

converted into a firm pellucid mass, similar in its external appearance to gum arabic, which in a gradual manner, like the dried white of eggs, cracks and forms over its surface numerous *fulci* or fissures running in a somewhat spiral direction, and exhibiting a very singular appearance.

§ 12.

Besides those other properties of the serum already mentioned, there is one highly worthy our consideration, to which my attention was first called by the experiments of the illustrious Priestley *; but my belief of which has since been fully confirmed by repeated observations of my own, viz. the facility with which the air, surrounding a vessel filled with blood, is able to act through the medium of the serum or the crassamentum, though deeply covered by the former, in such a manner as to produce a very remarkable change in the colour of the latter, whereas, on the other hand, the same action of the air would be very much impeded, if not entirely prevented, if instead of the serum, the crassamentum were covered with any foreign liquid, such as water, or oil, &c. or even with any other fluid of the human body itself, as the saliva or urine.

* Philof. Transact. vol. LXVI. P. I. pag. 244, seq.

§ 13.

The cruor constitutes another very striking and important part of the blood, and is a source of many singularities, whether we consider the colour and figure of its particles, or the elementary parts into which it is resolved when subjected to the action of an intense heat. It appears to deserve a place among the most elaborate juices of the body, as it seldom appears in the tender fœtus previously to the fourth week after conception, nor in the nascent young of gallinaceous fowls till the fortieth hour of incubation. After profuse hemorrhages it likewise appears to be replaced by the powers of the system, with much more difficulty than the other constituent portions of the blood.

§ 14.

It consists of globules, first observed by Leeuwenhock. In blood recently drawn they are always present, of a constant, uniform figure, and of an equable magnitude; which circumstances, added to the further consideration, that in no other fluid (milk alone excepted, the particles of which are somewhat analogous), are similar bodies to be met with, leave not a shadow of doubt, but that those globules form a part very obviously and essentially different from the other constituent portions of the blood, though at the
same

same time the formation of those globular bodies themselves appears in reality to be much more simple than some celebrated characters would induce us to believe. For to pass over in silence the complexity of the sixfold form fictitiously bestowed on them by Leeuwenhoek, neither the annular figure attributed to them by the illustrious de la Torre, nor the form of vesicles enclosing an opaque nucleus, such as Hewson apprehended he discovered in them, have appeared to me to be well founded*. In my observations, indeed, I have been able to detect nothing more than bodies of a simple spherical appearance, and, if I am not deceived, of a solid gelatinous consistence. I have not, indeed, absolutely denied the lenticular figure bestowed on them by some observers: I dare not, however, venture to assert, that I have been so fortunate as to observe it.

It has been a subject of controversy whether or not they can alter their figure when it becomes necessary for them to pass through a vessel of a very narrow diameter. I am inclined to believe, in conformity to the opinion of that accurate observer Reichel that under the above circumstances, they do actually change their spherical for an oval figure, and again resume their former

* *Philos. Transf. Vol. LXIII. P. II. p. 303. seq. tab. XII.*
 globular

globular shape, when they advance into vessels sufficiently capacious; though I must confess, I never had the happiness to be a spectator of this interesting phenomenon.

This spherical figure of the globules is never perceived unless in the blood circulating in the vessels of a living animal, or in that which is recently drawn; they lose all regularity of form in process of time, and appear to dissolve, as it were, and again unite with each other into one uniform shapeless mass.

§ 15.

Physiologists differ in determining the size of the globules of the blood. Hales reckons them equal in diameter to the $\frac{1}{24}$ th part of an inch. Senac estimates their diameter at about the $\frac{1}{11}$ th part of the same measure, while others again entertain different opinions.

§ 16.

Their colour is red, and therefore the beautiful crimson cast of the whole mass of blood appears to be evidently derived from them. The intensity of this colour changes with a multiplicity of varying circumstances; it is more pale in animals which are too sparingly nourished, or in such as have suffered profuse hemorrhages. The blood contained

tained in the arteries is more florid, together with that which has been subjected to the action of *atmospheric*, but more especially, that which has been exposed to *dephlogistated* air; while venous blood is more obscure, as well as that which has been acted on by fixed or inflammable air.

§ 17.

Upon the whole, the causes, which augment the quantity of the red globules in general, and also heighten the intensity of their colour, are sufficiently evident: but to discover from what secret source their disposition to this crimson dye is originally derived, is a matter of Herculean difficulty indeed. Haller ascribed it to the presence of *crocus martis*, because the blood abounds more with iron than the bones, or other parts of the body, although the quantity contained, even in the blood itself, is very small; and although authors differ astonishingly in their attempts to ascertain it. Thus, for instance, Menghinus estimated its relative proportion to the whole mass of the blood, to be as 1 to 110; whereas, the illustrious Rhades calculated it to be only as 1 to 427; and again, in some future experiments, to be no more than as 1 to 503, &c.

On the present subject it seems proper to make the following observation; viz. that no iron can
be

be discovered in the cruor of the blood unless it be previously calcined; whereas, on the other hand, when it was dried with a gentle heat, and reduced to the most impalpable powder, I could not observe a single particle of it attracted by the magnet, whether the experiment was made in water, or in that most fluid of all vehicles, quicksilver.

§ 18.

We now come to the consideration of that constituent part of the mass of blood, which stands last in our order of enumeration, viz. the *Lymph*; which is by some called the basis of the crassamentum, by others, the mucous or glutinous part, and by others, the fibrous portion of the blood.

This, in former times, was very erroneously confounded with the serum, from which it is notwithstanding very widely different, in all its essential properties. When the lymph is exposed to the action of air, especially of such as is of a low temperature, it is immediately coagulated; but by the admixture of quicklime, (which has been already said (§ 11.) to have the power of coagulating serum), it is preserved in a fluid state; or, even though it be already coagulated, yet, by the addition of this substance, it is again immediately resolved.

§ 19.

We have already touched on the methods, by which this part of the blood may be separated from the cruor (§ 9.). It is also by other artificial methods, such as whipping or agitating the blood with small twigs, induced to assume the appearance of a membrane, which has been named after Ruyfch its celebrated discoverer.

The similitude which prevails between the membrane thus formed by art, and certain remarkable phenomena in diseases, especially in those of an inflammatory nature, reduces it to a certainty, that such phenomena are to be entirely referred to the coagulation of the lymph, of which we are now treating.

It may be proper on the present occasion to mention a few of those numerous phenomena alluded to, which evidently derive their origin from this property of the lymph; thus we may instance in particular, the *pleuritic crust*, which is formed on the surface of the crassamentum of blood received into a vessel and suffered to remain some time at rest; the *membrane-like* appearances which usually transude from, and completely invest the surfaces of the several viscera when in a state of inflammation; and also the *membrana caduca*
of

of Hunter, which exudes from the cavity of the uterus, when impregnated, and still under the gentle glow of the venereal orgasm. From the same source originates likewise, that production of cellular membrane by which we see frequently the lungs connected to the pleura in cases of peripneumony; as also the preternatural portions of the same substance often found in the cavity of the abdomen after profuse hemorrhages; and finally, to no other source can we rationally refer those membrane-like productions, which, in that singular species of disease, vulgarly denominated Lithopædion, firmly attach to the contiguous viscera such parts as are irritated to inflammation by the too long retention of the calculus or stone in the abdominal cavity. It seems to be also an opinion founded at least on probability, that polypi, and such like preternatural coagulated excrescences, owe their existence to the same cause.

§ 20.

Those phenomena just enumerated, together with a variety of others which every where occur, demonstrate, in a most striking manner, the superior importance of this lymphatic portion, in which the vital principle of the blood appears immediately to reside, if indeed the blood possess any such principle, an opinion which I think both ingenious and highly probable.

§ 21.

Besides those general portions of the blood already enumerated, we have on a former occasion observed that this fluid contains also, in a state of mixture, other elementary principles. (§ 10.)

What I principally advert to at present is *air*, which is commonly believed to constitute $\frac{1}{11}$ part of the whole mass of blood, but which in the blood of a living and healthy subject does not exist in a free and perfectly elastic state, but is so intimately united and involved, and so permanently fixed, as to be with difficulty extricated and restored to its native æriform state. Indeed I have learned from actual experiments, that even a very small quantity of the most pure air injected through an artificial opening into the jugular vein of a dog, has excited symptoms of a very formidable nature, such as palpitations of the heart, drowsiness, convulsions, and, when the quantity was slightly increased, even death itself quickly succeeded.

§ 22.

The elementary parts of the blood thus concisely treated of, differ very widely in the proportion they bear to each other in different subjects, according to the complex ratio of age, nourishment, and other circumstances of importance, which regard the sound health of each individual.

§ 23.

Neither has any thing more certain or decisive been advanced with respect to the proportion which the whole volume of blood bears to the entire bulk of the body. Haller was of opinion, that in an adult it amounts to 30 or 36 pounds by weight; while the calculations of others have been widely different.

 SECT. III.

OF THE SOLIDS OF THE HUMAN BODY IN GENERAL,
BUT PARTICULARLY OF THE CELLULAR MEM-
BRANE.

§ 24.

THE solids of the body are originally derived from the fluids themselves; thus in the first rudiments of the embryo, while yet in a gelatinous state, the solids, each in its own appropriate situation, begin in a very gradual manner to assume their proper form and texture, infinitely different from each other in point of cohesion, from the most tender and almost pultaceous consistence, such as the medullary substance of the brain, to the most firm and durable, as the vitreous cortex, or enamel of the teeth.

§ 25.

In all the solids of the body an earthy basis of a calcareous nature abounds more or less, not indeed in a simple state, but united to the phosphoric and saccharine acids, the former of which exists in by far the largest proportion. Their cohesion depends not only on the peculiarity of their texture, but is also much promoted, as well by the quantity of air contained in them in a fixed state *, (which is ascertained by the experiments of the illustrious Hales to be more abundant as the parts are more solid); as also by the substance called animal glue, which is procured in large quantities from the solid parts of animal bodies, and is in general use in some of the mechanical arts. The origin of this tenacious substance may be very easily explained and comprehended from what has been already said respecting the viscosity or gluey nature of the blood.

* “The properties and powers of air have not yet been ultimately developed. It is, however, in the mean time certain, that this substance constitutes, at least, a part of the gluten or cement by which all the more compact bodies in nature are consolidated and bound together. Thus the dissolution of metals, bones, stones, shells, and salts, is uniformly attended with an extrication of air.” See Haller de corp. hum. functionib. Vol. III. pag. 271.

The elementary substance of iron, to which has been attributed the important office of increasing the powers of cohesion in the different parts of the human body, scarcely deserves to be taken into consideration at all, as I have found its quantity to be so very minute as not to exist in a greater proportion than one fifth part of a grain to two pounds even of the bones, the hardest and most coherent parts of the animal system.

§ 26.

A great portion of the solids of our body very evidently exhibits a fibrous texture, composed of small filaments running more or less parallel to each other. These filaments or fibres may be evidently enough perceived in the bones, especially the bones of a foetus, in the muscular flesh, in tendons, ligaments, aponeuroses, and some membranes, as the dura mater, &c.

§ 27.

In various *other parts* of the animal body, the texture is so widely different from that of which we have just spoken, that in them it is scarcely possible to trace the appearance of a single fibre; their structure is indeed of a very singular and specific nature, distinguished in Greek by the name *parenchyma*. This parenchymatous substance is almost exclusively confined to some of the secreting
viscera

viscera of the system ; thus it exists in the kidneys, in the liver, &c. though assuming a somewhat different and peculiar appearance in each.

§ 28.

Through all those varieties of composition and texture, whether of a fibrous or parenchymatous appearance, there is interwoven, in common, more or less of a certain web-like substance, which is called *cellular membrane*, and which deserves a place among the primary, the most important and essential, constituent parts of our system.

§ 29.

For, in the first place, there are several of the solid parts of the human body, which appear to consist of little else than cellular membrane, in a condensed or compacted state ; of this description are most of the membranes and cartilages ; which, by long maceration, may be again resolved into a cellular web, of more or less laxity. It is, again, so intimately and minutely interwoven in the composition of other parts, as to serve the important purposes of a receptacle and basis to the other portions of substance which assist in their formation. Thus, for instance, the hardest bones made their first appearance in the tenderer state of cartilage, which, as already observed, is nothing more than condensed cellular membrane : this cellular membrane, yet in a lax condition, became afterwards

distended, and at length completely saturated, as it were, by the constant accession of osseous matter, till it finally assumed the nature and appearance of perfect bone. Indeed it would appear, that none of the solids of our body exist, without containing more or less of this web-like substance in their composition, if we except the enamel of the teeth, in which I was not able to discover the smallest portion of cellular substance, even when the enamel was subjected to the action of one of the stronger acids.

§ 30.

This cellular substance, which serves the great purpose of a boundary, or partition-wall, to adjacent parts, is especially interwoven in, as well as spread between, muscles and membranes. To other parts, again, particularly to vessels and nerves, it answers as a bed or basis of support. Finally, it constitutes one common and general bond of union, which connects the neighbouring individual parts to each other, and establishes between the whole an extensive medium of communication.

§ 31.

From what has been already said, two conclusions naturally present themselves.

First, in as much as it appears, that the cellular membrane certainly constitutes the ground-
work

work of the structure of the whole body, if we figure to ourselves the entire removal of every other substance which enters into, and assists in completing, the composition of the system, the cellular membrane, still remaining in its proper situation, unmolested and alone, will nevertheless preserve and exhibit the complete figure of the whole and every part of the body.

Secondly, as by means of this cellular foundation, a certain connection and medium of communication are formed, between all the parts of the body, however widely different from each other they may be, in nature, or remote, in situation; the knowledge of this fact serves an important end, not only in deciding controversies which respect the continuation of membranes, but also in explaining many phenomena of diseases which daily present themselves.

§ 32.

As the cellular membrane appears thus to afford origin and foundation to most of the solid parts of the body, so it appears itself to owe its own existence to the lymphatic part of the blood, of which we have already spoken. I am induced to entertain this opinion from having seen the lymph, after transfusing from the lungs of pleuritic patients, converted by the powers of the animal economy

into real cellular substance, which afterwards assuming the appearance of more compacted membranes, oftentimes attaches those viscera to the surrounding pleura.

§ 33.

What has been already advanced on the subject, may be sufficient to show the general nature, and establish the importance, of the cellular membrane. We will now proceed to consider some of its varieties.

And, in the first place, its firmness is not always uniform.

For, in general, other circumstances being alike, the cellular membrane of the human body is very tender indeed, when compared with that of other animals. If I am not deceived, this very softness and pliancy of the cellular substance in the human system, deserves to be ranked among the leading prerogatives of man; because, in consequence of it, his susceptibility of impressions from the more refined and subtle stimuli is greatly increased, as well as his capacity to perform motions and various functions, with facility and perfection.

But with regard to the more lax or firm texture of the cellular membrane, even among mankind themselves,

themselves, a very great variety occurs, depending on age, sex, mode of life, climate, &c.

Finally, the condition of this membrane as to density and firmness, is various, as it is found existing in different parts of the same body: thus, it is more lax on the eye-lids and prepuce, more compact and firm about the ears, &c.

§ 34.

We now proceed to consider another use or office of the cellular membrane, besides that which we have already said it performs to the body in general, (§ 29, 30); namely, that by means of its numerous small cells, it affords convenient temporary receptacles for fluids of different kinds.

That fluid, which those minute cells are more particularly destined to receive, is a fine halitus of a serous nature, or a very subtle water, by which almost all parts of the body are moistened, and lubricated, and which this cellular web appears to absorb, after the manner of a sponge*.

If it be admissible to designate by the name of *vessels*, those *minute interstices* of the cellular membrane, by which it absorbs fluids after the manner of a sponge, I readily acquiesce in the opinion of William Hunter, (see Medic.

Obs.

§ 35.

But, besides this, the cellular membrane, in certain parts of the body, serves as a reservoir to humours of a different and somewhat specific nature. Thus, that portion of it which constitutes the vitreous substance of the eye, is charged with a fluid of the same name :

That which forms the meddullary membrane of the bones (commonly, though improperly, called the internal periosteum) contains the medulla : and,

Finally, A large portion interwoven through the soft parts of the body, furnishes a convenient receptacle for the other portions of oily substance.

Obs. and Inquiries, vol. ii. p. 27. seq.) that this web-like expansion, now under immediate consideration, is composed of a congeries of vessels, in like manner with the other parts of the body. But if he entertained a belief, that this membrane consists of small *cylindrical veins*, which anatomists commonly mean to represent by the term *vessels*, I must acknowledge, that microscopical observations, conducted with the utmost degree of minuteness, and the most cautious circumspection, have not been sufficient to furnish me with any unequivocal testimony that such vessels actually exist, but have rather induced me to embrace a contrary opinion.

§ 36.

And here indeed a threefold variety presents itself to our consideration :

There are, in the first place, certain parts of the body, the cellular substance of which, though of a very soft and extremely flaccid nature, is notwithstanding, never filled with fat in a healthy subject ; such, for instance is that which lines the eyelids, and that spread on the genital organs of the male, &c. But further, in numerous parts throughout the body, there are not unfrequently found irregular and transient collections of fat, which appear to reside in the same kind of cells, which at other times act as reservoirs to the attenuated serous fluid already mentioned.

But finally, in certain parts of the body, and, unless I am deceived, in cells of a peculiar nature, and given description, fat is found constantly enclosed, designed to subserve stated, uniform, and specific uses in the animal economy, such, for example, is that which, in the female system, forms the *mons veneris*, which appears to me to constitute a very peculiar and completely circumscribed protuberance*.

* This circumstance I had an opportunity of ascertaining in a much more satisfactory manner in the dead body of a female ape. After having for some time subjected the corpse to the action of cold, I was able, by removing the skin, to expose

§ 37.

On the subject of the fat itself we will now proceed to make a few observations, this being so very proper a place for entering on the consideration of it.

It is an oil, not unlike the unctuous oils of vegetables; bland, inodorous, and lighter than water, consisting of phlogiston, united to phlegm by means of an acid of a peculiar nature.

§ 38.

It is formed at so late a period in the fœtus, that scarcely an indubitable vestige of it can be discovered earlier than the fifth month after conception.

Its consistence is various in different parts of the body. That for instance which lines the inside of the orbit of the eye, is more fluid, whilst that on the contrary which surrounds the kidneys approaches to the firmness and appearance of suet.

§ 39.

A controversy has existed with respect to the *secretion* of this substance, namely, whether it is performed by a peculiar set of glandular bodies, expose entire the circumscribed globe of fat situated beneath the pubes.

agreeably

agreeably to the opinion of William Hunter, or whether it merely transfuses, by simple diapedesis, through the patulous mouths of arteries? The latter of these opinions, besides other arguments which might be advanced in its favour, appears the most probable from hence, that not unfrequently preternatural collections of fat have been discovered in other parts than those commonly occupied by this substance: this circumstance can be much more aptly and rationally explained by attributing such unusual collections of fat to an *error-loci*, arising from a morbid state or disposition of the vessels, than by referring it to an unnatural and recently formed system of glands: thus for example, in the very ball of the eye itself, fat has been sometimes found; and a substance of a nature like fuet, usually fills up the cavity from which a testicle has been extracted; indeed there scarcely exists a cavity in the body in which steatomatous collections have not made their appearance.

But to conclude; those small glands to which certain celebrated characters have been solicitous to attribute the secretion of fat, appear as yet to be in reality nothing more than mere creatures of analogy.

But

But however this may be determined, it is in the mean time very certain, that both the secretion and absorption of this substance can be performed with the utmost dispatch.

§ 40.

The uses of the fat are numerous. It lubricates the solids, and thus facilitates motion. It obviates and prevents a morbid excess of sensibility. It acts as a defence against cold: and, finally, by its uniform distention of the skin, contributes to comeliness and beauty. Not to mention the peculiar uses of the fatty matter constantly bestowed on certain parts of the body, as the medulla of the bones, &c.

This substance appears, however, to contribute scarcely any thing to the nourishment of the human species *, when in the enjoyment of entire health.

* That bloodless insects, however, derive a principal part of their nourishment from the fatty substance with which their bodies are plentifully supplied, is a conjecture of naturalists founded at least on probability.

SECT. IV.

OF THE VITAL ENERGIES IN GENERAL, BUT
PARTICULARLY OF CONTRACTILITY.

§ 41.

WE enter now on the consideration of a difficult subject, namely, *the living solid*, and shall attempt a full account of the vital energies, by which the different parts of our body appear to be animated and fitted, as well to receive the impulse of stimuli, as to perform the various motions which are necessary in the economy of the living system.

§ 42.

But with respect to the *living solid*, it will first be necessary to ascertain its exact limits, and to define it with precision and accuracy; whence it will evidently appear, that it is not our intention, on the present occasion, to treat either of *those properties*, which the human body possesses in common with numerous other bodies in nature, such as *elasticity* (the powers of which, however, are notwithstanding exhibited in various motions and functions of the animal economy), nor yet of *those* which reside exclusively in the *mind*; tho' we flatter ourselves no one will deny the powerful influence of these latter over the energies possess-

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ed by the living solid itself, considered as a material body. We will confine ourselves solely to the consideration of those energies which reside in our body as a system of organised matter, and which appear to be related to each other in the following order.

§ 43.

The first and most universal species of those vital energies, and which may indeed be regarded as an inferior degree of the others, or rather as the threshold leading to them, is simple *contractility*, i. e. a propensity in a part to contract itself. As this property appears in reality to reside in every part of the cellular membrane, it must be equally extensive with that membrane itself, and therefore may be said to pervade almost the whole body. Hence this may be called, with perhaps sufficient propriety, the *vis cellulosa*.

§ 44.

Another of the vital energies is, the *irritability of Haller*, which resides in muscular fibres only, and may therefore be called the *vis muscularis*. It manifests itself by a very singular, oscillatory and tremulous motion, easily distinguished from simple contraction, by its being more readily excited to action on the application of any acrid stimulus.

§ 45.

The third is *sensibility*, which resides solely in the nervous medulla, communicating with the sensorium, called therefore *vis nervea*; when any part endowed with this property is acted on by irritating stimuli, an impression is immediately made on the sensorium.

§ 46.

The three foregoing may be, with propriety, considered as *common* or *general* vital energies; because they exist, more or less, in almost all, or at least in a great many, parts of the body, which the ancients called therefore *similares*, *i. e.* parts of a similar nature.

§ 47.

But besides the foregoing, there exists also a fourth energy worthy of our consideration, namely, the *vita propria*, or *specific life*; under which denomination I mean to arrange such powers as belong to certain particular parts of the body, destined for the performance of peculiar functions, and which cannot with any propriety be referred to either of the classes of *common energies*, formerly mentioned.

Inferring synthetically, or *a priori*, as it is termed, it is not repugnant to sound induction to conclude, that parts differing from all others in

texture, in arrangement, and in peculiarity of function, must also be furnished by nature with peculiar properties and powers, adapted to the performance of such specific action.

But reasoning analytically, or *a posteriori*, we are likewise taught by accurate observations made on nature herself, that there are certain parts of the body, particularly some of the viscera, which perform motions so very singular, as cannot by any means be supposed to arise from either one or other of the common energies, of which we have already spoken, but must be referred to a *vita propria*, or specific energies of their own.

Instances of such singularity of action we have in the motions of the iris; the erection of the papilla in the breasts of females; the motions of the fimbriæ of the fallopian tubes; the action of the placenta; the action of the uterus in parturition; the descent of the testes in the male fœtus; and, if I am not deceived, in a great part, if not in the whole of the process of secretion.

§ 48.

The fifth and last energy which claims our attention is, the *nifus formativus*, or formative propensity, which should be considered as the efficient cause of the whole process of *generation* (taken in
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so extensive a latitude as to include both *nutrition* and *re-production* as modifications of itself). In consequence of this propensity, the matter of the animal system, whether appropriated to generation or nutrition, being lodged in the places destined for its reception, and having acquired sufficient assimilation and maturity, assumes forthwith its due arrangement and figure, and enters into the composition of those parts which are afterwards furnished and enlivened either with the whole or part of the energies we have already enumerated, viz. *contractility*, *irritability*, *sensibility*, or finally *specific life*.

§ 49.

Of this *nifus formativus*, or formative propensity, more will be said when we come to treat of the process of generation.

Irritability will be more fully considered when on the subject of *muscular motion*.

The subject of *sensibility* will be again resumed when we come to consider the action of the nervous system.

Of the *vita propria*, or specific life, we will every where treat, when the subject under consideration may render it proper.

But with respect to *contractility*, the present is a very suitable place to offer on it a few additional and particular observations.

§ 50.

I have already said that this energy pervades almost the whole body, at least, that its extent is commensurate with the extent of the cellular membrane.

In the first place, therefore, it resides in all such parts as consist of compacted cellular substance, of which the different membranes of the body serve as examples. That these possess *contractility* will not be denied by any one who reflects on the constriction of the *dartos tunic*, or who calls to mind the spasms of the skin, or of the peritoneum, which alone appears sometimes to incarcerate and strangle the intestines in cases of hernia.

Further, It also exists in such viscera as are composed chiefly of this kind of membrane; of this description are the lungs, the external superficies of which is highly contractile, as I have lately learned from frequently puncturing and irritating them in a living state; but I have not found them possessed of any real irritability, as has been lately asserted by Varnier.

Even

Even the bones themselves do not appear to be entirely destitute of contractility, as we learn, not only from the alveoli, which are well known to become narrower after the extraction or loss of the teeth, but also from the morbid affection termed *necrosis* (*i. e.* mortification), from which it appears, that after a lifeless part of bone is quite removed, the new production of bone, by which the vitiated part was before surrounded, contracts itself very gradually, almost to the natural thickness and former figure of the part.

But as we observed on a former occasion, that the vitreous substance of the teeth was quite destitute of cellular membrane, so it appears to me probable, that it is entirely destitute of contractility also, because, when a part of it is either consumed by a caries, or broken off by accident, the remaining portions or sides are not approximated to each other, as we have already said takes place in the alveoli, but an irreparable hiatus or chasm continues without a shadow of diminution.

§ 51.

This very power of contraction, possessed by the cellular membrane, should be ranked among the primary and leading securities or supports of firmness and health; and to it should be referred that *tone* of parts, so highly and favourably spoken of

by the acute and ingenious Stahl. To advance one argument in favour of the foregoing position, from many which might be adduced, it is the cellular substance which, in a healthy subject, absorbs, after the manner of a sponge the aqueous liquid, of which we have already spoken, and by means of its contractility propels it forward into the lymphatic vessels: on the contrary, in a diseased state, being deprived of its proper tone, and reduced to an atonic condition, it becomes oppressed and distended with a load of water, and thus gives rise to œdema and other cachectic symptoms.

§ 52.

Finally, from the universal prevalence of contractility throughout the whole body, we may plainly infer its influence and contagious effect, as it were, on the other vital energies; and also from its infinitude of modifications and degrees in different men, we learn its highly influential part in the constitution of both the proper health and peculiar temperament of each individual.

SECT.

SECT. V.

OF SOUND HEALTH, AND OF THE NATURE OF MAN.

§ 53.

THOSE three subjects (§ 1.) in the consideration of which we have been hitherto engaged, perpetually act and re-act on each other in the living human body. The fluids, for example, act by their stimulus on the solids; while these again, in consequence of their vital energy, are fitted and prepared both to receive the action of the stimulating fluids, and to re-act on them in turn. In a sound and healthy subject, this whole routine of action and re-action, corresponds with such exactness and definitude, as to constitute a perfect and harmonious *equilibrium*.

§ 54.

There further exists in the living system a wonderful consent of parts, even the most remote; this consent is derived not from one, but seems to owe its origin to different sources.

One of those sources resides in the nerves, depending as well on the astonishing net-like anastomoses, formed by their numerous branches, as on the intricate nature of their *plexus* and *ganglia*;

by the medium of which, the impulse of stimuli being communicated to the sensorium, may from thence re-act on parts more remote.

Another source of this wonderful consent must be referred to the different vessels of the system, as well the sanguiferous as the lymphatic.

Another, again, arises from a certain similitude of structure, giving origin to what may be called a native sympathy.

The cellular membrane, which, as has been already observed, appears to constitute a common bond of union to the whole body, may be readily conceived to possess a very striking and powerful influence in promoting the consent of distant parts.

§ 55.

Finally, to this head belongs what is justly esteemed one of the greatest mysteries of nature, namely, the connection of the mind with the body, and the diversified and astonishing power of the one over the other. As this subject will be again resumed, and treated more fully in another place, it will be sufficient on the present occasion briefly to observe, that besides the obvious power of the *will* over most of the muscles, there are also *other faculties* which exert their influence on
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the body, even without the concurrence or aid of the will.

Of this description are those blind and purely animal instincts of our nature ; such, for example, as that which excites to the gratification of venereal enjoyments.

Further, the body is greatly under the influence of the *internal senses*, more especially of the *imagination*, and those passions of the mind which it contributes to excite.

Finally, it is by the interposition, and through the medium of these, that a communication and reciprocal influence are preserved between the powers of the body, and the more exalted faculties of the mind.

§ 56.

By this diversified consent of the solids, of the fluids, and of the vital energies (§ 53.), by this sympathy of parts (§ 54.), and by this intimate connection between the mind and the body, (§ 55.), *life* and *health* are preserved in vigour ; yet not always existing in the same, but in widely different degrees of perfection and energy.

§ 57.

§ 57.

Between the two extremes of *life* there exist different grades, of which one is called *vita maxima*, or perfect life; the other *vita minima*, or imperfect life.

Life is said to be *perfect* in the flower of age, when the functions of the body have reached that pinnacle of perfection, called by the Greeks *acme*; this might also be denominated the *athletic state*.

Life, on the other hand, is said to be *imperfect* when the functions are performed with less vigour; although their perfection may be the most consummate, when the situation of the subject, and its mode of existence, are taken into consideration: thus life is imperfect in a *fœtus in utero*, and that in proportion as the fœtus is tender and young. Finally, life is less perfect in the *sleeping* than in the *waking* state; less perfect also in a subject advanced in years, than in one basking in the meridian blaze of manhood.

§ 58.

The varieties in point of *health* are no less numerous and considerable: there is indeed a certain state of health which may be said to be peculiar to each individual. Such persons as we suppose

pose to be in the enjoyment of the most complete health, differ, notwithstanding surprisingly from each other, as well in consequence of a difference in the constitution of the blood, as of a diversity of tone, and of the other vital energies; hence different individuals are so differently affected by the same stimuli acting on their bodies. Perhaps each individual may possess peculiar idiosyncrasies, though so very inconsiderable as to be scarcely observable: the influence of custom is so powerful, as to create, in different subjects, an intolerance of different impressions, though in themselves quite innocent; it also produces a facility of bearing, and finally creates a desire for, such things as appeared at first both unnatural and disagreeable.

§ 59.

This appears to be the very hinge on which revolves the nature and variety of *temperaments*, so frequently the subjects of physiological discussion. The constitution of the temperaments depends, not only on the proportion and mixture of the constituent parts of the blood (§ 22.), but also on the peculiar vigour of the vital energies already treated of; and likewise on the consequent variety in the mode of the reciprocal action and re-action of the body and mind on each other. From this combination and concurrence arises that peculiarity

city of sensation to the impressions of stimuli ; and also that singular power of performing motions with greater or less facility.

§ 60.

Hence the varieties of temperaments are literally infinite, and can never be reduced to any certain and definite classes. But as it has been the pleasure of physiologists to arrange them under certain heads, for the sake of regularity, we may with sufficient propriety give our assent to the common mode of arrangement, by which they have been reduced to four *orders*, namely, the phlegmatic, the sanguineous, the choleric, and the melancholic.

§ 61.

For although Galen erected this division on an absurd foundation, falsely supposed to be derived from the nature and constituent parts of the blood, yet if this erroneous foundation be kept entirely out of view, the division appears in other respects so consonant to nature, that the different temperaments of all men generally, and of every individual in the different periods of life, may be with propriety referred to one or other of these four leading classes. Thus, in the tender age of infancy the *phlegmatic* temperament chiefly prevails. This in youth is exchanged for the *sanguineous*.

guineous. The *choleric* marks the period of manhood. And the *melancholic* is the temperament of old age.

But, as has been already observed, the variety in the existing degrees of the same, and in the mixtures of different temperaments, is so unbounded, as to afford an open and a very extensive field of speculation to such as would wish to amuse themselves with tracing out, and establishing, on this subject, more minute combinations, or divisions and orders.

§ 62.

This whole collective assemblage of all the faculties and laws hitherto mentioned, by which the functions of the human body are performed and regulated from the opening, to the closing pulse of life, are called *human nature*, or the *nature of man*; from whence arose the name of *physiology*, the *science* now under our immediate consideration.

§ 63.

Those functions of the body may be themselves properly enough divided into four classes; which division, although not entirely free from exception, nor perfectly conformable to nature, may nevertheless be aptly enough retained as a useful assistant to the memory.

I. The

I. The first class of this division embraces the *vital functions*, so called because their incessant and unmolested action, is more especially and essentially necessary to the continuance of life. To this class belong the *circulation* of the blood, and after birth the process of *respiration*.

II. The second class embraces the *animal functions*; these serve to distinguish *animals* from organised bodies belonging to the vegetable kingdom *. This class in man includes the connection

* I lament it as a serious misfortune to the science of *natural history*, that his final object did not call on the very learned and ingenious professor to be more explicit and minute on that class of functions denominated *the animal*. He has told us in terms very general and definite, that they are such as serve to constitute the great barrier of distinction between animal and vegetable bodies. I am sorry that neither the object nor extent of an elementary work permitted him to descend to a more minute specification of those characteristics, in which the difference between animals and vegetables more immediately consists. Few points of investigation can be proposed which have given rise to a greater diversity of opinion, than that which respects the difference between these two classes of natural bodies; and fewer still perhaps can be advanced, with regard to which philosophers, even in the present imperfect state of physical science, should more unanimously agree. Be this later position, however, true or false, I have always been led to consider the strangely diversified, and even contradictory opinions, entertained by naturalists respecting the difference between animals and vegetables, as
so

of the mind with the body, but it regards more especially sensation, and muscular motion.

So many unanswerable testimonies of the equivocality of the whole. The discovery therefore of an exclusive line of distinction between the animal and vegetable kingdoms, (if indeed the supreme author and arbiter of nature permits such a line to exist) must still be considered as a peculiar *defideratum* in the science of natural history.

From all my speculations on this interesting subject (and it is with me a favourite object of pursuit) I am firmly of opinion, that there exists no incommunicable characteristic, and I will venture to add, no congregation of characteristics, which serve to constitute a complete partition-veil between the animal and vegetable kingdoms. The numerous and highly diversified subjects of these two important kingdoms of life, appear to be nothing else than different individuals of one extensive family, descended from a common parent, and exhibiting the most unequivocal testimonies of their kindred nature. Like the delicate tints of light and shade in a well finished picture, they so gradually intermingle, and run into each other so insensibly, that it is literally impossible to say with definitude, where the one terminates and the other begins

All researches therefore after an exclusively distinctive characteristic between vegetables and animals, appear to me equally irrational and visionary with the late enthusiastic pursuits of the deluded alchemists, after the philosopher's stone, or their more chimerical researches after their flattering *panacea*. Why then should man, presumptuous man! attempt the establishment of an essential distinction between physical bodies, where wiser *nature* acknowledges none!

III. The *natural functions* constitute the third class. These are subservient to the nourishment of the body.

IV. The fourth and last class consists of the *genital functions*, which are destined for, and employed in the propagation of the species.

Let us now consider each class of functions in order, beginning with the *vital*.

SECT. VI.

OF THE MOTION OF THE BLOOD IN GENERAL.

§ 64.

THE blood as we have already seen, affords the primary origin to the principal parts of the body, and continues afterwards to convey to them uniform and perpetual supplies of nourishment, and ought therefore, with a very few exceptions (§ 5.) to be distributed far and wide, through even the most subtle and distant recesses of the whole body. That such a minute distribution actually takes place, we learn not only from a fine injection of the vessels, but also from every day's experience, from which it appears that very

few parts of the body can be punctured with the point of the smallest pin without the occurrence of a greater or less hemorrhagy.

§ 65.

This vital liquid does not, as was the opinion of the ancients, flow and ebb like the waves of Euripus *, through channels of the same nature and order, but is so moved onward in an orbit, or *circulates*, as they express it, in such a manner, as to be carried from the heart, by means of the arteries, to every part of the body; and being there taken up by the veins, conveyed back again by them to the same original fountain, *the heart*.

§ 66.

After a few, and those very indefinite, expressions † of his predecessors, William Harvey esta-

* A narrow arm of the sea, extending between Bœotia and Eubœa, said to ebb and flow seven times during each diurnal revolution of the earth, or each term of 24 hours. In this extraordinary portion of sea, Aristotle, that celebrated ancient philosopher, is falsely reported to have drowned himself, because he was not able to develop the cause of the constant flux and reflux of its waters. C. C.

† The unfortunate *Servetus*, and that truly illustrious character *Andr. Casalpinus*, appear to have advanced nearer to a true knowledge of the genuine circulation of the blood, than any of the other physiological writers who are commonly enumerated in the same class.

blished, in a manner tolerably conclusive, the circulation of the blood, in a small but immortal work published in the year 1628.

In process of time, however, every shadow of doubt on this subject was removed. This was effected chiefly by frequent recourse to actual and simple observations with the microscope; but *in part* also by injections of wax and other substances into the arteries, which were seen passing again to the heart by the route of the veins; and, further, by the elegant and sublime experiment of

It may not be improper on the present occasion to advert to a remarkable clause in the writings of Servetus, contained in a physiological dissertation, which he included in his celebrated and very scarce work, that occasioned the death of its illustrious author. The work is entitled "*Restitutio Christianismi,*" &c. (Viennæ Allobrog.) 1553-8. The dissertation particularly alluded to, is contained in the fifth book of the abovementioned work, "*de trinitate divina, in quo agitur de spiritu sancto,*" in which we are presented with the following words, "*Vitalis est spiritus qui per anastomoses ab arteriis communicatur venis, in quibus dicitur naturalis.*"

But from the memorable problem of Cæsalpinus, "*de venis ultra vinculum tumescentibus, non citra,*" it appears obvious as the blaze of day, that that truly illustrious physiologist trod on the very confines of a complete knowledge of the circulation of the blood. See his "*Quæstionum medicarum,*" L. II. quæst. 17. page 234.

transfusing

transfusing the blood of one living animal into another, or into a human subject; as also by various other experiments which may be performed on animals in a living state.

§ 67.

What should be esteemed the definite standard of the celerity of this motion, in a healthy human subject, we are not well able to determine. In this respect there is not only a difference between one subject and another, but there also occurs a great variety relating to this point, arising from the difference of ages: there indeed exists a difference in the celerity of the blood's motion, even in the different parts of the same body.

Finally, the venous blood appears to glide on more slowly than the arterial; and when flowing through the *trunks* of vessels, its motion is more rapid than when passing their smaller ramifications. Former physiologists, however, have notwithstanding exaggerated these several diversities, in the celerity of the blood's motion, beyond their natural magnitude.

The common conclusion, however, on this subject is, that the blood, flowing through the aorta with its mean velocity, passes over a distance of about eight inches during the space of one pulsa-

tion ; at which rate it would travel about fifty feet in the first minute of time.

§ 68.

The globules of the cruor appear to revolve on their axes or centres of motion ; and it is said that the same are propelled forward with greater velocity than the other constituent parts of the blood. I know not whether this conclusion be drawn from actual experiment, or whether it be only an inference from an absurd application of the common laws of hydraulics to the circulation of the blood : I call the application absurd, because it is certainly the very summit of folly, to attempt to account for that motion of a vital fluid, by which it is carried through the living canals of an animated system, on the purely mechanical principles by which water is forced through hydraulic machines.—As to myself, I must acknowledge I have never been so fortunate as to be favoured with a view of this *prerogative* or precession of the globules.

§ 69.

I am fully persuaded, that those globules only glide forward, suspended or swimming in the fluid formed by the other constituent parts of the blood, but that they do not at the same time rotate on their own axes at all. To conclude, it is not
fully

fully and clearly ascertained, that the blood, besides its *progressive* motion, of which we are now speaking, is also subjected to one of a different kind, called an *intestine* motion; although there can be no doubt, but that the elementary parts of the blood may be occasionally affected in their arrangement and combination, when they are tumultuously agitated in consequence of the immensely varied directions, the minuté divisions and numerous anastomoses of the vessels through which they pass.

§ 70.

Thus much we thought proper to advance on the motion of the blood in general. Previously to our entering on a more close and minute consideration of this subject, we think it best to treat of the vessels in which the blood is contained, and also to consider with attention the energies, by which these vessels are animated, and fitted both to receive and again propel the blood.

SECT. VII.

OF THE ARTERIES.

§ 71.

THE vessels which receive the blood immediately from the heart, and convey it to all the different and minute parts of the body, are called *arteries*.

In their collective or aggregate dimensions, they are less capacious than the *veins*; but their texture is far more solid, more compact, very elastic, and, as appears, from the experiments of Wintringham, remarkably strong.

§ 72.

They are composed of three membranous strata, or coats.

I. Of an *external*, which Haller called a true *cellular* coat, Albinus a *nervous*, Vesalius a *cartilaginous*, others a *tendinous*, &c. It consists of condensed cellular membrane, externally more lax, but becoming by degrees more compact, as you advance nearer to its internal surface, where it is overspread with numerous small blood vessels.

To

To this coat the artery appears to be chiefly indebted for its tone and elasticity.

II. The second or middle stratum, is composed of transverse fibres, assuming a lunated or falciform figure and direction; its substance has a fleshy appearance, from whence it has been called the muscular coat, and in it the vital energy of the arteries appears in a very particular manner, to reside.

III. The last and most internal coat, is a membrane of an extremely smooth and polished surface, which serves as a lining to the cavity of the artery.

In the trunks and larger branches of the arteries, these coats may be distinctly observed; but they are less evident in the more minute ramifications.

§ 73.

All the arterial branches in the human body take their origin from either one or the other of two leading trunks.

The *first* of these trunks is the *pulmonary* artery, which, rising from the anterior ventricle of the heart, passes into the lungs.

The *second* is the *aorta*, which rises from the posterior ventricle of the heart, and shoots its ramifications into every part of the system.

These trunks are divided into branches, which again undergo farther and more minute subdivisions.

§ 74.

An opinion has been conceived and propagated as an established truth, that, throughout the whole sanguiferous system, the *aggregate capacity* of all the branches, taken together, is superior to that of the trunk from which such branches directly originate. I fear, however, that the authors of this opinion have expressed themselves on this subject in terms by far too general, and have sometimes even confounded the measure of the diameter of vessels, with that of their area. In my investigations and inquiries on this subject, I did not trust to the result of a single experiment, nor did I confine my experiments to vessels filled with wax, which, however improper, were the only kind used by some celebrated physiologists, in their attempts to ascertain the matter now under consideration; but, as the nature and importance of the subject evidently demanded, I made my experiments and observations on the sound and unaltered vessels of subjects recently dead. I took,
for

for example, that nameless trunk from which the right carotid and subclavian arteries diverge as branches, and also the brachial trunk, together with its branches, the radial and cubital arteries, and having formed a rectangular triangle, from the diameter of the trunk and the diameters of its appended ramifications, I found, from the well known theorem of Pythagoras, that the square of the hypotenuse was equal to the sum of the squares of the base and perpendicular.

Indeed, in arteries of the smallest orders, Haller himself acknowledged that the capacity of the trunks is greater than that of their ramifications; so that, at least, the common calculation does not apply universally, but, (if it be indeed ever admissible), must be restricted to a very few orders of vessels.

§ 75.

Each trunk and ramification, separately considered, have been commonly believed to possess a conical figure, the base, or that part next to the heart, being supposed more capacious than the opposite extremity. This opinion appears however to be hypothetical: for, whoever will take the trouble of examining the arteries with accuracy and attention, will find their figure to be perfectly cylindrical: indeed, on the other hand, there

there are not wanting instances of some arteries which in their progress rather widen and expand, such, for example, are the *mammariæ internæ*, or internal mammaries, and even the arch of the aorta itself is more contracted at its base than at its apex or top. All arteries, especially those of the larger orders, appear to be a little dilated and enlarged, just before their division into branches.

§ 76.

The number of orders, formed by the divisions of the main arterial trunk into the progressive series of uniformly decreasing ramifications, from its first origin at the heart, to its final termination in the extreme capillaries, cannot possibly be universally ascertained and established as a general and unvarying result. The truth of this position will be obvious to any one who considers, that in the different parts of the body, especially in the viscera, the arteries are subject to great variety with respect to their divisions; and that, on this account, they sometimes form more, sometimes fewer orders of vessels, previously to their separation into evanescent capillaries.

Hence the disagreement of authors who have attempted to amuse themselves with calculations of this kind. Thus, for example, Keil estimated the number of the orders of arteries at fifty, while

Haller

Haller contended that they amount to no more than twenty.

§ 77.

After numerous divisions of this kind, and various anastomoses, by which the neighbouring branches of arteries communicate with each other, they at length arrive at their final terminations, which are completely continuous with, or which fairly open into, the origins of *veins*; so that, their route being uninterrupted, they are reflected from extremities that can scarcely be discerned, and thus converted into those returning vessels, by which the blood, lately arterial, but now become venous, is conveyed back again to the heart.

§ 78.

But although this complete continuity of the arteries and veins be so extremely evident in numerous parts of the body, as to be obvious even to the naked eye, yet it still remains a matter of doubt, whether this be the only and exclusive mode, in which arteries communicate with veins, or whether there may not be, at least in certain parts of the system, an intermediate and parenchymatous substance, which receives the blood from the terminations of the arteries, and again deposits it in the incipient mouths of the veins?

There

There occur certain phenomena, such for example, as erections of the penis, and the common phenomenon of blushing, which render the existence of such a connecting medium between those two kinds of vessels, at least not improbable.

§ 79.

There are, again, vessels of a nature evidently different from those already spoken of, which appear to arise every where from the smaller arterial branches; these vessels consist chiefly of two kinds, namely, *the serous*, which are so narrow as not to be able in a healthy subject to admit the globules of the cruor, but only to receive the thinner fluid or vehicle in which those globules swim (§ 69.); and the *secretory*, which do not appear to attract any thing from the mass of arterial blood, but such specific fluids as are destined for secretion (§ 4.)

§ 80.

With regard to the former kind of vessels, which we denominated *serous*, it is necessary to observe, that we do not mean by them the imaginary orders of yellow and of white vessels, spoken of by Boerhaave, which appear to have been fancifully conceived, in conformity to the account given by Lecuwenhoek of his equally imaginary sixfold conformation of the globules of the blood:

neither

neither do we mean the neuro-lymphatic vessels of Vieussen and Ferrein, of which those gentlemen supposed the viscera to be in a great measure composed; but which do not indeed appear to be any better founded than the preceding conjectures of Boerhaave and Leeuwenhoek.

By the *serous* we mean those colourless vessels which are never visible, unless in certain cases of violent inflammation, where the impetus of the blood is very powerful; and indeed in some parts of the body, even this energetic process of nature is not of itself sufficiently powerful to bring them into view, unless they be still farther dilated by means of an anatomical syphon or injector: of this latter description are, for example, the vessels of the cornea, which can scarcely ever be filled with wax, unless in the dead bodies of such subjects as have died while labouring under a violent inflammation of the eyes.

§ 81.

The *secretory* vessels, on the other hand, appear to be different from those, and belong chiefly to the secreting viscera and conglomerate glands; they can also be traced by means of a very subtle injection, which, for instance, when thrown with force into the artery of the parotid gland, flows out and escapes through the duct of Stenonius.

But

But on these vessels we will have a stated opportunity of being more pointed and particular in a subsequent section.

SECT. VIII.

OF THE VEINS WHICH CARRY BLOOD.

§ 82.

THAT blood, which, by means of the arteries has been distributed throughout every part of the system, must be conveyed back again to the heart through the medium of the veins.

These vessels differ very widely from the arteries, both in their functions and structure : to this, however, veins of the smallest orders form an exception, as their structure does not differ from that of arteries of the same magnitude in so wide and obvious a degree.

§ 83.

The veins (if we except the pulmonary system) are more capacious in their collective or aggregate dimensions than the arteries ; their ramifications are also more numerous ; they are much more irregular in their courses and modes of ramifying ;
their

their texture is also much softer than that of the arteries ; they are far less elastic, but nevertheless extremely tenacious, and capable of wonderful expansion.

§ 85.

Their *coats* are considerably thinner than those of the arteries ; whence the blood which they contain appears in some measure through them ; they are also less numerous, being no more than a certain *cellular covering*, somewhat resembling what has been called the nervous coat of the arteries, and an *internal membrane* of a very exquisite polish, similar to that with which the arteries are lined.

No part of the venous system is furnished with muscular fibres, except the larger trunks near the heart.

§ 86.

In by far the greater number of the larger veins, such, for example, as exceed in their diameter the twelfth part of an inch, this internal membrane forms, by its foldings, an immense number of valves of the most beautiful structure, exceedingly pliant or moveable, and exhibiting the appearance of small sacks : they are, for the most part, simple and alone, frequently however, ar-

ranged in pairs, and sometimes in triplets; and are so situated and disposed, that the bottom of the little sack points to the origin of the vein, while its mouth or orifice opens, and is directed towards the heart.

Those small valves are, nevertheless, wanting in the veins of certain parts, as in those of the encephalon, the lungs, &c. and in the whole system of the *vena portarum*.

§ 87.

The small ramifications of the veins (which would, indeed, with more propriety be called their radicles or little roots) form, by their junctions, larger branches, and these unite finally into six leading trunks; viz. the two *venæ cavæ*, one called the *superior*, the other the *inferior*, and the four trunks of the pulmonary vein.

The *vena portarum* alone exhibits one phenomenon peculiar to itself. The trunk of that vein, on entering the liver is, after the manner of an artery, immediately divided into branches, the extreme ramifications of which become, at length, radicles to the inferior cava, and finally lose themselves in the bosom of that trunk.

§ 88.

We need not, on the present occasion, again advert to the common, and by far too general, opinion, that the areas of the branches are more capacious than the area of the trunk from which they rise, nor yet to that respecting the conical figure of single vessels, as what was said on those subjects, when treating of the arteries (§ 74, 75.), will apply with sufficient precision to the veins.

There are also among the veins, a few examples of vessels being more capacious at a more remote distance from the heart; such, for instance, is the *vena poplitea*, where it passes between the condyls of the os femoris.

What has been already said, with regard to the final terminations of the arteries (§ 77, 78, 80.), may, by making such obvious and necessary changes, as are adapted to the different nature and circumstances of our subject, be fitly applied to the origins of the veins.

SECT. IX.

OF THE HEART.

§ 89.

THERE exists, as we have already had occasion to observe (§ 65), a two-fold communication between the *arteries* and *veins*: one, for instance, at the minute extremities of each kind of vessels (§ 77); and the other at the heart, their common fountain, in which the leading trunks of the whole sanguiferous system meet.

§ 90.

The heart is, as it were, the first active organ and moving spring of the whole human machine, as it is by the perpetual and truly astonishing energy of this body, that the most important vital function, namely, the circulation of the blood, is performed, from so early a date of our existence, as the fourth week after conception, down to the closing period of transient life.

§ 91.

This active organ, by its alternate dilatation and contraction, first receives and again ejects the blood in the following manner. Into the anterior venous sinus, and its appendage, the anterior auricle

etc.

ele of the heart, the blood is conveyed from the whole body, by means of the two *venæ cavæ*, viz. the superior and inferior, and likewise from the substance of the heart itself, by means of the coronary veins, the common orifice of which is furnished with a valve of a peculiar structure; and from this auricle, it is again conducted into the corresponding ventricle of the same side.

§ 92.

From this anterior ventricle (formerly called the *right* ventricle, in conformity to the situation of the heart in brutes) the blood is thrown into the lungs through the pulmonary artery, which was called by the ancients *vena arteriosa*; from thence, by the four pulmonary veins, called in former times *arteriæ venosæ*, it is conducted into a common sinus, formed by their conflux, and thence again into the corresponding auricle; these were once called the *left*, but are now more properly named the *posterior*, sinus and auricle.

§ 93.

From the posterior auricle it passes on to the ventricle of the same side, from whence it is distributed, by means of the aorta, through the whole arterial system appropriated to the other parts of the body, and by the coronary arteries, through the substance of the heart itself.

§ 94.

The blood having passed from the extreme and ultimate branches of the *arterial*, into the incipient radicles of the *venous system*, re-enters the two *venæ cavæ*, (while that from the coronary arteries is also returned by veins of the same name), and thus the whole collective volume resumes again, and incessantly continues, the same circuitous route already described.

§ 95.

This circular and regularly progressive motion of the blood through the cavities of the heart, is powerfully directed, and the regurgitations of that fluid are completely prevented, by means of small valves, which surround and serve as portals to the principal avenues which lead to the heart. These valves are situated on the margins, or extreme lips, of the ventricles which are adjacent to, and look towards, their corresponding sinuses, and also at the mouths of the two great arterial canals leading out of those ventricles.

§ 96.

Thus a small venous ring or tendon, which forms a partition between the anterior sinus and ventricle, descending into the cavity of the latter, separates into three small valves of a tendinous appearance, each one of which was formerly believed to divide again into three apices or points,
from

from whence they received the name of *valvulæ triglochines* or *tricuspides*. These valves are connected at their points to fleshy columns, commonly called *musculi papillares*.

§ 97.

In like manner another small ring of the same kind, which constitutes a partition between the posterior sinus and ventricle, is also divided into two small valves, which, from a certain supposed resemblance to a *sacerdotal mitre*, have been called *valvulæ mitrales*.

§ 98.

At the entrance into the pulmonary artery, as also at the mouth of the aorta, are situated, in an annular or circular position, three valves much smaller indeed than those already described, but of a very elegant and beautiful figure and appearance, and furnished with fleshy fibres; these have been called *valvulæ semilunares* or *sigmoides*.

§ 99.

Now it evidently appears, that by means of these different kinds of small valves, sufficient provision is made against the irregular, confused and retrograde movement of the blood. They easily yield, and afford a passage to the blood when advancing regularly forward in the established course

of its circulation. But they prevent the regurgitation of this fluid, by becoming, in consequence of its reflux effort, fully expanded like the swelling of a well-filled sail, and thus completely closing the orifices round which they are arranged.

§ 100.

The valve of Eustachius which, in the foetal state, is stretched like a curtain across the mouth of the ascending cava, becomes after birth (sooner or later in different subjects) so gradually obliterated for the most part, as to be rendered wholly unfit for the execution of its former functions; neither indeed does the system stand any longer in need of it, as a passage is now opened and prepared for the blood through the lungs, and its return from those viscera prevented by the femiunar valves already spoken of, and as each subsequent column of blood, pressing from behind, must pursue the same route with that immediately preceding it. But as it does sometimes notwithstanding happen, that the passage of the blood from the right side of the heart into the lungs is by some means obstructed, we then learn from the preternatural pulsation observable in the superior cava, that the blood is repelled in a retrograde direction from the right sinus into the two adjoining great venous trunks.

§ 101.

It is a point of controversy, whether or not the femilunar valves suffer the ventricles to be perfectly and completely evacuated, or whether they do not rather by means of their expansion intercept a part of the blood in its escape from those cavities, and thus force it to take in some measure a retrograde course.

Observations made on frogs, and even on the minute heart of the nascent chick, prove that in those animals the heart is indeed completely evacuated; but whether or not the same thing takes place in man himself, when in a sound state of health, is not yet clearly ascertained; if, however, it be admissible, in physiological discussions to speculate and draw conclusions from the structure and mechanism of those valves themselves, as they appear on the dissection of the heart, the contrary opinion appears the most probable.

§ 102.

The *texture* of the heart is altogether singular, and peculiar to that organ. It is indeed fleshy, but remarkably close and compact, and widely different from the common constitution and appearance of muscles.

It is composed of small bundles of fibres, more or less oblique, frequently ramifying in a singular manner, contorted and wound spirally in diversified and truly strange directions; these fibres lie over, and rest on, each other in certain orders of strata, they are intermingled and closely knit together in the septum which separates the two ventricles, and are fastened and firmly connected at the basis of those ventricles by four cartilaginous rings or bands, which (according to the accurate unravelling and developement of the whole fibrous texture of the heart, lately executed by the indefatigable and illustrious Wolff), appear to serve as a stay and support to the *fleshy structure* of the ventricles, and also to separate and distinguish it from the fibres of the sinuses.

§ 103.

Those fleshy fibres are every where overspread with an infinitude of small nervous ramifications of extreme softness, but they are more particularly supplied with such an immense apparatus of blood vessels, arising from, and belonging to, the coronary arteries and veins, that Ruyfch has declared in his writings, that the whole fabric of the heart appears to be composed solely of sanguiferous tubes.

§ 104.

By means of the foregoing *structure* (§ 90. seq.) and texture (§ 101. seq.) the heart is fitted for the performance of those perpetual and uniformly equable movements, which return in such general order, that the preliminary appendices and ventricles themselves, are alternately *contracted* and *relaxed*, or perform, in alternate times, those motions, called in physiological language, *systole* and *diastole*.

§ 105.

With such definitude do they preserve this harmonious order in their routine of contraction and dilatation, that as soon as the appendices contract themselves, to propel the blood, returning from the lungs and *venæ cavæ*, into the ventricles, these latter are at the same instant relaxed and fitted to receive the same advancing wave of blood; but in the subsequent and next moment, when it is the point of time for the ventricles, now recently filled, to contract and force the blood into the two arterial trunks, the appendices are again relaxed, and their mouths rendered patulous for the purpose of drinking in a fresh tide of venous blood as it rolls on in its usual course.

§ 106.

§ 106.

This systole of the ventricles, which is supposed to consume about one third part of the whole time of the heart's pulsation, is performed in such a manner, that the exterior sides of those cavities are approximated and contracted towards the intermediate septum which separates the right ventricle from the left; which contraction, especially if we attend to the conical figure of those cavities, appears fully sufficient to evacuate them of their contents.

But besides this approximation of the lateral parts of the heart towards each other, the apex of that organ is, during its systolic motion, contracted towards, and brought nearer to its basis; as has been frequently observed not only in the inferior animals both of *cold**, and *warm* blood, but even in man himself, while in a living state†.

* I have not in the live-dissection of any animal discovered the heart more evidently shortened, during its systolic motion, than in that of *coluber natrix* or water serpent. Throughout the forests in the neighbourhood of our city, this species of serpent may be sometimes found four feet in length. Having taken one of these animals and subjected it in a living state to the anatomic knife, I observed that the length of its heart during the *diastolic*, exceeded its length during the *systolic* motion, at least the space of two lines,

† It does not, however, appear that this diminution of the longitude of the heart during its systolic motion is an absolute

An argument seemingly in favour of a contrary opinion has been derived from, and founded in, vulgar experience, from which it appears that the apex of the heart strikes, during its systolic motion, against the left mamma or breast, and seems therefore to be rather elongated than contracted and shortened; this apparently conclusive argument will however have no weight with one who considers, that those sensible percussions or strokes of the heart are to be attributed as well to the *impetus* of the venous blood rushing into the appendices of that organ, as to that of the arterial blood forcibly ejected from its ventricles; by both which sources of propulsion the whole heart is carried towards and impinged against that region of the ribs.

§ 107.

The impetus, which is by this systolic contraction of the heart imparted to the blood, is com-

plete condition of life. I am led to the adoption of this opinion from a variety of observations made on the heart of a duck, in a great portion of which a complete ossification had taken place. This heart was deposited in my anatomical collection by my very liberal and worthy friend C. F. Michaelis, and is marked by completely ossified strizæ running from its base to its apex. On its sides, however, it was still furnished with fleshy substance sufficient to continue the lateral motion of its ventricles, and thus preserve the circulation of the blood.

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municated to the arterial system, receiving the blood, in such a manner, that every systole of the heart may be plainly perceived in such arteries of the other parts of the body as can be felt by the touch, (of which description are all those that exceed in their diameters the sixth part of a line), and likewise in such other arteries as can by any means whatever have their pulsations rendered obvious to the senses: this can be easily effected, for example, in the internal ear or eye, in either of which a singular kind of motion can be excited and rendered sensible, which (as well as the same kind of throbbing or pulsatory motion so perceptible in the other parts of the arterial system) is called the *diastole* of the arteries: of this diastolic motion we shall have an opportunity to speak on a future occasion, at which time we will take up the inquiry, whether or not it is to be attributed solely to the action of the arteries themselves, or derives its existence from some other source.

§ 108.

In whatever manner this point may be determined, one thing we learn from experience, the surest guide to truth, viz. that in a healthy subject, what is called the pulse of the arteries, is precisely synchronous with, and perfectly correspondent to, the motions of the heart; and likewise in a morbid intermission of the pulse, the
heart

heart and arteries still harmonize in their action, by ceasing from, and again commencing, motion at precisely the same moments.

§ 109.

The frequency of the pulsations of the human heart in a healthy state, is extremely different in different subjects. This diversity arises principally from diversity in point of age, but partially also from other conditions of the system, which at any and every period of life constitute the health proper to each individual; so that it is not possible to ascertain and establish, on this subject, any certain and definite rule. It may nevertheless be proper to mention the general result of my observations (made in our own climate) on the frequency of the pulse in the different periods of human life.

In the first days after birth I have generally found the pulsations of the heart of the tender infant, while found asleep, amount to about 140 in the space of a minute.

At the expiration of the first year, they amount to 124 in a minute.

At the end of the second year to about 110.

At the end of the third year to about 96, &c.

At

At that period in which the first set of teeth, usually called the milk-teeth, drop out, the pulsations of the heart amount to 86 in a minute.

At the age of puberty to about 80.

In the prime of life, or at the period of manhood, to about 75.

And to about 60 at the sixtieth year of human life.

In subjects still farther advanced in years, I have scarcely found two in whom the number of pulsations were the same, at the same period of old age.

§ 110.

All other circumstances being alike, the pulsations of the heart are more frequent in females than in males.

If proper and necessary allowance be made for the habit of body, they are less frequent in men uncommonly tall, than in such as are rather low. This circumstance I have ascertained to be a truth by comparative observations made on the pulses of *dwarfs*, and *giants* or men remarkably large.

§ 111.

On the subject of those varieties in the pulse, occasioned by *extraneous circumstances*, vulgarly called *non-naturals*, it is necessary to observe, that a cold climate produces a slow pulse; thus, for instance, the heart of a Greenlander when in perfect health, does not pulsate oftner than from thirty to forty times in a minute.

But it is an observation as common as it is true, that the pulse becomes more frequent after the taking in of aliment, and after an emission of semen. The same effect is also produced on the pulse by a want of sleep, by bodily exercise, or by passions of the mind.

§ 112.

The foregoing observations relate to the natural or healthy pulse, in the consideration of which it seems more consistent, and agreeable to nature, to direct our views to the *heart*, as its exclusive source, than to the arteries, on which physiologists have usually fixed their attention when engaged in the investigation of this subject.

In this incessant routine, the heart continues its pulsations, down to the extreme glimmerings of life's perishable flame; and even *then*, all its parts do not cease from action at the same moment,
but

but it is the prerogative of the right ventricle with its appendices, the right auricle and sinus, to survive the left ventricle, and its appendices.

This may be sufficiently illustrated in the following manner: After the last act of expiration, the lungs now in a collapsed state, can no longer admit the blood to flow through them in its customary channel, while at the same time that wave of blood which they have just returned to the left side of the heart, is from thence forceably expelled through the aorta, and thus urges forward by a *vis a tergo* the advancing column of venous blood: from this combination and concurrence of circumstances, the blood returning with precipitation and impetuosity, rushes violently into the appendices and ventricle on the right side of the heart, in consequence of which the parietes of those cavities are thrown into convulsive efforts, and thus continue to be agitated, for some time, after the left side of that organ is completely deprived of all vital motion.

§ 113.

From a knowledge of this *fact*, viz. that during the last vital efforts of declining nature, the blood is propelled into the cavities on the right side of the heart, we deduce, with the utmost ease, the *cause* of that state of depletion in
1
which

which the larger arteries are found after death. To the same cause also Weifs, and after him the illustrious Sabatier, were desirous of attributing the superior size of the cavities on the right, to that of those on the left, side of the heart, especially in the corpse of an adult subject.

§ 114.

The whole of this motion of the heart, which has been the subject of the preceding observations, is to a very considerable degree limited and directed by the *pericardium*, in which the heart loosely hangs, and by which it is completely enclosed as in the walls of a prison.

The pericardium is a membranous sac, considerably capacious, and accommodated to the figure of the heart which it encloses. It takes its origin from the membranes constituting the mediastinum, and although, from its fineness, it may appear somewhat tender, yet we learn from the experiments of Wintringham, that it is so very tenacious and firm, as far to exceed in strength all other membranes of a similar nature in the human body.

That the pericardium is a part of the first importance in the animal economy, we safely infer from this single circumstance, namely, that throughout all classes of animals possessing red

blood, it is found as constantly and uniformly existing as the heart itself; and records do not furnish more than one or two examples of the human heart having been found completely destitute of a pericardium. These singular examples of such an unnatural state of the heart are recorded in the writings of Dinkler.

§ 115.

The internal surface of the pericardium is kept constantly humid by a dew-like serous effusion, which appears to exhale from the small arteries of the heart itself.

In like manner a fluid, of a similar nature, appears to transude into the very cavities of the heart, and to moisten and lubricate their surrounding *parietes* or walls.

In either case the effusion during the healthy state of the part is of a serous nature, and not accompanied by any real *lymph*, unless the heart be labouring under inflammation; but when this organ becomes the seat of an inflammatory affection, then genuine lymph transudes, giving rise, on the external superficies of the heart, to fine filaments of a hair-like appearance, together with those preternatural portions of cellular membrane, which in such cases connect the heart to the pericardium,

pericardium, but on the interior surfaces of the cavities themselves producing excrescences of a truly polypous nature. (§ 19.)

S E C T. X.

OF THE POWERS BY WHICH THE BLOOD IS
KEPT IN MOTION.

§ 116.

HAVING thus completed the consideration of the organs in which the blood is contained, we now pass on to take a view of the powers, by which those organs are qualified and fully prepared to keep that vital fluid in motion.

Let us, in the first place, take an attentive and accurate survey of those powers which reside in the heart itself, and which ought, without doubt, to be considered as by far the most active and essential in the great business of circulation: we will then proceed to consider what may be called the secondary and assistant powers, which we will also find of high importance in the animal economy, from the concurrent and effective aid which they afford to the action of the heart.

§ 117.

It will at first view appear obvious to even the most superficial observer, that it is a matter of Herculean difficulty indeed, either to ascertain by accurate calculation the force of action exerted by the heart, or to determine with precision the quantity of blood thrown into the aorta by that organ at each pulsation; neither will the speculative physiologist find himself beset with difficulties of less moment, when he attempts to ascertain and establish with definitude, either the distance to which each projected wave of blood is carried by the impetus it receives from the heart alone, or yet the celerity with which such wave rolls forward; but he will be surrounded with difficulties, still increasing at each advancing step, in his attempts to render a just statement and accurate account of all such obstacles as oppose, and thus greatly diminish the effects of the force exerted by the heart, in its action on the circulating mass of fluids.

§ 118.

A certain estimation may nevertheless be formed of the power of the heart, by collecting and comparing the most probable conjectures which have appeared on the above points of physiological speculation. Thus for instance, if we suppose the whole mass of blood to amount at a mean rate to

33 pounds, *i. e.* 396 ounces (§ 23), and estimate the number of pulsations at 75 in a minute, *i. e.* 4500 every hour (§ 109); and further, if we adopt the opinion that at each systole the left ventricle ejects two ounces of blood, it will then follow, that during the course of every hour the weight of the whole volume of blood makes $22\frac{1}{2}$ complete transitions through the heart. We may also form a tolerable conception and estimation of the impetus with which the circulating blood is propelled from the left ventricle of the heart, by observing with what astonishing violence, and to what a considerable height, the blood spouts from one of the larger arteries when wounded in the neighbourhood of the heart. Thus, from the wounded carotid of an adult subject, I have seen the blood, during a few of the first contractions of the heart after the accident, mount in jets to the height of at least five feet.

§ 119.

But when we institute an enquiry for the discovery of those unfailing fountains or springs, which supply the heart with a force so powerful, and at the same time so uninterrupted and lasting, that which first attracts our attention, as being foremost both in point of time and importance is its *irritability*, (§ 44). This vital energy, as has been already evinced (§ 90), is much longer pos-

fessed by the heart, than by any other muscular part in the whole human body.

That the parietes, or walls themselves of the cavities, are irritated and excited to contract by reiterated impressions from the circulating waves of blood, is manifest from a well known experiment of the illustrious Haller. From this celebrated experiment, of that indefatigable physiologist and acute philosopher, it appears, that he could at pleasure grant, either to the right or left side of the heart, the prerogative of a more protracted vital motion, (*i. e.* of longer life) accordingly as he first deprived the one side or the other of its peculiar stimulus, the blood*.

§ 120.

When the proportional quantity of the blood is well adjusted to the size of the containing vessels, and its quality uncontaminated by any morbid change, its action on the heart, and the re-action of that organ again on the blood, proceed with such an equable, regular and happy facility, that, when in a state of rest, we are scarcely sensible of the circulation of this vital fluid, which is the kind and constant dispenser of life and vigour to every part of our bodies.

* See Haller "De motu cordis a stimulo nato," in Commentar. Soc. Scient. Goettingens, tom. i.

But

But if the circulating volume of blood be either too abundant, or preternaturally scanty, but especially if this vital fluid be contaminated by the admixture of any foreign substance, as noxious miasmata, air in an elastic state, or poisons injected into the veins, &c. the heart, either roused immediately into excessive action, or depressed to the opposite extreme of prostration and debility, continues no longer fit for the salutary discharge of its important function, but falls into motions convulsive, irregular, and very widely different from the equable tenor of its healthy action. Foreign substances of the same kind, as air blown into the veins, &c. are also sometimes able to rouse again, and excite to motion, the heart of an animal recently dead.

§ 121.

It has been a point of controversy, even in very modern times, whether this extreme irritability of the heart be essentially inherent in its own substance, or if it be not rather adventitious, and derived, as some celebrated characters would induce the world to believe, from the mysterious influence of the nerves? We will hereafter have a fit opportunity of declaring our sentiments respecting the whole of this controversy, when we come to consider the doctrine of *muscular irritability*, under which head, this subject of inquiry most naturally

falls. On the present occasion it may suffice to observe, that I am daily more and more convinced, that irritability is a species of vital energy altogether peculiar in its nature, belonging exclusively to muscular fibres, and completely distinct from the *vis nervea* (§ 34, 45.) But, on the other hand, it is no less evident and incontrovertible, that the nerves do also possess a very powerful influence and command over the action of the heart: this we learn, as well from the peculiar habit and appearance of the cardiac nerves, from their softness, their defect of covering, and their singular disposition and arrangement, as from the astonishing consent of the heart with by far the greater number of the functions of the human body, even with those of the most opposite nature. In testimony of the reality of this consent, it may be sufficient barely to mention, the sudden and transient sympathy which, even in a healthy subject, exists between all the passions of the mind and the heart, together with that, which, in a great many species of disease, manifests itself between this organ and the *primæ viæ*.

§ 122.

But, besides those vital energies of the heart, it possesses also another power, arising out of its mechanical structure, which appears to contribute not a little towards carrying on the circulation of the

the

the blood. The cavities of this organ being closely contracted, in the time of its systole, and the blood by this means completely expelled, a vacuum is thus produced, into which, on the principles of the well known law of *derivation*, the neighbouring blood must of necessity flow; for, as the valves prevent the regurgitation of the wave just ejected, it follows of course, that the cavities of the heart must then drink in, and swallow down, with rapidity, the blood advancing in the trunks of the veins.

§ 123.

We proceed now to enquire, whether or not, any of the other organs through which the blood passes, besides the heart itself, are furnished with powers contributory to the continuance of the circulation of that fluid. Judging from first principles, or *a priori*, as it is termed, we are led to suspect that such powers do exist; for it appears hardly probable, that the wisdom of nature has entrusted so important a function, on which the life of sanguiferous animals immediately depends, to one organ only, the faults and defects of which might, in such case, with too much facility, be attended with fatal consequences. But, reasoning *a posteriori*, as they term it, *i. e.* from actual observations, made on the animal economy, we are furnished with numerous facts sufficient to establish,
beyond

beyond a doubt, the existence of such powers, which we may therefore term *secondary powers*, and which are able, not only to aid the action of the heart, but, in some cases, to compensate for almost the complete absence of the influence of that important organ. A striking instance of this nature, is the continued *motion* of the *blood*, in certain parts of the body, on which the power of the heart can have but very little effect, if indeed it can extend to them at all: this phenomenon is observable, as well in the venous system of the liver, as in the placenta of the uterus; not to mention numerous instances of fœtuses having been born, without the smallest vestige of a heart.

§ 124.

Of these *secondary powers*, the first to be mentioned is, the *functions of the arteries*, the influence of which, in promoting and continuing the circulation of the blood, appears to be, indeed, very considerable; although the true principles and mode of their action, on this fluid, have not yet been fully developed and established.

Speaking in general terms, there exists a very considerable resemblance between the arteries and the heart itself: that the arteries, for example, have a *muscular coat*, is a fact of the utmost publicity (§ 72.)

That

That they also possess irritability, has been very generally known, since the famous experiments of the illustrious Verschuir.

And, further, as the aspect or disposition of the cardiac nerves on the heart itself is truly singular, thus also the larger branches of the arteries are, here and there, surrounded with astonishing reticular intertextures of soft nerves.

§ 125.

Finally, It is well known to every one that the arteries pulsate, and that indeed with such vehemence and force, that if we suffer one of our legs to lie over the other knee, the pulsations of the popliteal artery are sufficient to elevate in a subfultory manner, the superincumbent leg not only alone, but even with a very considerable weight appended to it. Indeed for a long time past, both a systolic contraction and diastolic relaxation have been attributed to the arteries, which motions have been said to correspond and harmonize with the alternate contractions and dilatations of the ventricles of the heart.

Though the truth of this last proposition is generally believed to be established and confirmed by the simple testimony of the senses themselves, the subject is nevertheless still embarrassed with
various

various doubts and difficulties: these difficulties immediately rise to view, when it is asked, whether this vibrating or pulsatory motion, which is felt on examination by the finger, is to be attributed to the inherent energy of the arteries, or to the impulse of the heart; and whether the whole motion of the arteries does not depend solely on the impetus with which the blood is projected into the aorta, and thus impinges against the sides of that tube, and its ramifications?

Dissections of living animals have not been sufficient to decide this controversy. For it sometimes happens that during the live-dissections of warm blooded animals you may discover the larger arteries pulsating, while at other times again they appear in a state of complete rest. In man himself, while in the enjoyment of vitality, I had once an occasional opportunity of observing the neighbouring trunks of the aorta and pulmonary artery, to be perfectly destitute of all motion; but it should not be forgotten, that this phenomenon appeared in a case of monstrous or preternatural formation of the parts. There are also arteries which we sometimes feel in a state of violent pulsation, and which we nevertheless know, from anatomy, are, in consequence of their situation, almost immovable; of this we have an example
in

in the cerebral carotid, where it passes through the canal of the *os petrosum*.

§ 126.

When all circumstances relative to this subject are impartially weighed and dispassionately considered, this appears to be the result, viz. that the *diastole* of the larger arteries takes place in consequence of their peculiar nature, and is to be attributed to the impetus of the blood rushing forcibly into them, and expanding their coats or tunics, which, by means of their elasticity, immediately return again to their natural dimensions. To the same impulse also should be attributed that lateral or curving motion of their axes, which may frequently be observed in the larger arteries when they run in a serpentine direction, and lie embedded in soft cellular membrane.

But in a sound state of the system, we contend that the arteries scarcely exhibit any unequivocal proofs of a *true systole*, i. e. they do not by a genuine contraction recede from their *natural*, to *smaller* dimensions, as long as the heart is adequate to the due performance of its momentous function; but although it be certain, that the arteries do not always, yet we acknowledge that they do sometimes, exhibit and exercise a power of real contraction: thus for instance, when the heart is
deficient

deficient in its action in consequence of labouring under either a morbid ossification, or some other species of disease, it is probable that then the duties of this important organ devolve on, and are discharged by, the arteries, and that the blood is thus kept in motion by the vital energy of those animated tubes.

§ 127.

As it has been the decided opinion of several celebrated physiologists, especially the famous Whytt, that the powers of the heart cannot possibly extend their influence to blood-vessels of the smallest order, as, for example, to the extreme terminations of the arteries, and to the incipient radicles of the veins; they have therefore attributed the motion of the blood, in that part of the system, to a certain oscillatory action of those minute vessels themselves, by the help of which their contents are propelled forward: and this same vibratory motion they have also applied, with a great deal of ingenuity, to explain and demonstrate the nature of inflammation, &c.

There are indeed a variety of phenomena, as well *physiological*, which shall be mentioned when on the subject of animal heat, as *pathological*, particularly observable in spasmodic affections, accompanied with fever, which seem to favour the
existence

existence of such a power of oscillatory motion, although no such motion has ever been actually observed, even with the assistance of glasses, in the dissections of living animals.

§ 128.

It yet remains to enquire also after those assistant powers, by which the other parts of the veins, besides their radicles or incipient roots, are fitted to complete finally the return of the blood to the heart. It appears, indeed, at the first view of the subject, that the veins possess and exert a much smaller portion of the active vital energies than the other parts of the sanguiferous system, because the return of the vital fluid, contained in those vessels, towards the heart, seems to be owing to the impetus of the arterial blood urging it on by a *vis a tergo*, as well as to the valvular structure of the veins themselves, which effectually prevents the blood from regurgitating. That these minute valves are of the utmost importance in promoting and continuing the regular and free circulation of the blood, is satisfactorily demonstrated by the frequent congestions and infarctions, which happen in those veins that originate in the inferior parts of the abdominal cavity, and which are entirely destitute of such valves.

But

But there are nevertheless a variety of arguments which render it probable, that the trunks of the veins do possess, and actually exert, certain degrees of the vital energies; as is well exemplified in the veins of the liver, and of the uterine placenta (§ 123.), &c.

It is also well known to every one, that the experiments first instituted by the illustrious Verschuir, are highly in favour of the existence of a vital energy in the veins.

And, that the two leading and extreme venous trunks have a stratum of a true muscular nature, we have briefly hinted on a former occasion (§ 84).

§ 129.

These are indeed the leading powers which are active in promoting the circulation of the blood, and which derive their origin from the very structure of the vessels in which this fluid is contained. I say nothing of the manner or degree in which the motion of this vital liquid is influenced by *weight*, *attraction*, or such other properties as are possessed by all bodies in common.

I also pass over in silence the more remote and inconsiderable aids, which, in a human subject after
 birth

birth, are afforded to the circulation of the blood, by the exercise of the other functions of the system, such as respiration, muscular motion, &c.

SECT. XI.

OF RESPIRATION, AND ITS PRIMARY USE.

§ 130.

THE *lungs*, which are very intimately connected with the heart, as well from the vicinity of their situation, as from their uniform intercourse in the performance of their important function, are two viscera, large in the human subject after birth, but of such specific lightness, as to float on the surface of water. They consist of a parenchymatous substance, of a spongy texture, and even exhibiting somewhat the appearance of foam, yet still considerably tenacious and strong.

§ 131.

The lungs fill up the two cavities of the thorax, and thus lie in perfect contact with the faces of the pleura, to which, as well as to the other parts contained in the thorax, they apply and accommodate themselves with the utmost definitude and exactness.

§ 132.

These viscera are appended to an air tube commonly called the *aspera arteria*, which, (besides an internal membrane, lined with mucus, under which is expanded a nervous intertexture of extreme sensibility), consists also of a muscular coat, which surrounds the nervous expansion, and on the posterior side is easily distinguished at the terminations of certain cartilaginous arches, which assist in the formation of the tube, but are not uniform in their number.

§ 133.

After the *aspera arteria* has entered the thorax it first forms, by bifurcation, the two trunks of the *bronchiæ*, which as they shoot still deeper and deeper into the *lobes* and *lobules* of the lungs, pass again, by reiterated divisions and subdivisions, into branches and ramifications, uniformly decreasing in size. During these progressive and multiplex divisions into inferior orders, both the small cartilaginous rings, and their muscular coat gradually disappear, till the evanescent extremities of the tubes finally terminate in those minute cells, which constitute by far the greater and more important part of the substance of the lungs, as their office is to receive, and again discharge the vivifying aerial element, in the process of respiration.

§ 134.

Those small air cells do not appear to possess uniformly, either the same *figure* or *dimensions*. With respect to the former of these, (viz. their figure), it is in general that of a polyhedron. The latter, (*i. e.* their dimensions), as far as their superficial extent is embraced in the consideration, cannot without the utmost difficulty, be ascertained; but, if we consider only their *aggregate capacity*, this, in the lungs of an adult subject, whose inspirations are full and strong, is sufficient to admit and contain about 60 cubic inches of air. We do not here speak of the immense size, to which the lungs may be expanded by inflation, after the thorax is opened, but only of the quantity and volume of air which they do actually admit in the living subject, when the process of respiration is performed with ease and vigour.

§ 135.

These vesicles or cells, destined for the reception of air, are every where surrounded and bound together by that common, but extremely tender, cellular membrane, which, as we have already learned, constitutes a general *vinculum* or bond of union to the whole body. But it is necessary to distinguish clearly and accurately between the two kinds of cells which exist in the pulmonic system. I have seen the air cells so separate and distinct,

in the lungs of a healthy human subject, that a person's breath, gently and cautiously blown through a very minute and tender ramification of the bronchiæ, would elevate only a single circumscribed cluster of vessels or cells, and would neither pass into the neighbouring cells of the same kind, nor yet into the common cellular membrane, which is every where interposed between those cells intended for the reception of air. But, if the breath be urged with considerable force, the air cells will be lacerated, and such a communication formed with the surrounding cellular membrane, as to give free passage to the subtle elastic fluid, and thus the whole and every part, of the pulmonary lobe, will appear to be inflated.

§ 136.

This exceedingly tender cellular membrane, which encloses and lies between the air vesicles of the lungs, is every where interspersed with innumerable small ramifications of both kinds of pulmonary vessels, viz. of the pulmonary artery, and of the four pulmonary veins, the branches of which accompany the branches of the bronchiæ, and afterwards, form in their course, by an immense number of divisions and subsequent anastomoses, reticular intertextures, and expansions of extreme fineness and subtilty. This truly astonishing reticular tissue, running in all directions through
the

the cellular membrane, so completely surrounds, and closely embraces, the cells destined for the reception of air, that the whole volume of blood, which passes in an incessant round through the pulmonic system, is separated from the air taken in at each inspiration, by nothing else than membranes so amazingly fine and subtle, as scarcely to be equal in thickness, (according to the observations and calculations of Hales), to the one thousandth part of an inch.

§ 137.

As we have already observed, that each individual ramification of the bronchiæ has appended to it its own peculiar cluster of air vesicles (§ 135), so likewise it appears, that to every individual vesicle of each cluster is peculiarly appropriated its own system of small blood vessels, the minute ramifications of which communicate very frequently with one another, forming those surprising reticular tissues already spoken of, but scarcely appear to anastomose, in any degree, with the small blood-vessels of the adjacent clusters. That this is a truth we are taught, if I am not deceived, as well from microscopical observations made on the lungs of living frogs and serpents, as from more minute and successful injections of the lungs of human subjects: the same thing is also further evidenced by certain pathological phenomena which may be

observed in *vomica*, and other similar topical affections of the pulmonic system.

§ 138.

It is necessary to mention also, in the last place, that singular and striking apparatus of lymphatic vessels, which spreads and appears, in a more particular manner, on the external membrane by which the lungs are invested. To this apparatus of vessels belongs that numerous assemblage of lymphatic or conglobate glands, which, though of a quite different and distinct order, are nevertheless commonly confounded, through mistake, with those glands in their neighbourhood, which are called *bronchiales*.

§ 139.

The *thorax*, in which the lungs are securely enclosed, has for its foundation or skeleton, bones and cartilages, arranged and disposed somewhat like the walls or sides of a cave. Though this bony cavity, taken together as an entire whole, be to a considerable degree firm and steady, yet most of its parts are so pliant and moveable, as to be well adapted for the performance of those motions which the business of respiration requires.

This pliability, or facility of motion is particularly observable in six pairs of the true ribs, which
being

being placed beneath the superior and first pair, are more moveable in proportion as their situation is lower; or their aptitude for motion is commensurate with the superior length of their bodies, and cartilaginous appendices, which connect them to the margins on each side of the sternum, by a species of articulation called *amphiarthrosis*.

§ 140.

Between the edges of those ribs lie two strata of intercostal muscles, the fibres of which assume indeed and pursue different directions, but which, nevertheless, co-operate in their action in producing the same motion in the parts to which they are attached.

Across the basis or inferior part of the whole of this cavity the *diaphragm* is stretched, somewhat in the form and direction of an arch. This is a muscle worthy of particular attention, and, to use the words of Haller, next in importance to the heart itself; its parts appear to depend chiefly on the phrenic nerve for their fitness to co-operate in the function of respiration, as was long since demonstrated by the celebrated live-dissections of the immortal Galen.

The diaphragm alternates for the most part, by an antagonizing motion, with the muscles of the abdomen, especially with the *external* and *internal oblique*, and the *transverse* muscles.

§ 141.

The thorax thus formed and finished is, in the living human subject after birth, alternately dilated at the time of each inspiration, and contracted again to its former dimensions in every subsequent act of expiration.

In inspiration, the enlargement of the thoracic cavity extends, in a more especial manner, *laterally* and *downwards*, so that the bodies of those ribs of which we have particularly spoken (§ 139) are elevated, and their inferior margins or edges turned in some degree outwards; while, at the same time, the arch of the diaphragm is somewhat depressed, and brought nearer to the position of a *plain*, or level surface.

But as to what is boldly asserted of the sternum, viz. that its inferior end is at the same time protruded forward, this is a phenomenon which I must confess, I have never been able to observe in the tranquil and unmolested respiration of a healthy person.

§ 142.

This alternate motion of the thorax, which in a healthy subject is indeed performed spontaneously and without effort, is uniformly continued from the moment of birth to the extinction of life, for the following necessary and important purposes, namely, that the lungs themselves may, by a similar vicissitude of motion, be expanded for the free admission and convenient reception of the air we inspire, and again contracted in order that the same may be forthwith expelled.

§ 143.

For man, together with all other warm blooded animals, is prevented, by absolute necessity, from a lengthy retention of the air which he inspires; he is obliged, after a very short period to discharge it again, and exchange it for a fresh supply of this *vital pabulum* or *food*, as the air has been termed, even from the most remote ages. It appears indeed from the most common observation, that the air which is inspired and retained any time in the lungs, however great may have been its original purity, suffers, in a very short time, such remarkable changes as affect it with the most obvious contamination, and, unless it be speedily renewed, render it wholly unfit to be any farther employed in the important process of respiration.

§ 144.

Enquiries have been instituted for the purpose of ascertaining the nature of those changes which the air we inspire undergoes in our lungs. Such changes certainly do not arise, as was formerly believed, from the loss of any mysterious principle of elasticity, which resides in the air, but are evidently produced by a decomposition of its elementary parts. For the atmospheric air which we breathe is truly an astonishing mixture of elementary substances, very widely different from each other in their natures. Not to mention the various heterogenous matters which this necessary fluid contains; such, for example, as the aerial seeds of the smallest and most simple plants, the odorous effluvia arising from numerous bodies, volumes of dust, and a thousand other similar substances, which for the most part float in the atmosphere. Not to mention, I say, these heterogenous bodies at all, the air which we breathe always contains aqueous exhalations in larger or smaller quantities, and is also more or less charged with the matters of electricity and magnetism. But finally, though the whole of the foregoing substances be left entirely out of view, yet even then the air of our atmosphere does not consist of one simple aeriform fluid, but is composed of dephlogisticated, phlogisticated, and fixed airs.

The proportion of those elementary matters, especially of such as are organic, is varied extremely from diversity of places, and by the nature of the bodies which exist in these places. It is in the mean time, however, the common estimation, that the air of our atmosphere consists of about $\frac{1}{4}$ th part of dephlogisticated, $\frac{1}{8}$ ths of phlogisticated, and $\frac{1}{2}$ th of fixed air.

§ 145.

It appears, that at each inspiration, (in which an adult subject, breathing in a quiet and tranquil manner, draws in about 30 cubic inches of air,) a fourth part of the dephlogisticated air is decomposed, and, in a great measure, exchanged for phlogisticated and fixed airs; so that the expired fluid, being received into a proper vessel, extinguishes flame or coals when immersed into it, precipitates lime from the water which suspends it, and far exceeds atmospheric air in its specific gravity, &c.

§ 146.

It is probable that the igneous parts of the dephlogisticated air, *i. e.* those parts suited to favour the process of combustion, being set at liberty by the decomposition which takes place in the lungs, enters the arterial blood, and is thus distributed throughout the whole body; while, on the other hand,

hand, the basis of fixed air is carried back, along with the phlogificated and venous blood, to the right side of the heart, and thence (as the ancients were pleased to express themselves) excreted through the lungs like foot.

The more florid dye of the arterial blood, the more obscure colour of the venous, and the similitude of colours imparted to both kinds of blood, when exposed to the action of those species of air now under our consideration (§ 16), are circumstances very much in favour of the preceding opinions.

§ 147.

In a foetus which has never yet received vital air into its own pulmonic system, there is in general less difference between the arterial and venous blood, than in an adult subject, in whom the process of respiration has already taken place.

After the infant is born, the new sensation, excited by the contact of an unusual element, in an animal which had hitherto led an aquatic life, and the application of various other stimuli altogether new, appear to afford us a happy clue for explaining the new motions which at that period take place in the body, more especially the dilatation of the thorax and the first act of inspiration.

When

When the lungs are dilated by this first complete act of inspiration, a new passage is thus opened through them for the blood, so that this fluid is ever after diverted from the umbilical vessels to the thorax.

But when this inspired air is, by that decomposition of its elementary parts, of which we have already spoken, rendered both noxious and troublesome to the lungs, I ascribe to the most simple preservative efforts of nature, the immediately subsequent motion, by which this poisonous mephitic is expired, and profitably exchanged for a fresh supply of the fostering pabulum of life.

From all the foregoing circumstances, taken collectively, (especially if we attend to the great influence of respiration on the circulation of the blood, as demonstrated by the well known experiment of Hooke), we are furnished with a much better explanation of the celebrated problem of Harvey, than has yet been given by most of the other reiterated labours of physiologists, who have attempted to solve that difficulty.

SECT. XII.

OF VOICE AND SPEECH.

§ 148.

THE leading function of respiration has been already the subject of our consideration. We will speak, in another place, of the part which this sublime process acts, in blending and intimately uniting the chyle with the blood, and also of the services which it renders, in a variety of ways, to almost the whole class of *natural functions*, (§ 63. 112.) We now proceed to consider its other uses in the animal economy.

The first object or phenomenon which attracts our attention, in this investigation, is the Voice, which belongs to the human subject after birth, and evidently proceeds from the lungs, as was long since very justly observed by Aristotle, who said, that no animals are vocal, *i. e.* possess the power of emitting sound, but such as breathe through lungs. For, by the denomination of *voice*, we properly designate that sound formed, by means of the expired air, in the *larynx*, which is a small apparatus or machine of the most exquisite structure, placed on the top of the wind-pipe or *aspera arteria*,

arteria, somewhat like a capital on the summit of a column.

§ 149.

This small machine is composed of various cartilages joined together somewhat after the form of a capsula or casket. These cartilages are furnished with a great and truly admirable apparatus of muscles, in consequence of which, not only the whole are rendered fit for motion collectively, but some of them are also enabled to move individually and alone, according to the different variations about to be produced in the voice.

§ 150.

That part which is more particularly engaged in the immediate generation of the voice is the *glottis*, a very narrow passage leading into the wind-pipe from above, to which is prefixed, or applied as a lid, a minute cartilage called the *epiglottis*. That sound is produced by the air expelled from the lungs, striking, in a proper direction and with due force, against the edges of this strait passage, is a matter too plain to admit of a doubt.

§ 151.

Controversies have existed on the subject of those changes that take place in the *glottis*, by which the modulations of the voice are produced, namely,

namely, Whether this cartilaginous part be alternately expanded and contracted, as was the opinion of Galen, and afterwards of Dodart? or, Whether the variations of the voice do not rather depend on the tension and relaxation of its ligaments, as was held by Ferrein?

The latter of those, therefore, compared the primary organ of the voice to a *violin*, the former to a *flute*—i. e. the one set of disputants conceived it to emit sound on the principles of a *corded*, the other on those of a *wind, instrument* of music.

From a faithful collection, and impartial consideration, of all the arguments which have been advanced on this contested point, we are of opinion, that both kinds of changes do actually take place in the glottis when employed in the emission of sound; but we, nevertheless, believe, that the principal and most important of those changes depend on and arise from the tension of the ligaments, more especially of the *thyreo-arytonoidei inferiores* (which appear to have been the vocal cords of Ferrein.

§ 152.

That all this mobility of the glottis, of whatever kind it may be, is influenced and wholly directed by the numerous muscles which belong, and are
1
attached,

attached, to the larynx, may be fully established by the following beautiful experiment, viz. If the recurrent or wandering nerves (as they are termed) be either secured in light ligatures, or completely cut afunder, the voice of the animals subjected to such experiments, will be in the former case, rendered extremely weak and low, and in the latter, entirely destroyed.

§ 153.

The faculty of *whistling* belongs in common both to the human species, and to small birds of note. To qualify them for this, singing birds are furnished with a bifurcated *larynx* at each extremity of the *aspera arteria*. But though human subjects be supplied with only one plain and simple larynx, yet they learn to imitate those small animals, as appears to me, by a contraction or puckering up of their lips.

§ 154.

But *song*, which is composed of speech and a harmonious modulation of the voice, I would consider as peculiar to man alone, and as constituting the leading prerogative of his vocal organs. The faculty of whistling is, as already observed, a part of the birth-right of birds: a numerous train of the feathered race, and sometimes even dogs themselves, have also been taught to pronounce a variety

riety of words. But I doubt extremely indeed, whether any brute animals have ever yet possessed a faculty of true and genuine song; whereas, on the other hand, I believe there scarcely exists a nation so barbarous, where song does not very generally prevail.

§ 155.

Speech itself is a peculiar modification of the voice, chiefly by the aid of the tongue, but partially also by that of the lips, the teeth, the palate, and by the further assistance of the nose, combined into the formation of words.

Hence the difference between *voice* and *speech* appears very obvious and plain: the first is evidently formed in the larynx itself; whereas the latter is effected by the singular mechanism of the other organs already mentioned. It is but just and proper, however, to observe, that this last position is not capable of universal application, as there are a few nations (of which the Sinensians may serve as an example), among whom their almost *homonymous** words are distinguished only by a varied modulation of the *voice* itself.

* A word is said to be homonymous, when it is highly equivocal, or used indiscriminately to represent a discordant variety of objects or things.

But further, voice belongs in common to brutes as well as to man; it is possessed also by the newborn babe, nor is it wholly denied to such unhappy infants as have passed their lives amidst the haunts, and in the gloomy society, of wild beasts, nor even to those that have been born without the sense of hearing. But speech is not acquired till after the cultivation and exercise of *reason*; it constitutes, therefore, no less than that operation of the mind itself, a characteristic privilege, and distinctive prerogative between man and the rest of the animal kingdom. To serve all the purposes, and answer all the demands of brutes, that instinct with which nature has beneficently supplied them, is completely adequate; of this instinct, however, man is destitute, as also of such other aids and individual powers as might enable him to preserve and sustain life by his own solitary exertions; he is therefore kindly furnished with the prerogatives of *reason* and *speech*, by means of which, embracing the advantages, and discharging the duties, annexed to a social state, he is able both to disclose his own wants, and relieve those of his fellow creatures.

§ 156.

That truly admirable mechanism, by means of which speech and the pronunciation of letters are

effected, has, since the celebrated researches of that paradoxical character, Franc. Mercur. Helmont, been very much illustrated and explained by further and later enquiries, especially those of Jo. Wallis and Conr. Ammanus.

That *divifion* of the letters by Ammanus into I. Vowels, II. Semivowels, and III. Confonants, is, of all others, by far the most simple and natural.

I. Vowels he again divides into *simple*, as *a, e, i, y, o, u*, and *mixed*, as, *ä, ö, ü*.

II. Semivowels are themselves either *nasals*, such as, *m, n, ng*, (i. e. *n* placed before *g* in the German language); or *Orals* (otherwise called *Linguals*) such as, *r, l*.

III. Finally, Confonants he divides, 1st, into the *Sibilantes* or *hiffing* (i. e. into those confonants the pronunciation of which can be continued for an indefinite length of time). These are *h, g, ch, s, fch, f, v, ph*.

2dly, *Explofive*, as, *k, q, d, t, b, p*, and

3dly, *Double* (or *Compound*), such as, *x, z*.

§ 157.

Finally, It yet remains to mention certain other modifications of the human voice, which usually occur as symptoms, or signs of either particular passions of the mind, or more violent affections of the organs of respiration. The greater part of these modifications of the voice, such for example, as laughing and crying, appear to belong exclusively to the human race.

§ 158.

Most of the modifications which immediately follow, are connected together by such a powerful kindred alliance, that one of them is not unfrequently observed to pass into another. It must be also further observed, that the greater part of them do not always assume and exhibit the same uniform appearance, &c.

To speak, however, in general terms, in the act of *laughing*, expirations short, interrupted, and in some measure broken, follow each other in quick succession.

Crying produces deep inspirations, which suddenly alternate with lengthy expirations frequently interrupted and broken.

Sighing consists in a lengthy, full, and strong inspiration, and a subsequent slow expiration, which is not unfrequently accompanied with somewhat of a *groan*.

Coughing is produced by quick and sonorous expirations succeeding a deep inspiration.

Sneezing is a more violent and somewhat convulsive expiration, which had been preceded by a short and forcible inspiration.

The *Hiccup* on the other hand consists entirely of a single inspiration, *sonorous*, extremely *sudden*, and at the same time of a *convulsive* nature.

The present seems a very suitable occasion to speak of the phenomenon of yawning, which consists in a full, slow, and lengthy inspiration, succeeded again by a similar expiration, while, at the same time, the jaws are drawn so very widely asunder, that the air which is received into the expanded fauces can enter with ease the *Eustachean tubes*. One thing peculiar to this phenomenon is, its being extremely contagious, i. e. it very readily excites to imitation: the cause of this is, without doubt, to be sought for in the remembrance of the agreeable sensations produced at a former time, by the languid operation of yawning.

SECT.

SECT. XIII.

OF ANIMAL HEAT.

§ 159.

IT is worthy of observation, that man in a living state, together with the other subjects belonging to the class Mammalia, as well as the whole feathered race, are distinguished from the rest of the animal kingdom by this peculiarity, that the native heat of their bodies far exceeds, in degrees of temperature, the usual heat of the medium or element in which they live. With respect to man himself, it is however to be remembered, that he appears to be inferior, in the heat of his system, to those other kinds of animals we have just mentioned. Thus, in our climate, the heat of the human body generally stands at about the 96th degree of Fahrenheit's scale, whereas, in other animals belonging to the class Mammalia, the vital [temperature very considerably exceeds this point, while it ascends still higher in individuals of the feathered tribes.

§ 160.

Indeed, the degree of native heat possessed by a healthy person is so constant and uniform, that in

general, (provided we make allowance for the state of health peculiar to each individual), its range will include but a very few degrees of the thermometer, whether the subject be exposed to the inclemencies of the most rigorous climate, or placed beneath the fervors of a tropical sky. For the opinion formerly delivered by Boerhaave, that man has not a power of existing in a medium of such a nature as exceeds in temperature the native heat of his own body, has, since the famous observations of that illustrious traveller and former governor of Georgia, H. Ellis, been refuted by a great number of characters learned in the science of physiology, and the reverse completely demonstrated and established by experiments well adapted to the nature of the subject. In this particular, indeed, appears to consist one of the great prerogatives of man, that imprisoned and confined to no one climate or zone of the earth, he is able to pass his life in any section of the immense globe we inhabit, and is free to fix his habitation either beneath the rigors of Hudson's stormy channel, where the quicksilver passes spontaneously to a state of complete congelation, amidst the tempests of Nova Zembla, or in the bosom of those glaring solar fires, which scorch the glowing shores of the Senegal,

§ 161.

We proceed now to enquire into the origin and source of that astonishing fire, which minutely pervades our bodies, and uniformly supplies them with their necessary degrees of warmth. To pass in silence over the visionary conjectures of the ancients on this subject, some of the moderns have attempted to derive animal heat, with all its phenomena, from the matter of electricity and the nerves, others from the attrition generated by the circulation of the blood, others from the reciprocal friction between the solid elementary parts of living animals, while others, again, have embraced and defended different opinions.

§ 162.

But all those hypotheses are embarrassed with insurmountable difficulties, whereas, on the other hand, the utmost simplicity, and an entire correspondence to the phenomena of nature, combine in recommending and confirming that doctrine, in which the lungs are considered as the *focus* or *fire-place* where animal heat is generated, and the dephlogisticated part of the air which we breathe, as the *fuel* that supports the vital flame. That justly celebrated character, Jo. Mayow, sketched out, formerly, the leading traces and first great outlines of this doctrine, which, in our times, has been greatly improved, extended, and farther elucidated,

elucidated, by the labours of the illustrious Crawford.

§ 163.

The whole drift and tenor of Crawford's theory obviously results in this, that *respiration*, no less than *combustion*, belongs to such processes as are called phlogistic; in which the phlogiston residing in, and constituting a part of, our bodies, is expelled by the accession of *free* or *sensible* heat, (which ought to be carefully distinguished from heat existing in a *fixed* or *latent* state.)

For phlogiston and the matter of heat are elements of such contrary and opposite natures, that the greater quantity of the one our bodies at any time contain, the less, at the same time, is their proportion of the other; thus, fixed air, for example, is not supposed to contain more than $\frac{1}{7}$ th part of the quantity of the matter of heat, which belongs to an equal weight of atmospheric air, &c.

But it appears, from experiments, that atmospheric air has a stronger affinity to phlogiston than to the matter of heat, so that it unites itself with the greatest readiness to the former, while, at the same time, it sets at liberty the latter, which had been hitherto held in a fixed and latent state.

§ 164.

When we come to apply the foregoing positions and principles to the phenomena of respiration, it appears highly probable, that animal heat is generated by a process of a similar nature.

For, as we have already had occasion to observe, the air which we expire differs, in a very remarkable degree, from what we had immediately before inspired; being deprived of its igneous portion, or of that part fit for contributing to the support of flame, it is returned highly impregnated, on the contrary, with phlogiston and the base of fixed air. (§ 146.)

§ 165.

It appears, therefore, extremely probable, that the igneous portion of the air we breathe enters those minute blood-vessels, which are every where dispersed throughout the substance of the lungs, and separated from the air-vesicles themselves by nothing more than subtle partitions of the most filmy texture (§ 136); that from the lungs it is conveyed through the pulmonary veins to the aorta, from whence it is again, by means of the arterial system, distributed throughout every part of the body.

During

During the whole course of this minute distribution, more especially while in the extreme ramifications of the vessels, it appears to be exchanged for phlogiston, which it every where meets with in considerable quantities. This phlogistic principle, being thus mixed with the blood, and occupying the place just evacuated by the matter of heat, is conveyed back, by means of the venous system to the right side of the heart, and from thence by the pulmonary artery, into the lungs, where, agreeably to these laws of affinity which we just now hinted at, it is immediately received and taken up by the volume of air recently inspired. In consequence of the accession of this quantity of phlogiston, and its union with the air contained in the lungs, a fresh portion of the element of fire or heat is set at liberty, which instantly enters the blood and is thus incessantly distributed throughout the system in the manner already described.

§ 166.

The truth of this theory is evidenced by those diversities between arterial and venous blood, to which we have every where adverted. It is also farther evidenced by the difference between the specific heat of arterial, and that of venous blood; thus the specific heat of the blood contained in the arteries is to that of the blood contained

tained in the veins, as $11\frac{1}{2}$ to 10. Finally, as an additional evidence of the same thing, we might mention, in the last place, that oscillatory action exerted by the smallest order of blood vessels, which was the subject of our attention on a former occasion.

§ 167.

For it seems altogether probable, that those extremely minute ramifications of the sanguiferous system, are parts of such utility and importance, that in proportion as their action is stronger or weaker, a correspondent increase or diminution takes place in that exchange of the element of fire for the matter of phlogiston, which goes constantly forward in the body, and also in the heat of the animal uniformly generated by such exchange.

Those memorable and striking phenomena, from which it appears, that animal heat (if indeed the matter be determined by a thermometer, and not trusted to the fallacious test of sensation), remains in general at very nearly the same precise point of temperature, little augmented by the summer's blaze, little diminished by the winter's blast; and further, that on certain occasions the heat of our bodies is even increased in consequence of an immersion in cold water—Those phenomena, I say, seem to demonstrate, and reduce it to a certainty, that

that according to the variations that take place in the *temperature* of the medium in which we live, corresponding diversities immediately follow in the *action* of the smallest vascular ramifications of our bodies. From this singularly accommodating power, resident in the minute extremities of our vascular system, it follows, that on being exposed to cold (which appears to act by increasing their tone), they are immediately enabled to exchange a *larger quantity* of the principle of phlogiston for the igneous pabulum, and thus generate a higher degree of heat; whereas, on the other hand, they are obliged to exchange a much *smaller quantity*, as often as they are rendered inactive by being subjected to the influence of a relaxing and debilitating medium.

SECT. XIV.

OF CUTANEOUS PERSPIRATION.

§ 168.

SO various, and extremely diversified, are the functions of the *cutis*, with which the human body is invested, that an enumeration and complete account of the whole of them can scarcely be comprehended with propriety under one

one and the same head; they would appear to be more fitly arranged for consideration, each one under that *class* of *actions* to which, from its nature it belongs.

For, in the first place, the cutis is the organ of touch, of which we will speak when treating of the *animal functions*.

It is again the medium or instrument of *inhalation*, by which office it makes a part of the absorbing system of lymphatics; this shall be a subject of further consideration, when we come to take a view of the *natural functions*.

Finally, It is the laboratory or organ of *perspiration* also. This function agrees in a great variety of respects with the process of *respiration*, and appears therefore to be introduced with sufficient propriety as the subject of the present section.

§ 169.

The cutis is said to consist of a threefold membrane, or of a membrane composed of three laminæ. These laminæ or layers are the *corium* or true skin, lying on the interior side, the *cuticula* or cuticle making the exterior covering, and the *reticulum* (i. e. the *rete mucosum*), which is spread
between

between the two laminæ just mentioned. Of each of these we will treat severally and in order.

§ 170.

The *cuticle*, or epidermis, forms, as just observed, the external covering to the whole body : It is thus, from its situation, exposed to a free accession of the air, the immediate contact of which element, scarcely any other part of the body can bear with impunity, even in a sound state, except the enamel of the teeth, the tubes of respiration, and the alimentary canal.

§ 171.

The texture of the epidermis is simple to the utmost degree, being entirely destitute of vessels, of nerves and of pores. This texture, though on the whole scarcely organic, is nevertheless highly singular and striking ; notwithstanding its semipelucid and tender appearance, its tenacity is yet so very considerable as to resist effectually, for a great length of time, not only maceration, but various other modes of generating putrefaction.

§ 172.

The origin of this filmy expansion is as yet involved in doubts and difficulties. It is in the mean time, however, probable that it springs, along with the small bulbs surrounding the roots

of the hairs, from the *corium* or true skin expanded beneath it: that this is the case, we are led to infer, from the myriads of minute and extremely tender fibrils, by which it and the skin are connected together.

When by any means destroyed, it is reproduced again with greater facility, than any of the other solid parts of the human body.

§ 173.

That this membranous lamina is of the utmost importance in the economy of organized bodies, is incontestibly evinced by its universal prevalence throughout both the animal and vegetable kingdoms. It may be observed already formed even in the tender embryo itself, at so early a period as the third month after the time of conception.

§ 174.

Underneath the cuticle is expanded a thin mucous membrane, which, from an opinion entertained respecting it, by its celebrated discoverer, is called *reticulum Malpighianum*.

This reticulum or subtle net-like expansion, exhibits the habit and appearance of mucus, extremely easy of solution: it can scarcely in any part, except in the scrotum of Æthiopians, be separated

rated entire from both the cuticle and true skin, and thus be procured in the form of a genuine and complete membrane.

§ 175.

The part now under consideration, constitutes the primary and principal feat of colour in the human race. In all men the true skin is fair and shining; the cuticle also is semipellucid and whitish in all nations, except the inhabitants of Æthiopia, in whom it is more dusky and obscure. But in the human subject after birth, the colour of the *reticulum mucosum* is varied, in correspondence to the diversities of age, mode of life, climate, and also in proportion as the constitution is more or less sound.

Thus, for example, of the five *varieties*, into which the human race appears to me, to be with much propriety divided, the *first* has the *reticulum* more or less whitish. This description includes, besides Europeans, those who inhabit the west of Asia, and the north of Africa, together with the natives of Greenland and Esquimaux.

2dly, In the second variety, which includes the inhabitants of all the other parts of Asia, the *reticulum* somewhat tawny, inclining to an olive cast.

3dly,

3^{dly}, In the third, which embraces the inhabitants of Æthiopia, it is blackish.

4^{thly}, In the fourth, which consists of the aborigines of America, it is to a certain degree copper-coloured.

5^{thly}, Finally, in the fifth, which comprehends the inhabitants of all the South Sea islands, it is more or less tawny or brown.

But all, and each one of those varieties of colour, as well as all other varieties, by which man differs from man, and nation from nation, appear to be so intimately blended together, and are disposed to run into each other with so much facility, that it seems scarcely possible to establish any divisions or classes of them, but such as are plainly arbitrary.

§ 176.

The *Corium* or *true skin* itself, to which the *reticulum* and epidermis serve as a covering, is a membrane of a peculiar nature; it is porous, tenacious, capable of vast dilatation, varied in its degrees of thickness, consisting chiefly of condensed cellular membrane, and extremely close and compact on its external superficies; it is more lax on the internal surface, which, (if you except a few

regions or parts of the body) (§ 36.) contains, for the most part, a certain quantity of common fat.

§ 177.

Besides *nerves* and *absorbents*, of which we will speak particularly on a future occasion, the *corium* or true skin is also plentifully supplied with innumerable *small blood-vessels*, which run on its exterior surface, and, as we learn from a successful injection, invest the same with reticular expansions of the most close and subtile texture.

§ 178.

Over the same exterior surface is also interspersed an immense assemblage of small *sebaceous follicles*, which thoroughly anoint the whole cutis with a very subtile and limpid oil, of such a nature as not to be easily evaporated and dried up. This fine fluid should neither be confounded with the *common sweat*, nor yet with that fetid substance which infests only some particular parts of the body.

§ 179.

Finally, almost the whole of the true skin is planted with *hairs* of various kinds. The most numerous and abundant of these are very short and tender, inclining more or less to the nature of down; of hairs which fall under this description, scarcely

scarcely any part of the body is destitute, except the eye-lids, the male penis, the palms of the hands, and the soles of the feet. But, on certain parts of the body, the hairs, being destined for particular uses, grow to much greater lengths; examples of this we have in the hair of the head, in the eye-brows, in the eye-lashes, the hairs in the nostrils, the whiskers, the beard, together with such hairs as grow in the arm-pits, and about the anus and parts of generation.

§ 130.

In general, man is indeed less hairy than most other animals belonging to the class *mammalia*. A difference exists, however, in this respect, between the inhabitants of different countries. For, to pass in silence over those nations who are in the daily practice of plucking out, as well the beard, as the hairs which appear on other parts of the body, there are not wanting certain tribes, who are naturally destitute of hair; of this description appear to be the Tungusæ and the Buratæ. On the other hand, we are informed by travellers of the highest reputation in point of veracity, that the inhabitants of Nadigda, one of the northern Kurilikian islands, are remarkable for the unusual quantities of hair with which their bodies are protected.

§ 181.

Neither are the varieties fewer, which are exhibited by the hair, in regard to length, flexibility, curliness, and, more especially, in point of colour: this last property depends, in general, on the power of climate, on age, and other causes, which exert their influence in perfect conformity to the established laws of nature; but it sometimes also depends on a morbid and misplaced temperament, as appears to be the case in the white natives of *Æthiopia*. The colour of the hair corresponds, for the most part, to that of the eyes.

§ 182.

There is also a further peculiarity in the *direction* of the hairs, on certain parts of the body; thus, for example, on the *vertex* or crown of the head, they pursue a spiral direction; on the pubes, they diverge and point upwards; on the posterior side of the arm, they look, (as on the ape, and contrary to their direction on the fatyr), towards the elbow, (that is, they point from the shoulder downwards, and from the wrist upwards): of the directions pursued by the eye-brows and eye-lashes, it seems unnecessary to say any thing on the present occasion.

§ 183.

The hairs originate from the interior surface of the true skin, which contains a quantity of fat: they are fixed with considerable firmness in each of the small bulbs, which are composed of *two involucra*; the external involucrum is vascular, and oval; the internal is cylindrical, appears continuous with the epidermis, and serves as an immediate covering to those elastic filaments of which each individual hair is itself composed, and which are from five to ten in number.

§ 184.

The hairs are always completely besmeared with an oily halitus, and are almost incorruptible. They appear to possess more of the nature of original electrics (or of *electra per se*, as they are called), than any of the other parts of the body. Their nutrition is extremely simple and easy, as is also their re-production after having fallen off, unless the cutis itself be labouring under some morbid affection.

§ 185.

Besides other important purposes which these common integuments of the body serve, they are, in a particular manner, to be reckoned among the number of the *excretory organs* of the system; by

their assistance, in this point of view, certain foreign matters, which would from retention prove highly noxious, are hourly eliminated and totally removed from the general volume of our fluids.

The truth of the above position is fully demonstrated and established, by the well-known circumstance of miasmata being completely removed from the system, under the appearance of *exanthemata* or *eruptions*; it is also proved by the odours of garlic, musk, and other substances taken into the body, passing by the skin; it is still further demonstrated and confirmed by the process of sweating, and by other phenomena of a similar nature.

§ 186.

But above all, those excretory passages convey off a certain fluid, which is called the *perspirable matter* of *Sanctorius*, in honour of that most acute and ingenious philosopher, who instituted the first series of rational inquiries for the express purpose of ascertaining its utility and importance.

It is necessary, however, to observe, that under this appellation. physiologists commonly designate excrementitious matters, which, if not *opposite*, are at least exceedingly *different*, in their natures, and which ought, therefore, to be distinguished from each other with the utmost accuracy and care; as
the

the excretion of *sweat*, for instance, from the genuine matter of *perspiration*.

The former (*i. e.* the sweaty excretion) is a liquid of an aqueous nature, saltish to the taste, and which scarcely ever issues spontaneously from the healthy body when in a state of tranquility and rest.

But the latter, (*viz.* the genuine matter of perspiration), of which alone we intend to treat on the present occasion, is an aeriform fluid, permanently elastic, and bearing a very striking resemblance to that which we expire by the lungs.

§ 187.

Like that elastic fluid, it is highly charged with the principle of phlogiston, like that, it precipitates quick-lime from the water in which it was suspended, and, like that, it is also unfit both for contributing to the nourishment of flame, and also for supporting the process of respiration, &c.

§ 188.

The quantity of this fluid that exhales from the whole *superficies* of the body (which, in an adult human subject of the middle size, amounts by measurement to about fifteen square feet) can scarcely be reduced to accurate calculation.

For,

For, that the scales, which from the time of Sanctorius have been made use of for ascertaining the exact weight of the body, are not well calculated for determining the precise quantity of this elastic fluid, may be easily understood from what we have just now said respecting the different substances which are eliminated from the system by the skin, besides the true matter of perspiration.

It was long since discovered, that the nature and quantity of perspiration vary extremely, not only in different persons, but even in the same persons, at different times. It seems at present, however, to be a point too well ascertained to admit of a doubt, that there does really exist, with respect to the matter perspired, a national variety and peculiarity; the truth of this we confidently rest on what has been said, by authors of the highest veracity, with regard to the singular and specific odours which are transpired through the skins of the Caribbeans, of the Greenlanders, of the Æthiopians, and also of the individuals belonging to other barbarous tribes.

§ 189.

On considering what has been said with respect to the vascularity observable in the texture of the skin (§ 177), and also with respect to the analogy that exists between the matter of perspiration and
the

the air we expire (§ 187); and further, on considering what has been advanced respecting the power and influence of the smallest vascular ramifications, in the generation of animal heat—to him, I say, who carefully weighs and attentively considers all these circumstances, it will appear extremely probable, that there exists a striking similitude indeed between the action of the lungs in respiration, and that of the skin in the process of perspiration. It will appear that there exists between the cutis and lungs a reciprocal consent; so that the one may be supposed capable of assisting and somewhat relieving the other, and even of supplying its place, at least to a certain degree, in case of any accident or derangement.

§ 190.

In support of this opinion we can adduce the concurrent testimonies of a variety of phenomena, observable not only in a *sound*, but also in a *diseased*, state of the system.

Some of these phenomena are, for example, those leading points, in which the human fœtus, as well as that of the other animals belonging to the class mammalia, differ from the incubated chick, or the young of the feathered tribes, while yet enclosed in the *parietes* of the egg.

A further

A further evidence in favour of the same opinion, is that singular coldness of certain parts of the body, even in warm blooded animals, (as in the noses of dogs, &c.) which appears to be referred with sufficient propriety, to a less phlogistic action of the small vessels, with which those parts abound.

On the contrary, from an increased action of the minute vessels in certain parts of the body, we explain, with the utmost fairness and facility, a variety of morbid symptoms, such, for instance, as that singular heat and flushing in the palms of the hands, which occur so frequently, and are so strikingly observable in patients labouring under a hectic fever.

With regard to that *vicarious action* of which we formerly spoke, and by which we said it appeared probable, that the functions of the lungs and cutis lend mutual aid and assistance to each other; that such an action does unequivocally exist, we derive some force of testimony from those phenomena in pathology, where human subjects, after birth, and even after advancing to an adult age, having their lungs almost totally destroyed by a consumption, or highly vitiated by some other contamination, have nevertheless survived such melancholy misfortunes, for a long time, and in
some

some cases have even passed several years, during the whole of which period they appeared to be almost entirely deprived of the use and advantages of respiration.

§ 191.

Finally, It does not appear improbable, but that the interior surface of the *alimentary canal*, may also, besides its other primary functions, be perpetually engaged in the performance of a phlogistic process, not unlike that conducted by the *skin* and *pulmonary system*.

This canal or tube appears, indeed, to be the only interior part of the body, except the lungs themselves, to which the atmospheric air has free access; but that the air has really free access to the *primæ viæ*, or *first passages*, as they are called, and that we swallow that elastic fluid in considerable quantities, are matters, much too plain, to stand in need of any proof.

Further, That the air which we swallow undergoes a change very similar to the change suffered by that taken by inspiration into the lungs, is satisfactorily demonstrated by the nature of the air contained in the whole alimentary canal.

Finally,

Finally, To all those concurring circumstances we may further add, that truly astonishing congeries of small blood vessels, spread in profusion over the interior surface of the intestines, which is commonly believed to be equal in extent to the external superficies of the whole body.

SECT. XV.

OF THE SENSORIUM AND NERVES.

§ 192.

WE come now to treat of another class of the functions of the human body, which embraces what we denominated the *animal functions* (§ 63): by means of these, an uninterrupted commerce and intercourse are kept up between the body and the various faculties of the mind. They belong therefore exclusively, (as indeed the name itself plainly imports,) to organised and animated bodies; but as they pervade the whole animal kingdom more universally than the vital functions, they appear to have an exceedingly just and well founded claim to the epithet, *animal*.

§ 193.

The organs which are principally subservient to the exercise of these functions are, the *cerebrum*, the *cerebellum*, and their appendage the *medulla spinalis*, together with the nerves that originate from these three sources. The whole of these organs may, with sufficient propriety, be arranged under two leading classes, namely, the *Sensorium* and *Nerves*. The former of these embraces (if we except the nerves themselves, and those parts which constitute their more immediate origins) all the remainder of that whole system, which forms, more particularly, the *vinculum* or medium of connection, that exists between the offices or functions of the nerves and our nobler part, the faculties of the mind.

§ 194.

On this division is founded that beautiful observation of the illustrious Sommering, in which he alleges, that the relative magnitude which the two preceding classes of organs bear to one another, corresponds so accurately with the faculties of the mind, that the smaller and less bulky the nerves of animals are, when compared to the size of the other organs or parts which we have comprehended under the denomination of *Sensorium*, the more vigorous and active are the faculties or their minds. In this respect he observes,
that

that man may be said to possess the largest cerebrum or brain, if its bulk be compared to the small size of the nerves that originate and proceed from it, but not if its weight be compared with the relative weight of the whole body.

§ 195.

Besides the bony cranium or skull, in which the cerebrum itself is enclosed, it is still farther invested with three involucra or coverings; these are the *dura* and *pia matres*, between which is expanded the third, viz. the *tunica arachnoidea*.

§ 196.

The *dura mater*, which lines, as a periosteum, the cavity of the encephalon, is lengthened out into a variety of partitions or processes. By its falciform process, which is the most prominent and remarkable, it separates from each other, the two hemispheres of the brain; while, by means of that process called the *tentorium*, it forms a partition between the *cerebellum* and the parts situated above it, and thus, by giving support to the posterior lobes of the brain, prevents them from making an undue pressure on the subjacent *cerebellum*.

Further, the *dura mater*, by various duplicatures or doublings of its own membrane, forms what are called the *venous sinuses*, while it gives them at

the same time firmness and support, and prevents them from being unduly compressed. Through these sinuses the blood of the encephalon, or parts contained within the cranium, glides back towards the heart: this blood is said, by physiologists, to possess properties peculiar to itself, and appears, from actual calculation, to be so considerable in quantity as to amount, at least, to one tenth part of the whole mass of blood contained in the human body.

§ 197.

Next to the dura mater lies the *tunica arachnoidea*, so called from its extreme tenderness and filmy texture. It is destitute of blood-vessels, (§ 5.), and does not, any more than the dura mater, enter the various *fulci* or furrows, and receive the different eminences or ridges, which mark the surface of the cerebrum, but only expands, with uniformity, over the whole volume of that important viscus.

§ 198.

Very different from this is the state and situation of the internal *involucrum* or covering of the brain, on which the ancients bestowed the name of *pia mater*. This membrane every where accompanies the cortical part of the cerebrum so closely, that the innumerable small blood-vessels,

with which it is profusely supplied, enter, and even perforate the cortex itself, with their infinitude of minute ramifications; hence, when the *pia mater* is separated by force from the cerebrum, its external surface presents a smooth and exquisitely beautiful polish, while its internal surface, on the contrary, is considerably villous, and resembles, not a little, those delicate radicles by which the mosses adhere to their native soil, or places of growth.

§ 199.

Both the cerebrum and cerebellum are composed of a variety of parts, different from each other both in texture and figure, the uses of which have been hitherto generally unknown: these parts are particularly distinguished by the four *ventricles*, as they are called, the communication between which has been of late traced and developed, with the utmost accuracy, by the illustrious *Monro*: of these ventricles, the two anterior and the fourth contain what are denominated the *plexus choroidei*, the uses and functions of which are also involved, as yet, in intricacy and doubt.

§ 200.

In all parts, of both the cerebrum and cerebellum, there exist two kinds of substance, one of a cineritious or ash-colour, which is called the *cortical* part, although it does not always form the
 exterior

exterior stratum, the other white and shining, and therefore called the *medullary* portion. Agreeably to the observations of the illustrious Somering, there is interposed between the two foregoing substances, still a third, of a colour bordering on white; this body is most conspicuously observable in the *arbor vitæ* of the cerebellum, and in the posterior lobes of the cerebrum.

§ 201.

The proportion, which the cineritious substance bears to the medullary, decreases as life advances; thus, in infants it is greater, in adults less. Almost the whole of this cineritious substance, is composed of an immense assemblage and contexture of the smallest sized blood-vessels, together with vessels of an order still inferior, even so minute as to be incapable of admitting any thing except a white or colourless fluid of the most exquisite tenuity, (§ 79.): a small number of these vessels passes into the medullary portion, which appears to contain in its own composition, (besides these minute vessels and a quantity of very tender cellular membrane), a soft pultaceous parenchyma, in which physiologists, even when armed and aided by the most powerful glasses, have not yet been able to discover any uniform and definite texture.

§ 202.

In the cerebrum is observable a perpetual but very gentle motion, bearing such a relation and exact correspondence to the process of respiration, that while the lungs are collapsed, and their volume diminished in the act of expiration, the cerebrum is slightly elevated, but immediately subsides again, when the thorax is dilated by means of a subsequent act of inspiration.

§ 203.

What has been called by physiologists the *medulla oblongata*, terminates in the *medulla spinalis*, which is contained in that flexible tube, formed by the vertebræ of the spine or back, and is still clothed in the same membranes which we have already seen investing the cerebrum or brain itself: further, as the brain, so likewise the spinal marrow, is found to consist of two kinds of substance, with this striking circumstantial difference, however, that, in the latter, the cineritious or ash-coloured substance forms the internal, whilst the shining or medullary composes the external, part.

§ 204.

From each of the foregoing sources, namely, the cerebrum and cerebellum, together with the *medulla spinalis*, the *nerves* primarily derive their origins. These are small ropes or cords, of a colour

colour more or less whitish, differing likewise in their degree of firmness), which are minutely distributed throughout almost all the other soft parts of the human body. This opinion of the minute, and *universal*, distribution of the nerves through every part of the human system, though admissible as a general rule, is, however, subject to certain well founded exceptions.

§ 204.

For it appears from an infinitude of experiments made by the illustrious Haller, and other able observers, that there are several of the *partes similes* (or similar parts § 46) of our bodies, in which, the knife, and powerfully armed eye of the anatomist, have not been able to detect the smallest vestige of nerves, and where neither surgical observations nor live dissections, often repeated by the most dextrous hand, have succeeded in discovering even the faintest phenomena of sensibility.

In an enumeration of such parts, as appear to be destitute of sensation and nerves, we must embrace, besides the naked cellular membrane, the epidermis, the *reticulum mucosum*, the hairs, and the nails.

We include further, the cartilages, and bones, with their periostia and marrow.

To these must be added, the tendons, the aponeuroses, and ligaments; as also most of the broader and more extensive membranes, such, for example, as the dura mater and tunica arachnoidea; the pleura, with the mediastinæ and pericardium; the peritoneum; the cornea, &c.

Under the same head we arrange most parts of the absorbent system, but more especially the thoracic duct.

Finally, This catalogue of such parts as neither possess nerves, nor are endued with sensibility, shall be closed, by the addition of the *secundines*, and *umbilical cord*.

§ 206.

The primary or nascent origins of the nerves, emerging from the sensorium itself, have, as yet, eluded the most zealous researches of the subtle knife and prying eye of the anatomist: it therefore still remains a matter of controversy and doubt, whether the nerves on each side of the body derive their origins from the *corresponding*, or from the *opposite* side of the sensorium? Certain pathological phenomena appear indeed to favour

your

your the latter of these opinions. It has been also lately established by the illustrious Sommering that a true decussation or crossing of the optic nerves does actually exist.

§ 207.

A certain continuation of the pia mater accompanies the medullary part of the nerves in their course, in such a manner, as to form for them a vascular cortex, or covering, of extreme tenderness. No sooner, however, do these cords emerge from the cerebrum, or the spinal marrow, than they assume a very singular habit and appearance, by which they may be readily distinguished from almost all the other similar parts of the body. This peculiarity of appearance is produced by small plicæ or folds, which they exhibit, running in angular directions, more or less oblique. These folds were formerly described by P. P. Molinel, who compared them, not inconsistently with propriety and fitness, to the rugæ of the *lumbricus*, or round worm, or to the small rings of the aspera arteria.

§ 208.

The nerves, especially those of the single or unpaired orders, such, for instance, as the intercostal and vagantes or wandering nerves, are every where furnished with *ganglia*, *i. e.* small

bulbs, of a texture considerably compact, and of a cineritious colour, somewhat inclining to a pale red : the functions and uses of these bodies in the animal economy have not yet been satisfactorily ascertained and demonstrated. We are, however, in the mean time, most inclined to adopt the opinion formerly entertained respecting these substances by the ingenious Zinn. That acute physiologist believed the ganglia to consist entirely of mazy complications and intertextures of minute nervous filaments originating from different sources. In consequence of this intricate and uninvestigated texture of these bodies, he conjectured, that each nervous filament, or thread proceeding from them, participates, or contains in its composition, a part of every filament that enters into their structure, however numerous those filaments may be, or however different the sources from which they originate.

§ 209.

Neither does there appear to exist any very material difference between the nature of ganglia, as just described, and of what are called *plexus nervosi*. These latter are also indebted, for their existence and form, to a similar concurrence and anastomosing intertexture of nerves that originate from different sources. The composition of such nervous filaments as ramify and proceed from these
plexus

plexus nervosi, appears to be also perfectly analogous to the composition of those, that originate from the ganglia, of which we have already spoken.

§ 210.

But as the *nascent origins* of the nerves, so likewise (with a few exceptions), the *final terminations* of their *extreme ramuli*, or remote filamentary branches, are as yet involved in the depth of obscurity. For if we except those few nerves that terminate in a kind of medullary expansion, as the optic nerve in the *retina*, and the soft portion of the seventh pair, in that pulpy zone, contained between the spiral laminæ of the cochlea of the ear—If, I say, we except these two nerves, the evanescent filaments of such of the others as enter the viscera, the muscles, the skin, &c. become so minutely blended with the real parenchyma of the parts on which they are distributed, and gradually assume such a pulpy consistence, that the eye of the anatomist can no longer trace them through their mazy courses.

S E C T. XVI.

OF THE FUNCTIONS OF THE NERVOUS SYSTEM
IN GENERAL.

§ 211.

WE have thus seen, that of the sensorium, and nerves so generally and minutely distributed throughout most parts of the body, a complete system is beautifully constituted, which, during the continuance of life, serves as a medium of communication and mutual intercourse between the body and the mind.

§ 212.

Various circumstances and phenomena combine in rendering it probable, that the mind is indeed attached and closely connected to the brain itself. That the brain is thus honoured and dignified in its alliance is very powerfully and strikingly evidenced, by most of the instruments of sensation being situated in the very vicinity of that organ; by the astonishing conformation of its various parts, considered with regard to their figure and structure; but more especially by the phenomena attendant on its morbid affections.

§ 213.

§ 213.

With respect to that connection of which we have just hinted, I would further observe, that certain physiologists, wantonly sporting in the delusive fields of imagination, have suffered themselves to be so far influenced by the form and situation of particular parts of the encephalon, that they have considered, and even endeavoured to prove, sometimes one, sometimes another of these parts, to be indeed the very seat, and royal court, (as it were) of the mind. This honorary and sublime privilege, of affording a sacred seat to our nobler and *immortal part*, some metaphysical physiologists have been solicitous to bestow on the pineal gland*, others on the cerebellum, others on the corpus callosum †, and

* In favour of the Cartesian hypothesis, some degree of testimony appeared to be derived from the dissections of certain *maniacs*, in whom the pineal gland was found invested with calculous concretions. On more accurate observation, however, it was discovered, that not only in maniacs, but also in numerous other subjects possessing the most complete degree of mental sanity, this same glandular body was surrounded, from about the 12th year of life, by minute sandy concretions of a pearl-like appearance.—Cl. Sommering de lapillis vel prope vel intra glandulam pinealem fitis, f. de acernulo cerebri Mogunt. 1785. 8.

† Those fictitious prerogatives both of the cerebellum and corpus callosum are refuted in a very masterly manner by

Zinn

others, again, on that part which has been denominated *pons Varolii*.

§ 214.

We are not by any means to suppose, that the whole energy of the nervous system depends on the encephalon alone; it is also derived in part from the spinal marrow, and even the nerves themselves possess such a degree of inherent or native energy, as is sufficient of itself to throw the muscles into a state of convulsion. This native or exclusive energy of the nerves, appears to be principally supported and preserved by that vascular cortex or covering of those organs, of which we briefly spoke on a former occasion (§ 205). It is, however, a truth which ought not to be forgotten, that this inherent power of the nerves themselves is *less*, and that energy, on the contrary, which is derived immediately from the encephalon, *greater*, in man, than in other animals, especially such as are supplied with cold blood.

§ 215.

The office of the nervous system appears, in a particular manner, to be two-fold. *First*, by means

Zinn in his "Experim. circa corpus callosum, cerebellum, duram meningem, in vivis animalibus institut. Goetting. 1749. 4.

of this system, other parts of the body, especially such muscles as are subjected to the influence of the will, are excited to motion; of this function, however, we will treat more fully in another place. But, secondly, the nerves are peculiarly subservient to sensation; whatever sensible impressions are made on the body, they, like active heralds, convey and announce immediately to the sensorium, and there give rise to perception.

§ 216.

Finally, the sensorium is evidently possessed of the following very singular faculty or power, viz. that, having received sensible impressions through the medium and agency of certain nerves, it is able to re-act again in its turn, not only on the same nerves, but also on such as are completely different. In testimony of the truth and authenticity of this position, it will be sufficient to mention the action of the retina, when affected by light, on the sensorium, and the re-action of this latter, again, in either constricting or dilating the iris.

§ 217.

It is principally from this last source, that we are to derive and explain most of the effects of the imagination, and passions of the mind, on the human body: of these effects we will speak more

more fully on a future occasion. To the same source, also, must we refer that extensive and diversified consent of the *nervous system*, which prevails throughout almost the whole body (§ 14.), and the astonishing power and influence of the same, over most of the other functions of the animal economy.

§ 218.

That the phenomena which we have just mentioned, proceed from certain properties essential to the nervous system, is a position, that appears, from observation and experiment, to be founded on the most indubitable evidence. But, to elucidate and explain the manner in which this system acts, in the production of such phenomena, is, indeed, a difficulty of the utmost magnitude.

§ 219.

When we view the subject in a general light, the various opinions, which have at different times been advanced on this contested point, may be all referred to two leading classes: one of these alleges the action of the nervous system, to depend on a certain oscillatory motion; while the other supposes it to be produced by the motion of a peculiar fluid, respecting the nature of which physiologists, again, hold different opinions. Thus, while some believe this fluid to be animal spirits,
contained

contained in, and passing through, vessels, others contend, that it is a certain modification of matter, similar to fire, electricity, or the magnetic effluvia.

§ 220.

Although I am disposed to adopt neither of the above opinions as my own, yet it is proper to observe, that most of the arguments, by which the advocates of either *hypothesis* have endeavoured to invalidate the other, appear to me to be as crude and inconclusive, as they ought to be subtle, ingenious and forcible. This observation applies, as well to the arguments made use of to prove the oscillations of the nerves, as to those advanced for the purpose of establishing the existence of a nervous fluid.

§ 221.

If, indeed, our views of the subject be not erroneous, the two foregoing opinions may, without impropriety, be united, and thus a third one formed, more plausible, at least, than either of the originals, namely, that a certain nervous fluid does actually exist, and that this fluid is also capable of motion, and of being thrown into oscillatory vibrations, when subjected to the action and influence of stimuli.

§ 222.

§ 222.

Not to mention various other evidences, which might be obviously deduced, from the different phenomena of the nervous system, the *structure* of the brain itself, which bears a striking resemblance to *that* of certain secreting viscera, appears indeed to be highly in favour of the existence of a nervous fluid. It is surely a matter too obvious to admit of controversy, that there is no more need of any direct tubes and canals, for the distribution of such a fluid through the nerves, than there is, for the conveyance of a liquid through brown paper, or any other filtre.

The nugatory calculations, respecting the astonishing rapidity, with which the animal spirits have been supposed to hurry through their nervous canals, in all parts of the system, are subjects too hypothetical and visionary to merit our time, or command our attention.

§ 223.

That an oscillation of the nerves does indeed exist, is a position, powerfully supported by a great variety of very striking and pointed physiological phenomena. This oscillation must not, however, be supposed to bear any resemblance to the rude vibrations of tense chords, but is such a subtle, tremulous motion, as may be readily conceived to

take place in the tender, pulpy substance of the brain. That hearing is excited by an oscillation of a liquid, has been reduced to satisfactory demonstration. That an oscillatory motion somewhat similar takes place also, in the act of vision, is (though we should not be willing to repose implicit confidence in the opinions of Leon. Euler) a position founded, at least, on strong probabilities. That the action of the other senses depends also on an oscillatory motion of a similar nature, is an opinion, which was not only embraced by the illustrious Newton *, but has been since ably and successfully defended in the writings of the sagacious Hartley. It is on the principle of the existence of such a motion, that this last mentioned author, has first happily accounted for the association of ideas, and then, by the aid of this, proceeded to explain, with the utmost ingenuity, most of the functions performed by the different faculties of the mind †.

* Vide ejus Quæstiones ad calcem optices. Qu. 23. p. 355. edit. Lond. 1719-8.

† David Hartley's Observations on man, his frame, his duty, and his expectations. Lond. 1749, vol. ii. 8.

SECT. XVII.

OF THE EXTERNAL SENSES IN GENERAL, BUT
PARTICULARLY OF THE TOUCH.

§ 224.

ONE office of the nerves, as we have already had occasion to observe, consists in communicating to the sensorium, impressions made by external objects. This they do through the medium of the *external senses*, which officiate as watchful centinels to the body, and diligent instructors to the mind.

These, therefore, shall constitute, at present, the *sole object* of our consideration. For to arrange among the senses, the stimulus or propensity which animals feel to evacuate their fæces, the sensation of hunger to which they are subjected, or other internal calls of nature of a similar kind, would be, as Haller formerly observed, an unnecessary species of subtilty and refinement.

225.

It ought to be remembered, that no other class of functions belonging to the animal economy, is subjected to such an astonishing variety in different individuals, as that of the external senses, which constitutes

constitutes the subject of our present consideration. This infinite diversity, which exists between these senses in different individuals, is either natural or acquired, and relates to their greater or less acumen or sharpness, their subtlety, or to the manner in which they are affected by similar applications of the same stimuli.

§ 226.

In giving an entire and complete account of the external senses, it appears most proper to begin with *the touch*, this being the one which manifests itself at the earliest period in the human subject after birth. The organ of the sense of touch is expanded over the whole superficies of the body, and is so constituted and formed as to be affected by much the greatest number of the properties of external objects.

§ 227.

For we are not only made sensible of certain qualities of substances by means of the touch alone, as of heat, hardness, weight, &c. but there also exist other qualities, such, for instance, as figure, distance, &c. of which we acquire, a much more certain and accurate knowledge by the aid of the touch, though it must be acknowledged that these qualities are at the same time subject to the cognizance of some of the rest of our senses.

§ 228.

The touch is less liable to deception than the other senses; and is capable of becoming, by cultivation and attention, so exquisitely perfect and refined, as to be able to compensate, in a certain degree, for any deficiency in its sister senses, more especially in that of vision.

§ 229.

The organ of this sense is indeed the skin in general, concerning the fabric and texture of which we spoke formerly; but those parts that are more immediately subservient to the touch, are the papillæ of the *corium* or *cutis vera*; these papillæ exhibit various figures in different parts of the body; they are indeed, for the most part, *verrucoſe*, in other places they are *fungous*, in others *filamentous* or thread-like, &c. under all which appearances, the extremities of the cutaneous nerves terminate after the manner of small pulpy pencils.

§ 230.

But by far the most important and distinguished instruments of the touch are, in particular, *the hands*, the skin of which is impressed with a great number of striking peculiarities. Thus, for example, the skin on the palms of the hands, and on each side of the joints of the fingers, is sulcated and completely destitute of hair, for the purpose of facilitating

facilitating the folding or doubling up of those parts. The extremities of the fingers, on their *internal*, and of the toes, on their *inferior*, surfaces, are furrowed with slight and very elegant grooves running in directions more or less spiral: but the former, on the exterior, and the latter on the superior, sides, of their terminations, are protected from injury by nails.

§ 231.

These scutiform *nails* are possessed only by man, and a few other animals, (belonging to the class *mammalia*), which are also furnished with hands, and excel in the acuteness of their sense of touch. These nails appear to be designed for the purpose of making a gentle resistance to the pressure of the fingers when examining substances, and thus aiding their action.

The nails, though of a horny nature, must nevertheless be considered, on the whole, as productions or continuations of the epidermis: for immediately under them lies the reticulum mucosum, which in *Æthiopians* is black; and finally, beneath this again is expanded the corium or true skin, which is firmly attached to the periosteum of the extreme phalanx of the fingers. Also these constituent parts of the nails are striated in a longitudinal direction. At their posterior margins

(which are distinguished by small semilunar segments, of a shining or somewhat brilliant appearance) they are securely fixed in a groove formed by a reflection of the cutis, from whence by a daily, but very moderate, increase, they are gradually protruded forward, in such a manner, as to be completely renovated in every term of about six months.

SECT. XVIII.

OF THE TASTE.

§ 232.

TASTES are certain impressions made on, and perceived by, the tongue, and also, in some measure, by the adjoining cutaneous parts of the *os internum* (*i. e.* the inside of the mouth); these parts are, in particular, the *medium palati*, the fauces, the cheeks, and even the lips themselves; with respect, however, to the whole of these auxiliary parts, it is proper to observe, that they have no perception of any tastes except such as are acrid or intensely bitter.

§ 233.

The principal instrument of taste is *the tongue*, an organ capable of the utmost agility in motion, very pliable, and exceedingly changeable in point of form: it consists of a fleshy texture, which exhibits a striking appearance, somewhat resembling the texture of the heart.

§ 234.

It is invested with involucra or coverings, which bear a similitude to the different strata of the cutis: these are, the epithelion, which corresponds to the cuticle, the reticulum Malpighianum, and lastly, a papillary membrane, that differs but little in its structure from the corium or true skin.

§ 235.

The principal difference consists in this, that the epithelion, instead of a fine cutaneous oil, is lubricated and moistened by mucus, which exudes from that imperceptible orifice, named after Meibomius, and also from the rest of that glandular expansion, discovered by Morgagni: another point of difference is, the conformation of the papillæ, which are divided into the *petiolated*, the *obtuse*, and the *conical*; of these, the former, being very few in number, are placed in a lunated arrangement, at the root of the tongue, while the others, being of various sizes, are crowded promiscuously

and without order, on the back of the tongue, but more especially on its edges and tip, where the sense of taste is most acute and exquisite.

§ 236.

To these papillæ pass the extreme filaments of the lingual branch of the fifth pair of nerves, by the offices and aid of which it appears probable, that the sense of taste is proximately generated and preserved.

For the ninth pair of nerves, and also that branch of the eighth, which is distributed throughout the tongue, appear to be subservient to the various motions performed by that organ in chewing, swallowing, speaking, &c. rather than to its function as the immediate instrument of taste.

§ 237.

That the tongue may exercise the sense of taste in perfection, it is necessary for it to be kept in a state of complete humidity; the substance to be tasted should also be a liquid, and ought to abound with salts in a state of solution: for if either the tongue itself, or the substances applied to it be dry, it may then indeed examine them by the touch, which it generally possesses in an exquisite degree, but cannot with strictness and propriety be said to taste them,

When

When the tongue discharges the office of tasting with most perfection and acuteness, the papillæ, situated on its apex and edges, appear to be brought into a state of genuine, though slight, erection.

SECT. XIX.

OF SMELLING.

§ 238.

BY means of the sense of smelling we perceive impressions made by the odorous effluvia of substances, which being inhaled in inspiration, come in contact with that part, in particular, of the Schneiderian membrane, which invests each side of the septum narium, and lines the convex surfaces of the concha.

§ 239.

For although the whole of the internal nares, together with the adjoining sinuses, which open into them, be lined with a humid membrane, similar in appearance to the Schneiderian, it nevertheless appears to be diversified in its nature in different places.

That part of the membrane, which is situated near the opening of the external nares themselves,
bearing

bearing a stronger resemblance to the other parts of the real cutis, is overspread with sebaceous follicles, which are completely mantled in clusters of hair.

But that part which lines the *septum narium*, and *conchæ*, is of a fungous nature, and abounds with small muciferous cryptæ or cells.

Finally, Those portions which invest the *parietes* of the frontal, the sphenoidal, the ethmoidal, and the maxillary sinuses, are by far the most tender and delicate of all, and are completely overspread with an infinitude of minute blood-vessels, which constantly exhale from their extremities a subtle dew-like fluid of an aqueous nature.

§ 240.

The principal, if not, indeed, the only use of those *sinuses* appears, therefore, to be, to furnish a watery liquid, of such a nature, as has been just described, which being first conveyed into the three passages or avenues of the nares, may be from thence communicated to those adjacent parts, which, we have already said, constitute the immediate instruments of the sense of smelling. By thus supplying, with a due degree of humidity, the parts which proximately form the olfactory organs,

organs, those sinuses contribute, not a little, to preserve the acuteness and perfection of this interesting sense.

For the attainment of this end, such a wise provision is made by the very situation of those several sinuses, that in whatever position the head be suffered to rest, one or other of them may still discharge and deposit a quantity of this subtle dew, on the immediate seat of the sense of smelling.

§ 241.

The fungous part of the nasal membrane, of which we have already spoken, and which constitutes the proximate organ of smelling, besides, the immense number of minute blood-vessels with which it is overspread (and which are rendered in a particular manner remarkable, by this circumstance, that there are no other vessels in the whole body equally liable to spontaneous hemorrhages); besides these small blood-vessels, I say, this part of the membrane is also furnished with nerves, especially from the first pair, and also from both branches of the fifth pair: of these, the first pair appears to be of itself solely subservient to the sense of smelling; while the others supply the parts, to which they are distributed, with branches for the purposes of *common sensation*, such, for example, as that which gives rise to sneezing, &c.

§ 242.

§ 242.

The extreme filaments of this first pair of nerves are not, (as is the case in the organs of touch and taste), lengthened out and rounded into papillary elongations, but appear to deliquate, or melt down, as it were, into the spongy and uniform parenchyma of the membrane in which they terminate.

§ 243.

In new-born infants, the chamber destined for the immediate reception of odours is narrow, and as yet extremely imperfect. The sinuses, of which we have already spoken, have at this time scarcely made their appearance: hence, infants do not acquire the sense of smelling till a late period, as the expansion and complete formation of their *internal nares* are but gradually and very slowly accomplished. The larger those instruments become, and the more accurately they are formed and finished, the more exquisite will be the acuteness and perfection of this sense.

§ 244.

Finally, it is a truth well worthy of being remembered, that there is scarcely another external sense, which possesses such a powerful connection with, and influence over, both the sensorium itself, and the internal senses, as that of *smelling*.

There

There is none subject to such striking diosyn-
crasies; none better calculated either to produce,
to prevent, or to remove, paroxysms of fainting.

Neither is there any one susceptible of more
delicate and pleasing impressions; the *smell* is,
therefore, happily termed by Rousseau *the sense*
of the imagination.

Nor are there, lastly, any other species of sen-
sations that appear to excite so clear and vivid a
remembrance, as that which specific odours recal
to the memory.

SECT. XX.

OF HEARING.

§ 244.

SOUND, which is excited by a tremu-
lous collision of elastic substances, and propagated
from sonorous bodies, through the medium of the
air, is at length perceived by the sense of *hearing*,
after having proceeded onward in the following
order: viz. it is first received by a shell-formed
cartilage denominated the *external ear*, over which
a few

a few of the human species possess a power of voluntary motion: being collected and concentrated, as it were, by means of this *concha* or *shell*, it passes immediately into the *meatus auditorius*, which is thoroughly anointed and defended by a very bitter and somewhat yellowish cerumen, or wax-like substance: at the internal extremity of this *meatus auditorius* it strikes against the *membrana tympani*, which is situated in an oblique position, is firmly attached to an annular groove in the *os temporis*, and forms a complete partition between this *meatus auditorius*, or passage for sound, and the middle portion of the ear.

§ 246.

Behind this membrane, the middle portion of the ear, denominated the *cavity of the tympanum*, is so situated as to have its fundus or bottom pointing upwards and inwards.

It contains three *small bones*, belonging to the organ of *hearing*, the external of which, called the *malleus*, is connected by its handle to the membrane of the tympanum; from its *spinous process*, which runs in a forward direction, a bulb or globe is formed, (especially in an adult subject), with an annular groove surrounding its base; this small globular head rests on the body of the *incus*.

The

The incus itself is attached to the minute knob or head of the *stapes*, by its longer process, which extends nearly to the middle of the cavity of the tympanum.

Finally, the *stapes*, resting its basis on the *fenestra ovalis*, looks towards the *vestibulum* of the labyrinth, into which, sound, having percussed against the membrane of the tympanum, is propagated by means of the connections of those three *ossicula* or small bones.

§ 247.

The Eustachean tube, running from the interior parts of the fauces, opens also into the cavity of the tympanum; the inferior winding passage of the *cochlea* enters likewise into the same cavity; over the mouth or orifice of this passage, called the *fenestra rotunda*, a fine membrane of a peculiar nature is expanded. Physiologists have not yet ascertained and demonstrated, in a clear and satisfactory manner, the uses of either of those two last mentioned parts.

§ 248.

Lastly, in the deep and hidden recesses of the *os petrosum* lies the *labyrinth*, or *internal portion of the ear*, which embraces again three several parts.

These

These are the *vestibulum*, which is situated in the middle between the other two, and into which open, besides the fenestra ovalis, both the five mouths of the *femicircular canals* that run in a backward direction, and also the superior winding passage of the *cochlea*, which extends and lies anteriorly.

§ 249.

The labyrinth itself contains a very subtle, limpid water, which has been named after the illustrious Cotunnus, and which that celebrated physiologist discovered to be absorbed by two very minute canals: these small canals, called by Cotunnus, aqueducts, (and by Meckel *diverticula*), arise, the one from the vestibulum itself, the other from the inferior winding passage of the cochlea.

§ 250.

The soft portion of the seventh pair of nerves, together with the hard, (which afterwards passes through the *aqueduct* of Fallopius), having entered the internal chamber of hearing, transmits its medullary filaments through the perforated bottom of that cavity. These filaments pass, in part, to the vestibulum and semicircular canals, but are distributed more especially over the base of the cochlea, where their extremities are arranged in such a manner as to run between the

laminæ or plates of the septum of the cochlea, exhibiting the appearance of a fine medullary zone, beautifully ornamented with plexiform striæ or streaks.

§ 251.

The oscillatory tremor which we formerly traced and followed up, even to the fenestra ovalis, (§ 246.), is from thence propagated to the vestibulum, where, finally, through the medium of the subtle aqueous liquid already described (§ 249.), it strikes and impresses the auditory nerves themselves, which are distributed with infinite art and ingenuity throughout the mazy circumvolutions of the labyrinth.

§ 252.

The impetus of sound, striking against the *membrane*, and being propagated through the *cavity* of the tympanum, is thought to be modified and regulated, not only by the muscles of the *malleus* and *stapes*, which appear, in their contraction and relaxation to be subject to the influence of the will, but also by the *chorda tympani*, which is situated in the middle, between the handle of the malleus and the longer leg of the *incus*.

SECT. XXI.

OF VISION.

§ 253.

THOSE rolling or versatile globes, denominated eyes, are to be considered as the immediate instruments of the sublime sense of *vision*. They are fixed as if on footstalks, by their optic nerves (respecting the decussation of which we have already spoken, § 205.), in such a manner, that their insertions are not directly opposite to the centres of the cornea and iris, but are placed behind the imaginary axes of the eyes, in situations somewhat nearer to the nose.

§ 254.

Each orb is composed of various tunics or coats, which inclose humours of different densities, and so extremely pellucid, that the rays of light, having entered the pupil or window in the anterior segment of the orb, can pass through, without the least interruption, to its bottom or opposite side.

§ 255.

The external involucrum of the globe of the eye is called *sclerotica*, the anterior *hiatus* or chasm of which

which is closed up by the transparent *cornea*, which is a lamellated membrane, more or less convex, and projects in a slight degree forward, like a segment of a smaller globe protruding out of a larger.

§ 256.

Next to the sclerotica lies the *tunica choroidea*, which abounds in blood-vessels, more especially in verticose or circuitous veins: this coat is stained on each side by a black pigment, which loosely adheres to its concave surface after the manner, and with the appearance, of mucus.

§ 257.

The choroides encloses, finally, the *retina*, which is the most internal of the common tunics embracing the visual orb. This coat consists entirely of the medullary substance of the optic nerve, which having perforated the sclerotica and choroidea, is expanded on the concave surface of this last involucre, and there arranged with the utmost beauty and elegance of structure.

§ 258.

The anterior border of the *tunica choroidea* terminates in a cellular ring, which is denominated *orbiculus ciliaris*, and by means of which the choroides is more firmly attached to a corresponding

groove or depression in the sclerotica. From this cellular girdle or attachment, two other membranes of different kinds, (namely, the *iris* and *ciliary processes*), originate and diverge from each other, like two expanded circles.

§ 259.

The *iris* (the posterior surface of which, being overspread with a dark pigment, is denominated *uvea*) is situated anteriorly, is gently convex on the surface next the cornea, and is surrounded on all sides by a humour of an aqueous nature. That segment of the iris, which lies next the nose is narrower, while that which looks towards the temples is possessed of greater expansion. Its texture consists entirely of condensed cellular membrane, without the smallest vestige of muscular fibres; upon the whole, it appears to be in reality a membrane *sui generis*, as was formerly well observed by Zinn, and not by any means an appendage to the choroides. On its anterior surface it is differently coloured in different individuals, and while distended and animated with a plenitude of life, it exhibits somewhat of a floccose appearance.

§ 260.

The blood-vessels of the iris run principally on its anterior surface, and, in the foetus, are continued

tinued into what is called the *membrana pupillaris*: respecting the nature and use of this membrane, I have spoken more fully in another place*. It appears to be intended for the purpose of preserving the iris, (during the rapid growth of the ball of the eye), in a state of expansion, and thus rendering it more fit for future motion.

About the seventh or eighth month of pregnancy, when the ball of the eye has now acquired a considerable magnitude, this membrane begins to open and give way in its centre; the elliptical arches of its vessels are retracted in a very gradual manner, and thus form, in my opinion, the *small interior ring of the iris*; it is, at least, certain, that not a single trait of this ring can be discovered in the eyes of a fœtus previously to the above-mentioned period.

§ 261.

The *posterior* of those two orbicular membranes, of which we have already spoken, (§ 258) is called the *ciliary body* or *band*; it runs in a backward direction, and therefore, in its progress, diverges still farther from the iris; by its *external border*, which is gross and firm, it is attached to the *orbiculis ciliaris* (§ 258), but by its *internal*,

* Commentat. societ. scient. Goettingens. T. VII.

which is more fine and delicate, it embraces the margin of the capsule of the lens: it is also shaded with that same dusky pigment, of which we have twice already spoken.

Its anterior surface, lying opposed to the *uvæa*, is somewhat striated.

Its posterior surface, resting on the vitreous substance, is distinguished by about seventy *plicæ* or folds, which exhibit an extremely elegant floccose appearance; these are called *ciliary processes*, and are remarkable for a vascular apparatus of inexpressible subtlety and beauty.

§ 262.

In the eye-ball itself, the membranes of which we have been hitherto describing, there are enclosed, in particular, three different *humours*.

The *vitreous* humour occupies and fills the posterior, and by far, the greatest, portion of the visual orb. It is distributed, in a countless number of minute drops, throughout as many minute cells of the *membrana hyaloidea*, in such a manner, that the whole mass, consisting, in part, of membrane, and in part, of lymph, exhibits the appearance of a peculiar, tremulous jelly.

263.

The anterior part of this vitreous substance, has appended to itself, and embraces, in the *ciliary girdle*, a capsule, in which is contained the *crystalline lens*, surrounded on all sides by a very subtle water, first discovered and described by Morgagni.

This lens itself, is also composed of extremely pellucid cellular membrane; it is by far more dense than the vitreous substance, and is furnished with so minute a quantity of genuine humour, that, when pressed between the fingers, it resembles glue of the most tenacious consistence, but at the same time of astonishing transparency.

§ 264.

The remaining portion of the internal cavity of the eye, is filled up by an exceedingly limpid *aqueous humour*, and, by the expanded orbicular curtain of the iris, is divided into two *chambers*: these are, the anterior, or more capacious chamber, which separates the cornea from the iris, and the posterior one, of smaller dimensions, extending from the uvea to the *corpus ciliare*.

§ 265.

These most precious and inestimable parts of the body, as Pliny, the elder, has emphatically

called the eyes, are securely protected from external injuries, as well by their recluse situations in their orbits, as by their valviform coverings, the *palpebræ*.

Between the folds of the *palpebræ* are planted, in immense profusion, the crowded sebaceous follicles of Meibomius; their *extreme* or *lower* edges, fringed with three or four phalanges of *cilia* or lashes, are kept in an expanded state by certain cartilages called *tarsi*, which are also of further service in facilitating the motion of the *palpebræ* on the eye-balls.

But (to adopt the language of the eloquent Cicero) the parts situated immediately above the *palpebræ*, being closely mantled in the *supercilia* or *eye-brows* intercept and turn aside the sweat flowing down in streamlets from the head and face, and also serve to moderate, in a certain degree, the excessive effulgence of light.

§ 266.

For the purposes of lubricating the eyes, of preserving their splendor, and of washing out heterogeneous substances, *the tears* are provided: the principal source of this fluid is a small conglomerate gland, deeply situated in a depression towards the external part of the circumference of the
the

the orbit. The excretory ducts belonging to this gland are numerous, but extremely tender; they are supposed to convey, from both eyes, in the course of twenty-four hours, about two ounces of tears; After having been excreted, the tears are again absorbed by the *puncta lacrymalia*, from whence they are conducted through what are called the *cornua limacum*, or *snail's horns*, to the lachrymal sac, and from thence finally discharged into the lowermost passage of the nares.

§ 267.

Thus much it was necessary to premise respecting the admirable structure of the visual organ. We come now to treat of the functions of this organ, or, in other words, to consider the *doctrine* of vision.

All the rays of light which fall on the convex surface of the cornea pass through it, provided their angle of incidence be less than that of 48 degrees. In consequence, not only of the density, but also the figure of the aqueous humour, the rays are refracted in that medium, and turned a little nearer to the real axis.

As many of the rays as, having passed through the pupil, enter the crystalline lens, must necessarily

farily, in this more dense medium, be subjected to a still higher degree of refraction.

But by means of the more attenuated and less refractive vitreous medium, wise provision is made to prevent these rays from uniting in a focal point at too short a distance: this point, being thus farther removed from the convex surface of the cornea, falls on the *retina*, and there exhibits, in an inverted position, the images of all objects presented, and that in perfect correspondence to the nature of surrounding and attendant circumstances.

§ 268.

This difference in the density of the refracting media of the eye, exhibits a very striking instance of the exquisite and inimitable workmanship of the divine creator. By means of this diversity, such a complete remedy is provided against the twofold separation or divergency of the rays of light, (the one arising from the different refrangibility of the different coloured rays, the other from the very figure of the lenses), that they are all finally collected and united in the same focal point.

§ 269.

The celebrated problem, in which the cause is demanded, wherefore we see those objects erect,
the

the images of which are nevertheless exhibited in an inverted position on the retina? appears to admit of an easy solution, when we consider, that objects are said to be inverted, only from the relation they bear to others, which are exhibited in an erect position.

In as much then as the images, not of a few, but of all objects, even of our own bodies, are received by the retina in the same relative position, the situations and relations of the whole of them harmonize and correspond to one another, equally as well, as they could possibly have done, had their positions been truly erect: in consequence of this, the mind, (which does not attend to the image itself, but to the sensation excited by its impression), is sufficiently guarded against embarrassment and mistake.

§ 270.

In as much as the conditions, essentially necessary for the purposes of acute and distinct vision, are extremely numerous and varied, the creator of man has made the wisest provision for these, by endowing the part, subservient to this sublime sense, with a great variety of functions.

As a certain *adequate*, but yet *definite*, quantity, and not too potent a *glare*, of light, is essential

to the existence of clear and perfect vision, a two-fold caution is thus taken; first, to admit, (according as the light is stronger or weaker), a greater or less column of rays to fall on the lens; and secondly, that all superfluous rays which enter the eye, and tend only to dazzle by the intensity of their splendour, be absorbed and rendered inactive.

The former of these purposes is effectually accomplished by the motion of the iris; the latter, by means of the black pigment.

§ 271.

The iris possesses an astonishing mobility, by which it accommodates itself so perfectly to the quantity of light acting on it, that when exposed to a more intense glare, it is immediately expanded, and thus diminishes the size of the pupil, but when subjected to the action of a weaker light, it is again retracted, and the pupil consequently enlarged.

Physiologists have attempted a satisfactory explanation of this motion, in a variety of modes, founded on different principles; by some it has been derived from diversified impulses of the blood on the tender vessels of the moving part, while others have figured to themselves the existence of
certain

certain imaginary muscles in the *iris*, and have committed to them the whole of the phenomenon in question, &c. But I have lately made it appear in a separate paper, that neither of these modes of explanation is well founded, but that it is much more agreeable to evidence, and correspondent to the phenomena of nature, to derive the immediate cause of the motion of the iris from its *vita propria*, or *specific life*. (§ 47.) The more remote cause of this motion, as we observed on a former occasion (§ 256), cannot be referred to any other source, than the re-action of the sensorium itself.

§ 272.

The function of this dusky pigment, of which we have already so repeatedly spoken (§ 256, 259, 261,) to wit, that it is destined to absorb the superfluous rays of light, and is hence of the utmost importance in the business of perfect vision, may, besides other arguments, be safely inferred from dissections of the eyes of various animals; but is more completely demonstrated and established, by the morbid constitution of the white *Æthiopians*, or *Albinos*, as they are called, in whom, from a deficiency of this pigment, the organs of vision are painfully tender, and the impulse of light consequently too powerful to be borne.

§ 273.

§ 273.

It is further requisite, that the focus of refracted rays be perfectly formed on the retina, so that it may strike the very *point* of vision, and be neither so far extended as to fall behind it, nor so much contracted as to terminate before it, in the vitreous substance.

The latter of these deviations from perfect vision is what takes place in those individuals called *myopes*, in whom the lucid cornea is rather too convex and gibbous.

But the former deviation is that under which the *presbyta* labour, as the conformation of the anterior parts of the eyes is directly the reverse.

§ 274.

But as an eye perfectly sound is able to discern, with equal distinctness, bodies, whether at a greater or less distance, it must, without doubt, be furnished with peculiar faculties or powers of accommodating itself to the various distances of objects. That these internal and accommodating changes of the eye, are in a great measure produced by the pressure of the *recti* muscles on the ball which they embrace, is a position so clear, and apparently well founded, as scarcely to admit of a doubt. Besides other arguments which might
be

be advanced in favour of this opinion, I am induced to adopt it in consideration of the very singular structure, and extreme flexibility, of the *sclerotica*, in the eye of the Greenland phoca, or sea-calf. By this peculiarity of fabrication and arrangement, nature has made the most exquisite provision to enable this amphibious animal to enjoy at all times, the advantages of vision, though passing its life alternately in media of very different densities.

§ 275.

By means of these same muscles, our eyes, whilst we are awake, are perpetually agitated, although with an almost insensible motion, and so directed as to have their visual axes arranged in right lines with the objects viewed. For although the whole of the retina be possessed of sensibility, yet it is not in every part equally well adapted to receive the images of objects.

For at the genuine axis of the eye-ball, in the place, for example, where the optic nerve enters, it appears, from the well-known and celebrated experiment of Mariotte, that the human eye is destitute of the power of vision.

But the *principal focus* of the retina, and that which ought to be considered as the leading and

immediate instrument of distinct vision, is situated in an imaginary axis of the eye-ball, which is supposed to pass through the centre of the cornea, and to be thus continued through the centre of the whole orb. It is not, however, (as was lately observed by the celebrated Kæstner in his comments on certain works of Boerhaave), to be from hence understood, that we are unable to see clearly and distinctly, more than one single point of an object while the eye remains perfectly at rest, and that we are obliged to shift or alter its axis in order to distinguish any other point. The case is quite otherwise, because the sensation produced by one entire object, is also itself, like its original, or exciting cause, one and entire.

§ 276.

The habit of directing the axis of the eye with dispatch and facility towards the object of vision, is finally acquired only by use and daily exercise. That this is a position founded in truth, is demonstrated not only by the example of such individuals as, having been born blind, acquired afterwards the power of vision in adult age, but also by that of tender infants, who seldom attain to this happy facility of moving their eyes previously to the third month after birth.

§ 277.

To the same power of custom and habit, must we also attribute the remarkable circumstance of our seeing objects only single, though our eyes be two in number. New-born infants appear to see objects double, and double vision, which frequently continues sometime after certain diseases of the eyes, may be at length overcome and removed by use and exercise.

§ 278.

The *joint power* of both eyes, with regard to the *acumen* and strength of vision, does not, according to the calculation of Jurin, exceed that of one eye, more than a thirteenth part.

And, agreeably to an observation, long since made by that celebrated painter Leon. da Vinci, it is much best in judging of the distances of objects to make use of one eye only.

§ 279.

Finally, In treating of the strength and perfection of the eye, our former illustrious countryman, Tob. Mayer, demonstrated, by a series of very elegant and ingenious experiments, that the angle of vision ought to exceed, in dimensions, at least 34 *seconds* of a degree. From hence he at the same time illustrated and proved the extreme

perfection of the human eye, because this extent of the angle of vision may continue nearly the same, under any light whatever, whether that of the meridian sun, or that of a weak lamp, so that though the window or pupil of the eye be greatly contracted and diminished, yet the clearness of vision can, from that source, be scarcely in any degree affected.

§ 280.

From hence we may infer, the inconceivable smallness of the images of objects which are thrown and delineated on the retina, and which are nevertheless impressed with so much force, that, under certain circumstances, vestiges of them remain a considerable time, even after the objects themselves have been entirely removed from the eye.

SECT.

SECT. XXII.

OF THE INTERNAL SENSES, AND OTHER FACULTIES
OF THE MIND.

§ 281

THROUGH the medium of those external senses, of which we have hitherto treated, ideas are conveyed to our nobler part, *the mind*; for, agreeably to the tenor and spirit of a well-known theorem, nothing can enter the understanding save by the route or avenue of the senses.

§ 282.

For the purposes of receiving and preserving the ideas thus acquired, by the aid of the senses, and also for making the best use and improvement of the intellectual stock received, various faculties of the mind contribute their united exertions. Though these faculties be, (as we have already had occasion to observe, § 42.), widely different from the vital energies which reside in the body, nevertheless, by means of the nervous system, they are so closely connected with those corporeal energies, that an astonishing intercourse is thus established and supported between the body and mind, (§ 211.)

§ 283.

The first of those powers, possessing indeed, apparently, the lowest grade, is the faculty of *perception*, by means of which the mind is rendered conscious of impressions made on the different organs of sense.

§ 284.

This faculty is aided by another, of better rank and higher dignity, namely, *attention*, which so directs and determines the mind towards any idea when once excited, as to rivet its thoughts to that object alone.

§ 285.

For the important purposes of preserving ideas, which have been already perceived, of re-exciting them, and associating them into more lively and picturesque species of imagery, two other faculties, called *internal senses*, are brought into action: these are *memory* and *imagination*, two powers, which, though nearly allied to each other, may, notwithstanding, be readily distinguished by the following characters: *memory* appears to be more subservient to, and engaged in, the reception and retention of *arbitrary signs* of things; whereas, *imagination*, on the contrary, wakes up rather the *very images* of things, bestows on them form and colouring, and marshals them under the view of
the

the mind, as if the objects themselves were again actually present: this faculty is more particularly and powerfully exercised on such objects as are calculated to excite sensations of pleasure or disgust.

§ 286.

Upon the whole, the *faculty* of *choosing* and *refusing*, and, (when we consider the matter a little more minutely), even the foundation of the whole *will* itself, appear to rest and depend entirely on certain agreeable and disagreeable varieties of sensation.

§ 287.

From the same prolific source, namely, the *imagination*, are also to be derived the *affections* or *commotions* of the mind, to which we see different individuals variously subjected, in conformity to the countless diversities of existing temperaments (§ 59.) The very intimate and instantaneous consent of these affections with certain functions of the body, appears strikingly evident in an infinitude of examples; thus, for instance, there is scarcely a single passion of the mind, which does not possess considerable influence over the *motion* of the heart, the *appetite* for food, and the powers of *digestion*,—not to descend to a minute specification of particular effects, such, for example, as the action of shame in giving rise to

blushing, the action of love or hatred on the *organs* which serve to distinguish the sexes, the action of anger on the *secretion* of bile, &c. &c.

While speaking of the effects produced in the economy of the human body, by the commotions of the mind, it is proper to observe, that they may be divided into *stimulant* and *sedative*, or into those which *excite*, and those which *depress*.

Of the former description are joy, love, hope, anger, &c.

Of the latter, fear, sorrow, nostalgia, and other species of permanent desire or longing, terror, envy, &c.

§ 288.

Those faculties of the mind hitherto enumerated, are observed to exist in brutes as well as man, though the latter undoubtedly possesses them in by far the highest degrees of strength and perfection: thus, for example, in none of the interior animals do we discover a memory so extensive in its range, and so powerful in its tenacity; in none do we discover such a splendid brilliancy, and glowing warmth of imagination; in none do we discover such an unbounded, and sometimes fatal, vehemence of mental passions, &c.

§ 289.

The leading prerogative of the human mind, consists in this, that it alone possesses the exclusive power of *reason*, by means of which it is able to judge, to form abstract ideas, &c. and which exerts also the greatest influence over most of the other faculties of the mind. In place of this divine power, other animals are endowed with various *instincts*, or blind and involuntary *impulses*, which lead them to the performance of such actions, as are suitable to their several economies and modes of life. Of these instinctive impulses man, on the other hand, is furnished with scarcely any, save that which prompts him to participate in venereal gratifications.

§ 290.

The immense and striking difference between *animal instinct* and *human reason*, will appear glaring as the noon-day light to him who considers:

That instincts are faculties co-eval with birth, whereas, on the other hand, the use of reason is acquired only by culture and education :

That instincts remain stationary, and admit of no improvement, whereas the expansive improvement and exercise of reason, are literally free from circumscription :

That instincts are suited only to the destined mode of life, to the climate, &c. of each species of animals, and, on this account, are not adequate to the exigencies of man, who, confined to no climate, exclusively restricted to no mode of life, is destined to be an inhabitant of the world at large: from which boundless and splendid prerogative, an inconceivable diversity of wants arise, which simple instinct is too weak!—far too weak to supply! but which, the powers of reason, from resources equally diversified as the emergencies themselves, are able to satisfy, in the most ample and complete manner.

Lastly, another high prerogative of man, depending on the powers and exercise of his reason, is the use of speech, of which we have briefly spoken on a former occasion (§ 154.) This invaluable privilege is the exclusive boast of man alone, brutes being only furnished with voice, or a power of emitting sound.

S E C T. XXIII.

OF THOSE ACTIONS OF THE BODY WHICH ARE
SUBJECT TO THE POWER OF THE WILL.

§ 291.

THE nerves, as we have already seen, are so constituted as to perform two different functions (§ 215), namely, *sensation* and *motion*. The doctrine of the former we have already considered. It yet remains to add a few observations on the subject of the latter.

§ 292.

The motions in general of the several parts of the human body, are usually divided into two classes, one of which is excited and governed by the *power* of the *will*, while the other is not in any measure subject to its *influence*, or controul.

For examples of the latter class, physiologists commonly refer to the harmonious action of the heart, and likewise to the peristaltic motion of the intestines and certain other viscera, &c.

Instances

Instances of the former class we have in the motions of by far the greater part of the other muscles of the body.

Doubts are still entertained, with respect to the real nature of certain motions which take place in the human system; such as the motions in respiration, in sneezing, in the tension of the *membrana tympani*, &c. These are by some classed with the voluntary, by others with the involuntary, while others again refer them to a third class, called *mixed motions*.

§ 293.

When this division, however, is considered with a little more steadiness and attention, it is easily perceived to be embarrassed with such momentous difficulties, that it is scarcely possible to ascertain, and mark, with definitude, the precise limits between the classes.

For, on the one hand, a few of the functions of our bodies, over which the will, unassisted by other powers, may be said to possess no command at all, may notwithstanding be excited and brought into action, when the imagination and passions of the mind act in concert with the will.

On the other hand there are not wanting instances of muscular functions, which, though naturally subject to the immediate command of the will, have, notwithstanding, been rendered in a great measure *involuntary*, by the plastic power of *custom*, (the influence and energetic agency of which, on animal motions, are indeed of the utmost moment and importance.)

§ 294.

Of this latter description are those kinds of muscular motion, which, although at other times subject to the controul of the will, yet, under certain circumstances, take place not only without the consciousness, but even contrary to the inclination of the mind.

Thus, for example, we wink *contrary* to our determination, when the finger of a friend is hastily approached towards our eye, although it does not touch it; and in most persons, the flexion of the little finger is usually attended with a synchronous flexion of the ring finger, though a determination had been formed to preserve the latter entirely unbent.

Without the *consciousness* of the mind we frequently move our limbs, even when wrapt in the most profound sleep.

There

There are, on the other hand, examples of muscles, which, although for the most part perfectly obedient to the will, yet in certain cases refuse to obey its commands. To this head we may refer the difficulty of describing, by synchronous movements, circles in contrary directions, with the hand and foot of the same side, together with other motions of a similar nature, which, although truly voluntary, and extremely easy when practised alone, are, notwithstanding, performed with the utmost difficulty, if an attempt be made to associate them with certain other motions.

§ 295.

With respect to those motions, which physiologists suppose to be perfectly exempt from the influence of the will, I know of none which can be clearly and unexceptionably referred to this head, save the spasms of the uterus in the labour of parturition.

With respect to the pulsation of the heart, a very remarkable account stands on record of a British colonel, who possessed a power of suspending, at pleasure, the motion of both the heart and arteries. In confirmation of the truth of this, we have the public testimony of Baynard and Cheyne, two physicians of the highest reputation
and

and veracity, who were themselves witnesses to the astonishing phenomenon.

That the motion of the stomach may be voluntary, (as indeed the process of rumination in general seems to evince), I had once an opportunity of ascertaining, to my entire satisfaction, in a ruminating human subject, in whom this retrograde or reverted motion of the stomach, was under the most perfect subjection to the command of the will.

Although the motion of the iris be involuntary, in by far the greater part of the human race, I have, notwithstanding, been favoured with an account, sufficiently authenticated, of a man, who possessed a power of voluntary command over this membrane, in such a manner, as to be able, by a very singular effort, to contract the pupil of the eye even in a weak and dull light.

There are indeed a great variety of motions, which, though generally performed without the influence of the mind, are nevertheless voluntary in certain individuals, especially if a high degree of attention, and a vigorous effort of imagination be excited. Thus, I have known men, who were able at any moment, to produce and exhibit on themselves a spasmodic horripilation of the skin,
and

and also to renew and completely revive in themselves the ideas or perception of certain disagreeable sensations.

§ 296.

Perhaps those phenomena may be satisfactorily explained from the *re-action* of the *sensorium*, which appears to be indeed as powerfully excited by means of the imagination waking up and exhibiting before it, the *image* of an active stimulus, as by the *stimulus itself*, when impressing it by its actual presence. There are indeed an infinitude of phenomena of the animal economy, which admirably correspond to this explanation; as the various causes, for example, which excite erections of the male penis, &c.

§ 297.

With regard to voluntary motions in general, it may be proper finally to observe, that they are among the primary and leading characteristics which serve to distinguish the animal from the vegetable kingdom; for, as on the one hand, a *power of voluntary* motion is never observed to be possessed by any plant, so on the other, such a power constitutes an essential attribute of even the most simple and imperfect genera of animals.

§ 298.

§ 298.

In our own systems, the voluntary motions furnish the most full and striking evidence, of that intimate and truly astonishing harmony, which subsists between the mind and the body. Of the existence of this harmony every one will be convinced, who considers with attention, the amazing celerity with which such diversified motions succeed each other, in the fingers of an able and skillful performer on the violin, or in our organs of speech, while we are engaged in conversation.



SECT. XXIV.

OF MUSCULAR MOTION.

§ 299.

THE immediate organs of by far the greater number of the motions of our bodies, are the muscles, which constitute the principal portion and bulk of what are called *partes similes*.

§ 300.

The muscles are, however, distinguished, in a particular manner, from the rest of the similar parts, by a two-fold characteristic; *one* depending
on

on their texture; and the *other* of a very singular nature, derived from their vital energy.

§ 301.

Their texture is fleshy, composed of a peculiar set of fibres, of a very pale red colour: they are so joined together, that every muscle consists, in the first place, of fibrous cords, these cords again, of smaller bundles of fibres, which bundles, by a still further progressive division, may be finally separated and resolved into fleshy fibres and fibrils of inconceivable minuteness.

§ 302.

Each muscle is inclosed in a cellular sheath or covering, which, passing into the very substance of the muscle, appears to be interwoven throughout the whole of its volume, and thus forms partitions, first between the larger *lacerti*, then between the smaller fasciculi or bundles, and lastly, between the fibres and more minute fibrils themselves.

§ 303.

Besides this cellular expansion, the whole texture of the muscles is also interspersed with an infinitude of blood-vessels and nervous filaments; of these, the *latter* appear to deliquate into an inscrutable pulp, and to be thus very intimately
 2 blended

blended along with the muscular fibres; but the *former* are so extensively and minutely interwoven among those very tender fibres, as to paint the whole of the fleshy parts with that beautiful crimson dye, by which they are uniformly characterised. When these are thoroughly washed, they are again restored to their native colour, which, as already observed (§ 301.), is somewhat pale.

§ 304.

Finally, a circumstance common to most of the muscles is, that they terminate in *tendons*—parts, which, though likewise of a fibrous texture, are notwithstanding so extremely different, with respect to colour, structure, elasticity, &c. that their entire disagreement from both the preceding kinds of fibres, is very easily ascertained and demonstrated. Hence, therefore, we are enabled successfully to refute the opinion of those physiologists, who have erroneously supposed, that the *tendinous*, are nothing more than mere continuations of the *muscular* fibres. To the adoption of this opinion, they have been inadvertently led by attending to the following phenomenon, observable in the muscles of infants; namely, if we compare the *muscular parts*, of these tender subjects, with *those* of adults, we will find the proportion of flesh, to that of tendon, greater in the former than in the latter.

§ 305.

The other exclusive characteristic of muscles, which we have mentioned (§ 300.) is, the *irritability* of Haller. Although we endeavoured, on a former occasion, to give a general view of this vital energy, and to ascertain the difference between it and *contractility*, (§ 44.), yet it may not be improper, at present, to pursue the inquiry a little further.

§ 306.

This irritability, otherwise called *vis muscularis*, *vis insita*, or *vis propria*, is indeed common to all the muscular parts of our bodies, but does not reside in all of them in the same degree, some parts being observed to possess a much higher proportion of it than others.

The principal seat of this energy, where it most plentifully abounds, is the hollow muscles, subservient to the vital and natural functions: of these muscles, the heart, as was observed formerly (§ 119.), possesses the highest degree of the *characteristic* now under consideration: of this last mentioned organ, the internal surface, in particular, is endowed with the most exalted degree of life, and is by far the most tenacious of irritability.

Next to the heart, in point of this prerogative, is the intestinal canal, more especially that portion of it which constitutes what are called the *small intestines*: in warm-blooded animals, this part of the tube sometimes contracts on being irritated, even after the heart itself has become incapable of motion.

Next in degree is the stomach,—next, the urinary bladder, &c.

Among the remaining muscles of the system, irritability resides, again, in a very striking degree, in those actively concerned in the function of respiration, as the diaphragm, the intercostals, and the *triangularis sterni*.

Next in order to these are the various other muscles of the body.

The arteries doubtless possess irritability, though in a degree far inferior to what exists in the parts just mentioned (§ 123.)

This vital energy resides also in the trunks of veins contained in the thorax, (§ 84.)

In a degree *still lower*, does it exist, in the other parts of the sanguiferous veins, if, indeed, those

parts can be said to possess any *genuine irritability* at all (§ 128.)

§ 307.

Haller himself, that illustrious defender of the doctrine now under consideration, appears to me to have, without sufficient foundation, attributed irritability to *certain parts* of the body, which are found, indeed, on experiment, to be endowed with *contractility* (§ 50 seq.), but in which I have never been able to discover any indubitable testimonies of *genuine irritability*.

Among these parts may be reckoned the lacteal veins, the small glands, the gall-bladder, the uterus, the *dartos* covering, and the male penis.

On no better foundation, in my opinion, is irritability attributed, by others, to the iris, to the external surface of the lungs, &c. in all which parts (if, indeed, I be capable of judging rightly), there exists no more of this vital energy, than there does in the common cellular membrane, and parts composed of it, such, for instance, as the common integuments, the meninges, the pleura, the peritoneum, the periosteum, the medullary membrane, the tendons, the aponeuroses, &c.; or than there does in those viscera composed of *genuine parenchyma*, (§ 27.), such as the liver,
the

the spleen, the kidneys, the secundines, the brain, with the rest of the nervous system, &c. all which parts, as they are throughout, completely destitute of muscular fibres, so are they likewise destitute of irritability, which resides in muscular fibres alone.

§ 308.

As we have, thus, on the one hand, seen muscular *irritability* now and then confounded with cellular *contractility*, so on the other, certain celebrated characters have lately been desirous of ascertaining and establishing an identity between *irritability* and the *vis nervæ*.

For although we can neither deny the powerful influence of the nerves on *muscular motion*, (of which we will speak a few words presently), nor exhibit the smallest fibril of muscular flesh, perfectly destitute of the pulp of evanescent nerves, yet these circumstances are not sufficiently momentuous to compel us to a dereliction of the opinion, that irritability is, in its own nature, as widely and essentially different from the *vis nervæ* as it is from *contractility*. On the one hand, this energy is wanting in all parts not muscular, although they be supplied with the utmost profusion of nerves, as the skin, all the nervous viscera, &c.; whereas, on the other, we are not able to produce any portion of true muscular flesh, where

the genuine and obvious phenomena of irritability do not exhibit themselves. From a close and impartial consideration of the foregoing arguments, besides a great number of others which might be advanced, it appears more consonant to reason and sound induction, to attribute the singular *phenomena* of irritability to the equally singular texture of muscular fibres, than to refer them to the nerves, which, in so many other parts of the body, are as minutely distributed as they are through the muscles, and yet do not generate and exhibit, in those parts, the faintest shadow of real irritability. I say nothing of the weighty arguments which might be drawn from the following well-founded position, viz. that no steady proportional relation is observed to exist, between the degree of irritability in any part of the body, and the quantity of nerves with which it is supplied.

§ 309.

With respect to the extreme terminations of the nerves, which are well known to exert an influence over the muscles, the following appears to be the most rational conclusion, viz. that they may be considered as *remote* or *exciting* causes of muscular motion, but should not be confounded with the *proximate* or *efficient* cause, which is indeed *irritability* alone, and that residing exclusively in the muscular fibres.

The passions of the mind, for example, act on the sensorium, this again re-acts on the nerves of the heart, in such a manner, as to excite its irritability, and thus produce palpitations and other irregular motions of this organ.

The will acts on the sensorium, this re-acts again on the nerves of the arm, these nerves in like manner operate immediately as remote causes in exciting muscular motion, which, notwithstanding, depends ultimately for its existence on irritability itself.

§ 310.

This distinction, of the two kinds of causes which concur in the production of muscular motion, is indeed fully authorised and sanctioned by actual experiments: from a variety of these it appears, that certain parts of the animal system have been oftentimes rendered paralytic, by cutting, or inclosing in ligatures, the nerves leading to them, while they have, notwithstanding, still continued to retain their *irritability* for a long time afterwards.

§ 311.

In what degree the blood, with which the muscles are very abundantly supplied, contributes to their action, is not yet clearly and satisfactorily ascertained.

It appears, however, from an experiment of Steno, that a paralysis of the lower extremities may be generally produced, by passing a ligature round the aorta in its descent behind the abdominal cavity.

§ 312.

Besides these common inherent energies of the muscles, which have hitherto been the subjects of our consideration, they possess also certain specific and adventitious peculiarities, arising from varieties in their figures, situations, &c. by these peculiarities they are adapted, and rendered completely adequate, to the nice performance of their several functions.

§ 313.

From the contemplation of this circumstance, muscles are usually divided into hollow and solid: the former of these, as we have already seen, not being in immediate subjection to the command of the will, are particularly destined to the performance of the *vital* and *natural functions*, and cannot, therefore, be further treated of in this place, where we are considering what are called *voluntary* muscles, which are more especially subservient to that order denominated the *animal functions*.

§ 314.

§ 314.

Between these last-mentioned muscles themselves, there occur again very striking diversities. For to say nothing of the varieties in their relative magnitudes, they differ extremely from each other in the disposition of their *lacerti* and *fasciculi*, in the direction of their fibres, but more especially in the habit and proportional relation of their fleshy and tendinous parts, and, finally in their courses, their insertions, &c.

§ 315.

Nevertheless, in by far the greater part of the *fusiform* or tapering muscles, their figures are more or less oblong, so that their fleshy bellies terminate at each end in tendinous cords. These cords, which are inert and perfectly destitute of irritability, being attached to, and inserted in, bones, serve the necessary purpose of moving them after the manner of levers.

§ 316.

As there are, however, a few muscles in the body entirely destitute of tendons, such as the *latissimus colli*; so there are, in like manner, a few not attached to bones, namely, the muscle last mentioned, the *cremaster muscle*, as it is generally called, the *azygos uvulæ*, and most of those which move the ball of the eye.

§ 317.

§ 317.

By the co-operation and combined aid of all those energies, (as well the common, § 305, as the proper, § 312), with which the muscles are furnished these instruments of motion are fitted and completely qualified for the performance of their several actions, which may, in like manner, be also divided into *common* and *proper*.

§ 318.

During their common action, which arises immediately from irritability, and occurs in all muscles, their fleshy portions become shorter, more rigid, and, for the most part, unevenly and somewhat angular. It also appears from the celebrated experiment of Glisson, that they suffer at the same time a slight diminution in point of magnitude.

We are indeed prevented from joining Jo. and Dan. Bernouille, and other mathematical physicians, in an attempt to reduce the measure of this diminution to common calculation, *first*, by the immense difference in this respect, which is observable between the hollow and solid muscles, and *secondly*, by the diversity which also occurs, on the same point, between these latter muscles themselves;—not to mention various other difficulties, which obstruct the road to success.

§ 319.

§ 319.

The proper or specific actions of the muscles, (§ 317.), correspond precisely to their specific energies; from whence it naturally and spontaneously follows, that these actions are marked with such an infinitude of varieties, as to render it literally impossible to reduce them to any general laws, or to arrange them under any well-defined *orders* and *genera*.

With regard to the general principle, commonly taught and adopted on this subject, viz. that every muscle while in action, draws the more moveable part to which it is attached, towards that which is more permanent, it ought to be considered, (as has been very justly observed by the sagacious Winslow) in a relative point of view, and is indeed subject to a variety of limitations. Thus, for example, the two parts to which a muscle is attached, may be rendered, each more moveable than the other, in alternate vicissitudes, accordingly as the one or the other is fixed and rendered stationary, by the joint action of other co-operating muscles.

As to the action of the flexor muscles, it ought to be estimated on contrary principles, and a different opinion formed respecting it. Although these muscles, for the most part, predominate so much over their antagonists, the *extensors*, that
when

when the body is in a state of perfect quietude and rest, the arms, fingers, &c. are under a gentle degree of flexion, yet these parts do not appear to be drawn into this state and position by any actual force, but rather in consequence of a voluntary relaxation of their extensor muscles, by means of which, those muscles, subservient to the flexion of the parts, are left at liberty to act without opposition or resistance.

§ 320.

To all the foregoing considerations, it appears proper to add, in the last place, that each muscle possesses a peculiar and specific mechanism, by means of which it is adapted, in the most complete manner, to the performance of the various motions of its immediate destination.

Besides the peculiar advantages which the muscles severally derive from their determinate figures, their actions are also promoted by a variety of other concomitant aids, such, for instance, as the annular ligaments by which they are surrounded; the fat, in which a great number of them are imbedded; the lymphatic dew with which they all abound; and, what ought to have been mentioned in the very first instance, the conformation of the skeleton itself, especially as far as the same relates to the structure of the apophyses, and the articulation

articulation of the joints : under the same head of auxiliaries to the muscles, may be also arranged certain entire bones, as the *patellæ*, and ossa sesamoidea, of similar structures and uses, which nature appears to have very wisely adapted and destined to facilitate the motions of particular muscles.

321.

By these diversified and numerous aids, has nature made compensation for, or at least very considerably diminished, that inevitable loss of power, which necessarily arises from the conformation and stature of the whole body. The acuteness of the angles formed by the insertions of a great many muscles, and the vicinity of these insertions to the centres of motion, may be brought forward as incontrovertible testimonies in favour of such a loss of power, which would not have been sustained, had the tendinous cords been inserted at greater distances from the centres of motion, or in such directions, as to have formed more obtuse angles.

§ 322.

To our bodies, thus furnished with about four hundred and fifty muscles, together with a few occasional supernumeraries, (arising from sexual and individual varieties), two advantages of the utmost magnitude and importance are very obviously

ously derived. First, in consequence of this beautiful and complicated system of organs, not only our individual members, but also our whole bodies, are rendered capable of the most astonishing agility, in point of motion; and *secondly*, from the same source, we derive such remarkable degrees of strength, as qualify us to bear, without injury, the most arduous species of labour and fatigue. These two momentous advantages depend, indeed, in part, on a perfect state of the muscles, to which, no less than to a perfect state of the bones, we arrive by degrees, as youth advances towards maturity; but they are also, in part acquired by a frequency of use and exercise. The powerful influence which those two latter circumstances possess and exert over the muscles, in strengthening them and rendering them capable of the utmost agility of motion, is strikingly demonstrated by numerous examples of rope-walkers, of dancers, of runners, of wrestlers, of boxers, and of those robust barbarians, who constituted the glory and boast of former ages.

SECT.

SECT. XXV.

OF SLEEP.

§ 323.

THOSE two species of nervous action, (the history of which we have now completed) that have for their ultimate ends *sensation* and *motion*, are so reduced and debilitated by the diversified exercises of the day, that repose by night becomes absolutely necessary, for the purpose of refreshing their declining vigour and energy, which *sleep* alone, the image, or *semblance* of gelid death, is able completely to restore.

§ 324.

Sleep is a function perfectly periodical, which suspends, as it were, for a time, all intercourse and communication between the mind and body. The various phenomena of this function, some of which shall be immediately enumerated, appear to declare, with no small force of evidence, in favour of the existence of a nervous fluid.

§ 325.

Besides a variety of other circumstances, we may here enumerate as precursors and harbingers
of

of sleep, a sluggishness and gradually increasing dullness of the external senses, together with a relaxation of most of the voluntary muscles, especially such as are of considerable length. To these may be added a congestion of the venous blood in, and near, the heart, and an effort to remove the uneasiness thence arising, by the aid of yawning. Finally, the only additional precursor to be mentioned at present, which appears to constitute the very *isthmus*, as it were, between the waking and sleeping states, and the immediate transition of the former into the latter, is a peculiar species of transient delirium.

§ 326.

The following are what constitute the principal phenomena of sleep, when that state has actually occurred: the *animal* functions are wholly suspended from action, while almost all the *others* are at the same time performed in a more sluggish and torpid manner; thus, in subjects buried in sleep, all other circumstances being alike, the pulse is slower, and the heat of the body somewhat diminished; perspiration is also less plentiful; digestion less powerful; and (if the occasional discharge of the semen masculinum be excepted) all the excretions are suppressed, &c.

§ 327.

The *remote causes* which induce sleep are very plain and obvious. For to say nothing of narcotic substances themselves, we may consider as very energetic causes in the production of this state, all *waste* of the *animal powers* by means of preceding *fatigue*, by *watching*, &c. To these we may subjoin the influence of custom, together with darkness, silence, rest, &c. which appear indeed to derive their somniferous powers from the same source; we may also further add, gentle, uniform, and constant impressions acting on any of the senses, such, for instance, as the soft murmurings of the rill, or the appearance of a harvest field, agitated and thrown into wavy undulations, by the mild fannings of the western breeze, &c. Under the same head of remote causes we may also consider, full meals, and intense cold acting on the body, together with a variety of other circumstances, tending to derive the blood from the encephalon, as pediluvia, clysters, and profuse hemorrhages, &c.

§ 327.

Those remote causes which we have mentioned in the latter part of the preceding paragraph, are, of themselves, sufficient to conduct us to the *proximate cause*, which appears, from the best evidence

that can be collected on the subject, to consist in a diminution of the column of blood that goes to supply the encephalon.

That this is indeed the proximate cause of sleep, is powerfully illustrated and confirmed, by a very singular and striking phenomenon, which I had once an opportunity of observing in a living human subject, whose case has been already mentioned on another occasion. As often, and as long, as this person indulged himself in sleep, his brain subsided and continued in a state of considerable collapse, but during his waking hours throughout the day, this organ became again turgid and distended in consequence of a more copious afflux of blood.

As an additional argument in support of the same *cause*, we may observe, that *morbid watchfulness*, on the other hand, usually arises from congestions of blood in the region of the brain.

§ 329.

The quantity of sleep necessary, depends in a great measure on varieties in age, habit of body, temperament, &c. The general result, however, of all the existing evidences on this subject, appears to be, that a longer indulgence in sleep is either a concomitant of imbecility (as is the case

in tender infants. and subjects far advanced in years), or a very exuberant source of faculty and dullness.

§ 330.

We rise from sleep with renovated powers, and our return into the living, and completely waking state, is accompanied with symptoms and phenomena very similar to those which attended our transition from this state into that of sleep: we are attacked, for instance, by a yawning, accompanied for the most part with more or less of a stretching, we are also affected by a certain dullness and torpidity of the senses, &c.

§ 331.

The causes which rouse into wakefulness, appear to correspond exactly with those productive of sleep.

The proximate cause will be the return of a more copious column of blood into the encephalon.

The remote causes, besides the power of custom, which is confessedly very great, consist of an immense variety of stimuli, that may be divided into *external* and *internal*. The external are calculated to excite the slumbering senses, while

the internal act either immediately on the body itself, as the distension of the urinary bladder; or impress the nervous system through the medium of the imagination, the mode in which *dreams* operate.

§ 332.

Dreams are light sportings of the imagination, in which it recalls the images of things formerly perceived, and appears to exercise and busy itself in arranging and combining them into the most fantastical representations.

I have never been able to discover the slightest vestige of this faculty in new-born infants previously to the third month after birth.

There are also various examples of adults who explicitly declare, that they have no knowledge of dreams, having never been troubled by them.

Those visions of the night are, for the most part, indeed, confused and irregular; but they are, notwithstanding, sometimes marked with astonishing vestiges of reason.

The influence of stimuli acting on the body is truly great in the production of dreams: thus the stimulus of the male semen gives rise to lustful ideas;

ideas; the stimulus of an excessive plethora calls up images of a frightful and terrifying nature, &c. We have even received a well confirmed account of a man, to whom, while asleep, his friends could suggest whatever visions they pleased, by communicating to him the subject and matter of the dream in a soft and gentle tone of voice. This appears however, to belong rather to a preternatural state, consisting of somnolency and wakefulness, of which that truly morbid affection of the *somnambulantes*, or those who walk in their sleep, constitutes also another variety.

It is necessary previously to the final conclusion of this subject to observe, that Locke and others have thought proper to consider all dreams as belonging to this mixed or compound state.

END OF THE FIRST VOLUME.



E L E M E N T S
OF
P H Y S I O L O G Y .

SECTION XXVI.
OF FOOD, AND THE APPETITE FOR IT.

§ 332.

AS the waste of the animal powers is again restored by sleep, so in like manner the incessant loss of the natural powers, and even of the very elementary parts of the body, is repaired by fresh and repeated supplies of food.

§ 333.

To the acquisition and use of this food we are forcibly led by the frequent and irresistible calls of *nature*. These calls, though widely different from each other in their natures, tend notwithstanding to the final accomplishment of the same end: they consist, on one hand, of the insupport-

able torments of *hunger* and *thirst*; and on the other, of the very pleasing, but no less powerful, allurements of *appetite*.

§ 334.

The stimulus of *hunger*, some physiologists have sought for in the mutual friction between the rugæ of the stomach when empty; others in that which appears, indeed, to be of primary importance in giving birth to this potent sensation, namely, not only in a more copious secretion and afflux of the humours discharged into the first passages, more especially of the saliva, the pancreatic juice, and the bile, but also in a certain degree of morbid acrimony, with which these same humours are apt to be contaminated, unless such a state be guarded against by regular supplies of nourishment.

§ 335.

Thirst is a distressing sensation, arising principally from a very troublesome dryness of the fauces and œsophagus; and also from a peculiar impression produced by taking in acrid, but more especially saline, substances.

§ 336.

With respect to the absolute *necessity* of satisfying and removing these stimuli, no fixed and positive rule can with propriety be laid down, as such
necessity

necessity is doubtless rendered more or less urgent by varieties in age, habit of body, and more especially by the power of custom. From a general consideration of this subject, however, the result appears to be, that an adult and healthy person, who is under no undue impressions or influence, (in whom, for instance, those assuasive calls of nature are neither silenced by the louder ravings of enthusiastic fanaticism, nor by other preternatural causes) cannot refrain from the use of food, for even one whole day, without a very great prostration of strength; and can seldom fast for more than eight days without incurring the utmost hazard of life.

§ 337.

With regard to *drink*, although a desire for this appears to urge with the greater vehemence and intensity of the two, it is, notwithstanding, much less necessary to life and health than the article of *food*. This we infer, with apparently strict propriety and truth, not only from numerous species of warm-blooded animals, as mice, quails, &c. that are never impelled by necessity to the use of drink, but also from actual examples of certain individuals of the human race, who have continued, through a long series of time, in the enjoyment of life, health, and spirits, without recourse to the use of drinks of any kind.

§ 338.

As to *food*, controversies have existed respecting the kind most proper to satisfy the internal calls of our nature: whether, for example, the structure and constitution of the human body correspond most perfectly with food taken from the animal, or with that derived from the vegetable kingdom; and which of these two kinds of substances nature, therefore, designed to constitute the aliment of man?

§ 339.

That man is by nature an herbivorous animal, Rousseau attempted, with a great degree of acuteness, to prove, not only by arguments taken from the figure of his teeth, and the length of his intestines, but by the further consideration, that woman is naturally uniparous, and furnished with two mammæ, &c.; to all which might be added, actual examples of rumination having been performed by human subjects, a process well known to belong exclusively to herbivorous animals.

Those, on the contrary, who, with Helvetius, consider man as a carnivorous animal, attempt to support their opinion by the shortness of his *intestinum cæcum*, and other arguments of a similar nature.

§ 340.

But from more accurate observation, and a more minute investigation of the subject, it appears, that nature did not intend to restrict man to the exclusive use of either the one or the other of those kinds of *aliment*, but more indulgently destined him to a free participation of both. That this is indeed the kind destination of man with respect to the nature of his food, we very naturally infer from his teeth, especially the *molars*, and the conformation of his intestines, briefly mentioned above, possessing a middle state between the same parts, as they exist in carnivorous and in herbivorous animals. This prerogative of man is, however, still more forcibly demonstrated, by the nature of the articulation which connects the condyles of the lower jaw to the *ossa temporum* in human subjects.

§ 341.

If the observations be true (and they surely cannot be doubted) which we stated on a former occasion, respecting the high privilege of man, in being by far better calculated than other animals for traversing an extensive range of climate on the globe we inhabit, it from thence spontaneously follows, that he would have been indeed very illy accommodated, in being solely restricted either to the one or the other of the above kinds

of food: for as some regions of the globe afford *animal*, and others *vegetable* food alone, the obvious and unhappy result of such an exclusive restriction would have been, that man, though calculated and destined to reside in all latitudes of the earth, must, notwithstanding, in some of them, be denied the use of such aliments as nature had rendered essentially necessary to the continuation of his existence,

§ 342.

Of all animals, with which we are in any measure acquainted, man may, with the strictest propriety and truth, be said to be *omnivorous*. As on the one hand he is calculated to banquet in luxury, amidst the most profuse variety of delicacies that art can prepare from the immense resources of the animal and vegetable kingdoms, so, on the contrary, he is able to retain his health and vigour when subsisting on the most simple and frugal fare.

Thus, to produce only a very few examples, a great many men even at the present day subsist solely on a vegetable diet, such as potatoes, chestnuts, dates, &c. which constituted also the food of the first progenitors of the human race: for it appears highly probable, that those simple and hardy sons of nature, supported life first by the fruits and

roots

roots of plants, and afterwards, by the more substantial and durable fare of grains and pulse.

Some of the Moorish tribes in Africa live almost entirely on the gum fenegal.

The inhabitants of Kamschatka and of a great many other maritime situations subsist on fish.

In Europe itself, the *Morlachi* are supported almost entirely on a diet of flesh.

Some nations of Barbarians subsist even on raw flesh, a circumstance which is undoubtedly true, with respect to the Samoids, the Esquimaux, and certain tribes of people inhabiting South America.

Neither are the liquids made use of as drinks, in certain nations, less singular and striking.

Thus the inhabitants of several islands, which lie between the tropics, more especially those situated in the Pacific Ocean, are entirely destitute of sweet and pleasant water, and therefore, as a substitute for this fluid, use the delicious juice of the *lactescent cocoa*.

Others again drink the waters of the briny ocean;—from all which facts and circumstances,

taken collectively, together with an infinitude of others that might be adduced, we need not hesitate a moment to pronounce, that man is literally an *omnivorous animal*.

SECT. XXVII.

OF MASTICATION AND DEGLUTITION.

§ 343.

FOR the purpose of masticating the more solid species of food, both our under, and upper jaws, are armed with *three* different kinds of teeth.

These are *first*, the *incisores*, which, in most men, are chisel-formed, and well calculated to bite off morsels of food.

Secondly, the *canini*, strong, conical and completely adapted for breaking substances of greater firmness.

And *lastly*, the *molars*, of different sizes, exquisitely fitted for the process of grinding.

§ 344.

The mandible or lower jaw is connected to the other parts of the head, by means of a very singular variety of articulation, which appears to be of a middle nature between *arthroida* and *ganglimus*. Being furnished with a pair of double concave cartilages, it thus unites, to a sufficient degree of strength and firmness, a capacity of being easily and very considerably moved in all directions.

The under jaw is drawn back, in opening the mouth, chiefly by means of the *musculus biventer*, but in part also by the *geniohyoidei* and the *mylohyoidei*.

It is brought back again, when we attempt to cut any thing through with the *dentes incisores*, and pressed with astonishing force against the opposite jaw, during our efforts to crush any hard substances, by the *masseter* and *temporal muscles*.

It is moved laterally in chewing, by the action of the internal and external *pterygoid muscles*; the latter of which have also the power of moving it in a forward direction.

§ 345.

Substances taken into the mouth for the purpose of being chewed, are retained, placed in a proper situation, and thus effectually subjected to the action of the teeth, by means of the *musculus buccinator*, and the tongue, an organ of extreme flexibility, and very capable of changing its form (§ 233).

§ 346.

During the act of manducation we emulge, as it were, a certain quantity of *saliva*, which is an aqueous liquid, of a nature somewhat saponaceous; it contains a small quantity of earthy matter, (which gives origin to tartarous incrustations of the teeth, and to small sublingual calculi); this fluid, from being in perpetual contact with the tongue, makes no sensible impressions of taste on that organ, although it contains a small quantity of microcosmic salt; it possesses antiseptic and resolvent properties, and has also a power of speedily exciting the process of fermentation in vegetable substances, especially in those of the farinaceous kind.

§ 347.

The sources from whence this fluid is derived are, small conglomerate glands, of three several orders,

orders, the lateral and internal, of which are situated beneath the lower jaw.

The most considerable of these glands, called *parotids*, (remarkable, on account of being extremely subject to metastases), excrete their saliva through the Stenonian duct, just behind the middle molar tooth of the upper jaw.

The saliva furnished by the *submaxillary* glands, is discharged through the duct of Wharton.

That derived from the *sublingual* glands, which are the least of all, flows through the numerous ducts of Rivinus.

§ 348.

The excretion of saliva, (of which, in conformity to the opinion of Nuck, about a pint is commonly supposed to be secreted in the space of twelve hours), is considerably increased both by the application of any stimulating substance, and also by mechanical pressure, the latter of which appears to act merely by emulging the containing parts.

Thus, whatever hard substances we chew, become perfectly moistened and macerated, as it were, by a copious afflux of saliva produced in
confe-

consequence of the pressure, to which the *parotids* are particularly exposed from, being situated so near to the articulation of the lower jaw.

With regard to the operation of stimuli on the secretion of this fluid, it is necessary farther to observe, that when acrid substances are taken into the mouth, a plentiful afflux of saliva is immediately produced, which has the effect of diluting and thus effectually counteracting the irritating acrimony: an increase of the same fluid is also occasionally produced by the stimulus of the imagination; to this cause must we refer that afflux of saliva, which so frequently accompanies a strong appetite for food.

§ 349.

With the saliva are blended a fine aqueous, dew-like fluid, which transudes from the soft parts of the mouth, and also a mucus, secreted by small glands, situated in the lips and cheeks: it is a portion of this mucus by which the tongue is lubricated.

§ 350.

The morsel during mastication, being thoroughly moistened by this mixture of saliva and other animal juices, is thus, not only converted by degrees into a soft pulpy bolus, more fit for the purpose

pose of deglutition, but is likewise prepared, at the same time, for further digestion and final assimilation.

§ 351.

The actual business of deglutition, although it appears to be of a very compound nature, and is indeed performed by the co-operation of a great many different parts, may be considered as commencing and proceeding in the following order; viz. the tongue being first retracted towards its basis, and becoming therefore somewhat turgid and stiff, receives on its excavated *dorsum* or back, the lubricated and moistened bolus, which is from thence forced onwards into the fauces, where it is received by the expanded *infundibulum* of the *pharynx*, which appears, at the same time, to advance somewhat upwards; on the reception of the food the *infundibulum* makes a singular and violent exertion, which may be supposed to proceed from a species of *vita propria*; from this funnel-like entrance, the bolus is again protruded onward, by a threefold contraction of the *pharynx*, into the *oesophagus*. All the above motions succeed each other with the utmost degree of rapidity, and are of extremely short continuance.

§ 352.

For the purposes of expanding this passage, and rendering it at the same time steady and secure,
nature

nature has made the most ample provision by a variety of auxiliary parts.

The motion of the tongue, in this momentous business, is regulated and directed by the os hyoideum.

To prevent any of the substances swallowed, from passing, by mistake, either into the internal nares, or into the eustachean tubes, the soft palate is very wisely provided. This fleshy curtain, depending equally from the arched roof to which it is attached, is capable of being rendered tense by the action of a peculiar set of muscles, and thus the above passages may be completely closed.

The *glottis* is securely guarded by the tongue itself, because at the very instant in which we attempt to swallow, the larynx, being drawn upward and forward, is in a certain degree concealed beneath the retracted basis of the tongue, and is so compressed by it, that the glottis, not only by this constriction, but also by the additional security of the epiglottis, is thus very effectually guarded against the intrusive entrance of any heterogeneous substances.

§ 353.

Finally, the business of deglutition is greatly facilitated by means of a quantity of mucus, with
which

which the whole of the passage above described is lubricated; and which, besides the lingual glands already mentioned (§ 235), is chiefly furnished by the numerous sinuses of the tonsils, and by that infinitude of mucaginous *cryptæ*, so profusely bestowed on the larynx itself.

§ 354.

With respect to the *œsophagus* itself, through which all substances swallowed must necessarily pass, previously to their entrance into the stomach, it is a fleshy canal, rather narrow in its diameter, and exceedingly firm and strong, but at the same time pliable, dilatable, and possessed of a high degree of sensibility: it is composed of tunics or coats, which, if we except the difference in their thickness, bear no small resemblance to the coats of the other portions of the alimentary canal.

Thus, the external covering is muscular, made up of fibres running both longitudinally and in transverse or circular directions.

The middle coat is nervous, ending on each side in a very lax cellular membrane, by means of which it is connected, as well to the preceding, as to the subsequent tunic.

Lastly,

Lastly, the internal coat is lined by mucus of an exquisite degree of lubricity.

§ 355.

The following appears to be the mode in which this canal performs its office ; as soon as it has received either a draught or bolus completely within its *parietes*, the parts immediately above presently contract themselves, thus forcing downwards the substance to be swallowed ; which, if it be a bolus, can be protruded onward only by one uniform series of exertions in the surrounding tube, till it has passed through the diaphragm, and been finally received into the cavity of the stomach itself.

SECT. XXVIII.

OF DIGESTION.

§ 356.

THE chamber, or immediate seat of digestion, is the *stomach*, a viscus more uniformly possessed than any other, by almost every individual throughout the immense range of *animated nature* : if, therefore, we estimate the dignity of the several viscera from this circumstance alone, the stomach is, doubtless, to be considered as an

I

organ

organ surpassing all the others in utility and importance to the animal economy.

§ 357.

The human stomach resembles a leathern pouch, of very considerable dimensions, sufficient, for the most part, in an adult, to contain three pints, or more, of water, and furnished with two separate orifices or mouths :

These are, *first*, a superior orifice, called *cardia*, which is formed in the place where the œsophagus, by a plaited and somewhat oblique aperture, opens into the stomach itself, and points towards the bottom of this viscus, or that extremity which regards the left side of the body.

Secondly, an *inferior* one, which constitutes the termination of the right, and less capacious end of the stomach : this orifice is called *pylorus*, and descends a short distance into the cavity of the adjoining duodenum.

§ 358.

The situation of the stomach, when empty, is different from that of the same organ, when full : thus, in the *former* state, it hangs loose and flaccid in the abdominal cavity, in such a manner that its greater curvature looks in a backward direction ;

and its pylorus, being turned somewhat upwards, forms a plaited or twisted angle with the duodenum, to which it is connected.

But in the *latter* state, when distended with food, its greater curvature is again turned, and looks in an anterior direction, so that the pylorus enters now, by a more direct route, into the duodenum; whereas the cardia, on the contrary, is so folded and bent as to be completely closed.

§ 359.

The stomach is composed of four principal coats, distinguished and separated by three others, of an entirely cellular nature, which lie between them.

The most *external* of these coverings is common to the stomach, with all the rest (save a small portion) of the alimentary canal, and is continued over the *omenta*, which shall be spoken of hereafter.

Next to this, lies that *cellulo-muscular* coat, so very striking in its nature and properties, on which depend both the exquisite *irritability* of the stomach (§ 306.), and also its peristaltic motion; the latter of which shall be a subject of consideration in another place. This coat is composed of different

ferent strata of muscular fibres, which are usually divided into three orders, one longitudinal, and two circular; the circular fibres are again divided into those that are *directly*, and those that are *obliquely*, circular. It must, however, be observed, that so extremely variable and irregular are the fibres of this coat, with regard to their direction and distribution, as scarcely to admit of reduction to, and arrangement under, any determinate and general rules.

The third principal coat is called the *nervous*, an appellation extremely improper, as it is composed wholly of condensed cellular membrane, becoming gradually more soft and lax on each side; by which means it is connected externally to the muscular, and internally to what we shall presently call the *villous*, coat. It is, notwithstanding, so firm and robust, that it may be aptly enough called the *basis* of the whole stomach.

Lastly, the *internal* coat, which has been very improperly called *villous*, is exceedingly tender, somewhat spongy, porous, and folded into a very great number of rugæ or wrinkles, so that its area is much more extensive than that of any of the other coats which we have just described: it every where exhibits cells of the utmost minuteness, some-

what similar in appearance to those larger ones, with which the *reticulum* of ruminating animals is very beautifully and elegantly characterized.

The internal surface of this coat is lined with mucus, apparently secreted by small mucaginous cryptæ, some of which may be, indeed, readily enough distinguished near to the *pylorus*, or lower orifice of this organ.

§ 360.

The stomach is furnished with an astonishing apparatus of nerves, whence its sensibility is so exquisite, that it is capable of being very readily affected by stimuli of almost every kind, whether they be *external*, as cold &c. or *internal* as food, and even by the iniquine humours themselves. From the same source arises also that extensive, and truly admirable consent, which exists between this important viscus and most of the other functions of the body; to which head belongs, in a particular manner, the striking effects, produced on the stomach, by all mental commotions, and also, on the other hand, the very powerful influence of an entirely sound and healthy state of this organ, on the cheerfulness and serenity of the *mind*.

§ 361.

The number and functions of the *blood vessels*, belonging to the stomach, are no less considerable and striking, than those of the *nerves*. The small arteries, (of which an infinitude of different orders, are minutely interspersed throughout the cellular coats of this organ), appear to constitute the immediate sources of the *gastric juice*, a liquor which flows in perpetual streamlets from the internal surface of the stomach.

§ 362.

This juice bears, on the whole, no small resemblance to saliva, except that, agreeably to the experiments of the illustrious Spalanzani, its *powers* are counter to *those* which promote fermentation. As to the rest of its properties, it is saponaceous, equally antiseptic with the saliva, and is indeed, a very powerful menstruum, sufficient gradually to dissolve milk after it has been gently coagulated in the stomach.

§ 363.

The gastric juice appears to be the most powerful and active agent in the great business of digestion. If the *food* be carefully masticated, and sufficiently blended with the menstruum furnished by the salivary glands, this fluid of the stomach com-

pletely dissolves, and finally converts it, into a soft pultaceous chyme.

§ 364.

This momentous function is also further aided and promoted, by a variety of accessory and assistant powers: of these the most considerable is the *peristaltic motion*, by means of which the food, now reduced to a pulpy consistence, is thoroughly agitated, and kept perpetually in a state of wavy commotion. Although the force of the peristaltic motion fall far short of the chimerical calculations, formerly made on this subject, by mathematical physicians, and although it be not itself the sole cause of digestion, it is, notwithstanding, of the utmost efficacy and influence in this important process.

§ 365.

Among the auxiliary powers, of this kind, may be also reckoned another species of motion, which the pressure of the surrounding parietes of the abdomen, communicates to the stomach: to these we may still farther subjoin, the extreme warmth of the situation in which this viscus is placed; so very powerful was this *fotus* or bath, formerly esteemed, in consequence of the abundant quantity of blood contained in the neighbouring vessels
and

and viscera, that instead of the term *digestion*, that of *coction*, was used by the greater part of physiologists.

§ 366.

To determine, with precision, the period of time requisite for the *conversion* of our aliment into chyme by the joint co-operation of the foregoing powers (§ 361.), will appear almost impossible to any one, who may consider the great variety of circumstances, on which such conversion must depend: these circumstances are, the quality and quantity of the food taken in, the different degrees of force in the digestive powers, the greater or less attention and care bestowed on the preparation of the food for digestion, by previous mastication, &c.

For in a healthy subject, the unimpaired stomach does not discharge such alimentary matters as have been taken in, previously to the conversion of their digestible parts into a perfect pulp. From whence it is evident, that different periods of time are requisite, for the complete digestion of different kinds of food. If, however, it be allowable to form any general conclusion on this subject, it would appear, that from the third, to the sixth hour, after the use of aliment, the stomach has, for the most part, discharged through the pylorus,

in a very gradual manner, the whole of its pul-
taceous contents.

§ 367.

The pylorus is an annular rim, not formed, (like the other rugæ on the internal surface of the stomach), by the folding of the villous coat alone, but consisting, in part, also of a few *fasciculi* from the subjacent *nervous*, and also of certain fibres from the *muscular*, coat: all which parts are so organized and arranged, as to constitute a coniform termination to the stomach, that is extended into, and embraced by, the duodenum, in the same manner as the *os uteri* is received and embraced, by the superior part of the vagina.



SECT. XXIX.

OF THE PANCREATIC JUICE.

§ 368.

SUBSEQUENT to the expulsion of the chyme through the pylorus, that pulpy mass must be subjected, in the duodenum (a short, but remarkable portion of the intestinal tube), to new and considerable changes, previously to the formation

mation and final separation of complete, alimentary chyle. These necessary changes are effected in the chyme by the accession and admixture of various kinds of inquiline humours, the most striking and important of which, are, the *bile* and the *pancreatic juice*.

§ 369.

Of these two humours, we will speak in separate sections. We proceed therefore, to consider the liquor of the pancreas first, because it appears to bear a very considerable resemblance, both in its nature and uses, to those other two dissolvent humours, of which we have already spoken, namely, the saliva and the gastric fluid.

§ 370.

Although it be indeed a matter of no small difficulty, to procure the pancreatic liquor of a sound animal, in a pure and unadulterated state, yet the obvious and unequivocal result of all the facts, which the most attentive investigation has been able to supply, with regard to its nature, is, that it bears the strongest similitude to the saliva in all its general properties. Were it not for the purpose of showing how mischievous, and even destructive, the practice of medicine may become, unless directed by sound principles of physiology, I should not think it necessary nor even proper, at the

the present enlightened period, to mention the erroneous physiological hypotheses, entertained by Franc. Sylvius, and his humble followers, Regn. de Graef, Flor. Schuyl, and others, respecting the visionary or supposed acidity of the pancreatic liquor, especially as those opinions have been long since very ably refuted by *Pechlin*, Swammerdam, and Brunner, characters of the first celebrity in the annals of medical science.

§ 371.

The sources from whence the lymph and saliva are derived, bear no small resemblance to that which constitutes the subject of our present consideration, namely, the *pancreas*: this latter is by far the largest of all the conglomerate glands of the human body, and exhibits, in the whole of its structure, a very striking similitude to the glands, that give birth to the salivary fluid; with these last mentioned bodies it also further agrees, in this particular, that its excretory canals, arising from radicles of the utmost minuteness, run together and unite by degrees, till they constitute finally a common duct, which has received its name from Jo. G. Wirsung, who first discovered and demonstrated it in the human subject, in the year 1642.

This

This duct passes through the coats of the duodenum, and by a constant *stillicidium*, weeps into the cavity of that intestine, the fluid it had received from the gland to which it is appended.

§ 372.

Finally, the excretion of this fluid appears to be promoted by the very same powers, which were formerly said to be subservient to the excretion of saliva, namely, *pressure* and *stimulus*.

By means of the former, it is emulged chiefly when the stomach is distended and rests immediately on the pancreas.

The substances that contribute most, by their irritations, to excite a discharge of the pancreatic fluid are, first, the chyme itself, as it passes through the pylorus in a crude and unassimilated state; and secondly, the bile, which is discharged through the very same orifice with the liquor of the pancreas.

§ 373.

The use of this fluid is doubtless to dissolve the chyme, more especially that part of it, which has not been sufficiently digested in the stomach: by its abundant afflux, it contributes to assimilate this
pulpy

pulpy mafs ftill more and more to the nature of the inquiline humours, and thus finally mature it for the further procefs of chylication.

SECT. XXX.

OF THE BILE*.

§ 374.

THE fecretion of bile is the peculiar deftination of the *liver*, the largeft and moft ponderous vifcus in man. This fuperiority of fize is more efpecially obfervable, during the fœtal

* Doctör Maclurg, of Virginia, publifhed in the year 1772, an experimental treatife on the formation, the nature and the ufes of the human bile, which has acquired for its learned and ingenious author, no fmall degree of reputation both at home and abroad. That this elaborate publication poffeffes an uncommon fhare of merit, not even the avowed enemies of the Doctör are themfelves able to deny. The author has fhewn himfelf to be, at leaft, a very patient experimenter, and an extremely attentive obferver. He appears to have made himfelf perfectly mafter of the opinions of all authors of celebrity and diftinction, who had previously written on the fame fubject. With regard to the literary merit of the compofition itfelf, it is doubtlefs entitled to the higheft encomiums that even the moft partial eulogift can beftow. The
order

state, in which, the younger the fœtus the greater is the proportional magnitude of the liver, when compared with that of the other viscera of the

order is inimitably lucid, the style is chaste, manly and nervous in the highest degree, and as to closeness and propriety of argumentative arrangement, not even the supercilious logician himself, can find room to suggest the shadow of an amendment.

All human compositions are, however, like the sources from whence they originate, in some measure faulty and imperfect. To this general maxim, humiliating as it may appear to the pride of the self-adoring philosopher, the treatise of the illustrious Maclurg is by no means an exception. In several of the Doctor's experiments there appears to be a want of sufficient accuracy and definitude, in others a want of object and design. Over these faults, however, considerable as they are in the works of an experimentalist, we feel inclined to spread a kind mantle of palliation, when we recollect that our author experimented and wrote in the early morn of scientific chemistry. Experimenters had not yet become perfect adepts in their nice and momentous art; they had not yet acquired sufficient circumspection and address to obviate every source of fallacy, and to avail themselves of every circumstance that might pave the way to satisfactory and unequivocal results.

But another charge of a more weighty and important nature, lies against our learned and ingenious author. He has certainly built, on nothing more substantial than the flimsy basis of deceptive analogy, some of the leading principles of his favourite doctrine. Thus, for example, he supposes the
bile

body. The dignity and high importance of this viscus in the animal economy may be fairly deduced, from the universality of its presence; thus

bile to be a fluid, the direct result of a putrefactive degeneration in a portion of the circulating volume of the blood. His most plausible reasons in support of this opinion are, *first*, that the parts, from whence the incipient radicles of the vena portarum immediately originate, contain, and communicate with, matter already in a semiputrescent state. And *secondly*, that the bile is most abundant in quantity and most active with regard to its quality, at that season, and under those circumstances, which are most favourable to the commencement and progress of putrefaction in the living system, as well as in all other physical bodies.

Plausible as those arguments may, on first view appear, they are certainly, as already observed, founded on nothing better than fair, but fallacious analogy. The principle which they tend to establish stands in the most direct opposition to the result of experiment—sacred experiment! the only unerring guide to conduct the candid enquirer to the everlasting temple of truth. Did our learned author (I would beg leave to ask) ever faithfully experiment on separate portions of the blood, drawn from different parts of the body, in order to determine the comparative proximity of each portion, to the putrefactive state? I presume he never did, otherwise his opinion on this subject would have been, doubtless, very different from what we find in his ingenious publication. For it is a truth, nothing the less sacred and respectable on account of its novelty, that if equal quantities of blood be taken from the *vena portarum*, and from the lungs or any part of the arterial system, and exposed to the same incumbent circum-

in all animals possessing red blood, it exists no less generally and uniformly than the heart itself.

circumstances, the *pulmonic* or *arterial*, will assume the putrefactive process, much sooner than the *hepatic*, blood. The cause of this phenomenon must be sufficiently obvious to any one acquainted with the late discoveries, in the divine science of chemistry. We would attempt its solution in the following manner.

Vital air (which is indeed the genuine septic principle, if any such principle exist) is in all cases essential to the progress of putrefaction. This air, or rather its base (termed oxygene by the ingenious chemists of France) is, as we have the strongest reasons to believe, from the experiments of Goodwyn, Beddoes, Girtanner, and others, intimately blended with the circulating blood in its passage through the lungs. As the blood proceeds in its mazy route through the different parts of the arterial system, it is gradually robbed of its concomitant oxygene or base of vital air, by the mysterious action of the animal system. The consequence of this spoliation is, that the florid *arterial*, assumes a much darker colour, and suffers finally a complete transmutation into *venous* blood. In this latter state the putrefactive process is less apt to commence, because the blood contains less oxygene in a state of intimate mixture, or perhaps I might with more propriety say, in a state of combination. For in proportion as the base of vital air is more intimately blended with, and therefore more nearly approximated to, the constituent parts of the blood, the more powerfully can it co-operate with other auxiliary agents, in inducing *these parts* to assume that intestine motion, which constitutes the putrefactive process. Although our learned author is decidedly of opinion, that putrefaction commences more readily, if vital air be excluded altogether from

§ 375.

The substance of the liver is of a nature, *sui generis*, and may be readily distinguished, at first

from the putrefying substances, yet it is now well known, that the very reverse of this is true. Exclude vital air from a body, in the composition of which none of this energetic fluid exists, and you thereby embalm that body in a degree equal, if not superior to the embalmment of the unperishable mummies of the East.

No body, whatever, is capable of taking on the putrefactive process, that does not contain in its composition more or less of those simple substances that belong to the class of *inflammables*. Reasoning therefore *a priori*, or climbing the arduous steeps of science by the more laborious steps of experiment and observation, we are warranted in either case to conclude, that putrefaction consists, in a very considerable degree, in the intimate combination of the base of vital air to certain substances of an inflammable nature. Both the primary elements of which putrescible bodies are composed, and also the results of actual putrefaction, co-operate in the establishment of the same conclusion.

It is certainly a truth, that vital air is as essential to the putrefactive process as it is to the support of combustion, or the continuance of animal life.

Upon the whole, we may without the smallest hesitation conclude, that the former opinions of physiologists respecting the supposed putrescent disposition of the hepatic blood, are wholly insupportable by argument or fact, being indeed directly opposed to the literal result of positive experiment;

sight, from that of all the other viscera of the body : it consists of a parenchyma of a well known colour and very tender texture : this parenchyma is abundantly supplied with nerves, with lymphatic vessels (very visible on both surfaces), with biliferous ducts, and finally with blood-vessels, from whence these ducts originate : with respect to these blood-vessels, some of which are remarkably large, we will immediately state a few observations on each of their several orders.

§ 376.

The first vessel which here presents itself for our consideration is, the *vena portarum*, which differs very widely from every other portion of the venous system, not only in its singular appearance, but also in the peculiarity of its course and distribution, of which a few words were spoken on a former occasion (§ 37). This large vessel is formed by the conflux of by far the greater number of the venous branches that originate and run from the viscera, situated in the lower part of the abdomen, and is invested and strengthened by

and therefore, that the pious eulogia so profusely bestowed on the powers of the animal economy, in being able to form an *antiseptic* out of a highly *putrescent* fluid, appear to be as visionary and hypothetical, as *nature's* final intention in the preparation of this fluid was thought to be beneficent, and her process itself beautiful, and interesting.

a cellular covering, commonly known by the name of *capsula Glissonii*. No sooner does this trunk make its entrance into the liver, than it is divided into several branches, which as they run in various directions through its substance, suffer still farther divisions, till they are finally increased to a countless number of the most subtle ramifications, which pervade, with the utmost minuteness, every portion of this viscus. This whole system of the vena portarum was formerly compared, by Galen, to a tree, the roots of which are dispersed throughout the whole cavity of the abdomen, while its branches are enclosed in the more contracted volume of the liver.

§ 377.

Another blood-vessel of a different kind, with which the liver is furnished, is the *arteria hepatica*. This vessel originates from the cæliac artery, and although far inferior to the vena portarum, both in its capacity and in the number of its branches, is, notwithstanding, divided into ramifications of astonishing subtilty, and is also distributed with a great deal of minuteness throughout every part of the liver.

§ 378.

The extreme terminations of both the foregoing kinds of vessels, end in genuine veins, which gradually

gradually uniting, form by their general conflux, certain large venous trunks, that lose themselves finally in the inferior *vena cava*.

§ 379.

Those extreme terminations, by which these small branches of the *vena portarum* and *arteria hepatica* become radicles to the *vena cava*, form a very subtle vascular texture, exhibiting a singular and striking appearance, as if the vessels were convoluted, or wound up into globes of inconceivable minuteness. These globular bodies imposed so effectually on Malpighi, as to induce that illustrious physiologist to consider them as glandular, hexagonal, and hollow kernels, destined to constitute the immediate chambers of secretion.

§ 380.

From those same globular convolutions of blood-vessels arise, lastly, the *pori biliarii*. These are very tender ducts, which convey the gallish liquid from the blood, and completely eliminate the same from the system of the liver, through the *ductus hepaticus communis*, a canal which they form by their general conflux.

§ 381.

It is common for physiologists to enquire, from what kind of blood the bile is immediately

secreted ; whether from arterial, or from that contained in the *vena portarum* ?

Although the former of these opinions appears, on the first view of the subject, to be rendered most probable from the analogy of other secretions, which are evidently the result of arterial action, yet from a more accurate investigation of the matter we will readily be convinced, that by far the greater part, if not indeed the whole, of the biliary secretion, is derived from the *vena portarum* : the blood of this vessel being lurid, and highly impregnated with phlogiston, corresponds precisely with the nature of the bile ; but how extremely different, on the other hand, are the habit and constitution of the florid and fiery arterial blood, which the *cæliac* artery transmits from the aorta immediately to the liver !

With respect to arguments drawn from analogy we may observe, that as the *vena portarum* is subjected to an arterial distribution, so it may, in like manner, possess the power of performing an arterial function : this same opinion, for which we contend, appears also to derive additional support from the analogy which exists between the liver and the lungs : to perform the leading function of these last mentioned viscera, is doubtless the immediate destination of the large pulmonary arteries ;
 whereas,

whereas, on the other hand, the bronchial artery is only subservient to the nourishment of the parts, on which it is distributed :—the discharge of an office, similar to this latter, is also, if we be not greatly deceived, the more immediate destination of the *arteria hepatica*. Notwithstanding what we have here advanced, we are still ready to acknowledge, that the hepatic artery may possibly contribute somewhat towards the secretion of bile ; but, that its influence, in this respect, is indeed very inconsiderable, and not yet sufficiently ascertained and demonstrated, are positions to which we subscribe with the utmost confidence.

382.

The biliary *hepatic liquor*, when once secreted, flows in a gentle but uninterrupted streamlet through the *hepatic duct* ; and, when the *intestinum duodenum* is empty, glides directly onward, through the common *ductus choledocus*, into the cavity of that viscus ; but when the duodenum is distended with chyme, it becomes necessary for this fluid to pursue a different route, whence it regurgitates from the *hepatic*, and flows through the *cystic duct* into the gall-bladder, where it is retained a certain time, and thence derives the name of *cystic bile*.

§ 383.

The *gall-bladder* is an oblong sack, somewhat pyriform in its figure, attached to the concave superficies of the liver, and composed of three membranes or coats.

These are, first, the *external*, which does not invest the whole of the cyst, and is derived from the peritoneum.

Secondly, the *middle*, usually called the nervous coat, which, as in the stomach, the intestinal tube and the urinary bladder, constitutes here likewise the principal part of the tone and firmness of the sac.

And, lastly, the *internal*, which bears a certain similitude to the internal membrane of the stomach (§ 359.); like that it is interspersed with an infinitude of minute blood-vessels, and like that it is also marked by rugæ or wrinkles, which form, here and there, fine net-like checkerings, that exhibit the appearance of the most exquisitely elegant lattice-work.

§ 384.

The neck of the gall-bladder is conical, and forms, by its termination, the *cystic duct*, which pursues

pursues not a direct, but somewhat circuitous or serpentine route, and is furnished with a few minute valves of a lunated or falciform figure.

§ 385.

The gall-bladder retains the bile, when once received, till that liquor either flows out spontaneously, in consequence of being favoured by a reclined and somewhat supine position of the body, or till it is emulged from the cyst by the pressure of the neighbouring intestines, namely, the *jejunum* and *ileum*, or by the occasional passage of hardened fæces through the transverse colon.

Different stimuli acting on the duodenum have also the effect of solliciting a more copious effusion of bile into the cavity of that intestine.

The remarkable *contractility* of the gall-bladder, evidenced and satisfactorily established by live dissections and certain pathological phenomena, (although this sac be indeed completely destitute of all genuine *irritability*), (§ 307.), will appear to contribute, not a little, to the excretion of the bile; especially when we consider the stimulant impression which this fluid, after retention in the cyst, must make on its surrounding *parietes* or walls.

§ 386.

For although the *cystic* exhibits, in its general properties, the most striking similitude to the *hepatic* bile (§ 382.), it is notwithstanding concentrated, as it were, by rest and stagnation, and thence rendered more tenacious and bitter: this effect appears to be owing, in a particular manner, to the lymphatic vessels of the cyst, which slowly absorb the aqueous parts of the bile, while thus enclosed and retained in a quiescent state.

§ 387.

We proceed now to the consideration of the bile itself. This is an animal fluid of the highest dignity and importance in the living system: its nature and uses have, for twenty years past, laid a foundation for more literary controversies among physiologists, than have existed respecting any other fluid that belongs to the body of man.

What we shall advance on this subject will relate immediately to the *cystic* bile, as this is to be esteemed the more perfect of the two, and is therefore in a state more favourable for successful investigation.

§ 388.

Bile, taken from the recent corpse of an adult subject, who had not previously laboured under
any

any disease, is a liquor somewhat viscid, of a faint green colour, inclining towards a brown, inodorous, and, if compared with the gall of brutes, of a slightly bitterish taste.

§ 389.

Although the constituent parts of this fluid neither separate from each other spontaneously, nor yet by so simple a mode of treatment as is sufficient to produce that effect on the parts that compose the blood, they may, notwithstanding, be subjected, without much difficulty, to such an examination as will make it appear, that they doubtless possess and exhibit a certain analogy to the elementary parts of the blood, though this analogy should not be pursued to too great an extent.

The bile contains, in the first place, an aqueous menstruum, which has been denominated by some late physiologists, its *salivary* part: this may be aptly enough compared to the aqueous portion, and resembles also, though not in every particular, the serum of the blood.

From the bile we can also separate and procure a small portion of a white and grumous substance, which may be said to possess a certain, though remote resemblance to the plastic *lymph* of the blood.

Finally,

Finally, the most striking and important principle which the bile contains is the *matter of phlogiston*, derived in large quantities from the blood of the vena portarum, which is highly impregnated with this subtle element.

§ 390.

This active inflammable part evidently manifests its existence in dried bile, but more especially in gall stones, by bursting immediately into flame, when placed in contact with a burning substance. To the action and influence of this principle must we attribute those striking and singular qualities, formerly enumerated, such as colour, taste, &c. which serve to distinguish the bile from the other inquiline humours belonging to the system; and from the same source must we also derive the other remarkable properties of this fluid, which shall be mentioned hereafter.

§ 391.

The bile is not of such a nature as to possess, like soap, an equal affinity to oil and water, and thus serve to mix and intimately combine these two elements together. The contrary opinion (which was erroneously entertained on this subject by Boerhaave, and afterwards by Schroder) was formerly invalidated and refuted by certain remarkable experiments of my own (since confirmed
and

and further increased by other writers), and is now entirely repudiated by the greater number of physiologists. On the other hand, if bile be applied to the two foregoing elements, i. e. oil and water, when in a state of intimate mixture and combination, it produces an evident disunion and separation of them from each other. This fluid possesses indeed no alkaline properties, but is, notwithstanding, equally unfriendly to the existence of acid acrimony, to fermentation, and to putrefaction.

§ 392.

By considering with due attention the foregoing observations, we may easily ascertain the true, the important, and the diversified uses of the bile, in the process of chylification.

For in the first place, from that equable and uniform chymous pulp which the stomach has discharged into the duodenum, which the pancreas has diluted by an effusion of its own juice, and which moves spontaneously onward to the cavity of the small intestines, it gradually precipitates the fæces, and thus separates from them that cream-like fluid denominated *chyle*.

The bile itself suffers, at the same time, a division into two parts, the one aqueous, the other phlogistic. The latter part adheres to the fæces, rings them, and is afterwards discharged, along with them, out of the body ; whereas the former appears to be mixed with the chyle, and re-conducted back to the mass of blood.

Thus the abundant phlogiston, now become troublesome and noxious to the blood, is first directed to the liver, where it is rendered subservient to the formation of a singular and very important humour : After this humour has fully answered the end of its destination, its superfluous, or rather noxious part is included among the excrements, and finally eliminated from the system.

A further use of the bile is, to evolve and exterminate from the alimentary canal, the fixed air, which had been hitherto confined among the chymous mass : it appears also to act on, and aid, the intestinal tube, by means of its stimulus, thus exciting it to perform its peristaltic motion with greater vigour and energy.

I silently pretermit a variety of other uses, commonly attributed to the bile, which appear to me to rest on more doubtful and equivocal evidence, such,

such, for instance, as its power of regurgitating into the stomach when empty, and thus exciting appetite, a phenomenon that, in my opinion, can very seldom occur in a well formed and healthy human subject.

SECT. XXXI.

OF THE FUNCTION OF THE SPLEEN.

§ 393.

THE *spleen* is very intimately connected with the liver, not only by an intercourse of vessels, but also by the affinity and subserviency of its function: it is situated in the left hypochondriac region, opposite to the liver; its figure is oblong, generally, indeed, accommodated to the situation of the neighbouring viscera with which it lies in contact: it is subject however, to multiplex varieties with regard to form, number, and other species of *lusi naturæ*, or preternatural phenomena.

§ 394.

Its colour is livid, its texture altogether singular, being soft, friable, easily lacerated, and therefore

fore securely protected by two membranous coverings, the internal of which belongs properly to the spleen itself, while the external appears to be derived from the omentum.

§ 395.

The situation and size of the spleen are now and then, no less than its figure, subject to striking and singular variations, arising in a great measure from the different states of the stomach, with respect to fulness and depletion: thus, for example, when the stomach is empty, and hangs in a loose and depending position, the spleen is distended with blood; but when the former viscus becomes turgid again, the latter is emulged, and consequently diminished in bulk by the pressure to which it is subjected.

The spleen is also agitated by another perpetual, though gentle and uniform motion, in consequence of respiration, being subjected to the immediate action of a primary instrument of that function, namely, the diaphragm.

§ 396.

The texture of the spleen, physiologists formerly supposed to be cellular, and uniformly compared it to the *corpora cavernosa* of the penis: this opinion, however, is evidently founded in error, and
has

has been very satisfactorily refuted by a more accurate examination of the human spleen. For, from such examination we learn, that almost the whole volume of this viscus is composed of blood vessels, extremely large in proportion to its size; so that it is supplied with a greater profusion of blood, than any other part belonging to the body of man.

§ 397.

The splenic artery, conspicuous (agreeably to the experiments of Wintringham) on account of the astonishing fineness and strength of its coats, is divided into an infinitude of minute ramifications, which constitute finally, by their evanescent extremities, very small pulpy pencils: these pencils afford origin, again, to fine filiform veins, that constitute by their gradual confluence, large and lax trunks highly capable of dilatation.

§ 398.

This vast congeries of blood vessels, is, however, knit together and supported by a small quantity of cellular parenchyma, from whence the absorbent vessels arise, the trunks of which run on the plain or flat side of the spleen, between the two membranous coverings, of which we have already spoken.

§ 399.

§ 399.

This texture of the spleen, so very lax and highly capable of admitting blood, corresponds admirably with what we formerly said respecting the sanguineous distension of this viscus (§ 395): and we may further observe, that the phenomena of the congestion, and tardy progressive motion of this crimson fluid in the spleen, considered in conjunction with the nature of the surrounding and contiguous viscera, tend not a little to illustrate the peculiar state and condition of the splenic blood, which of themselves appear to shed considerable light on the *function* of this mysterious viscus, a subject of such repeated controversies among physiologists.

§ 400.

The blood contained in the veins of the spleen is very fluid, dissolved, coagulated with the utmost difficulty, and admits of but a slight and partial separation of the serum from the crassamentum; its colour is also livid and obscure, as in the fœtus; all which phenomena appear evidently to combine in ascertaining and even demonstrating the presence of an abundant quantity of the phlogistic element. That this element is, however, unequivocally present in large quantities, I further ascertained to my entire satisfaction, by the following simple and conclusive experiment: to the ac-

tion of pure dephlogisticated air, I exposed recent sections and slices of the spleen of a human subject; no sooner were these pieces brought in contact with this vital fluid, than they were overspread with a very florid and beautiful crimson blush, while the air itself, thus despoiled of its native fire, was on the other hand, contaminated by the splenic phlogiston.

§ 401.

When we contemplate the foregoing circumstances collectively, and consider in the last place, that the *spleen* is the only viscus of a similar nature wholly unfurnished with any vestige of an excretory duct, save those vessels which we have already said run to the liver, we are obliged from the force of concurring testimony to conclude, that the sole office of the organ now under consideration, is to act in subserviency to the function of the liver, and contribute towards the formation of bile by the co-operation of its phlogistic parts.

§ 402.

This opinion is still farther substantiated by a very curious and useful observation, made on such individuals of the animal kingdom, as have been deprived of the spleen by excision. It appears that in animals subjected to this operation (which, however singular and seemingly barbarous, has

been, notwithstanding, very frequently performed from remote periods of time) the cystic bile has been uniformly afterwards found to be pale, weakly impregnated with phlogiston, and disposed to a grume-like coagulation of its lymphatic portion.

S E C T. XXXII.

OF THE FUNCTION OF THE OMENTUM.

§ 403.

THE *omentum gastrocolium*, or *omentum magnum*, (so called to distinguish it from the *parvum* or *hepaticogastricum*), is indeed a very singular production of the peritoneum, originating immediately from the external coat of the stomach.

§ 404.

For notwithstanding the continuations of the *peritoneum*, in the abdominal cavity, be almost innumerable, and although all the parts contained in this cavity, whether viewed collectively or individually, be so uniformly invested by it, that, on opening the abdomen, it is impossible to discover a single viscus which this membrane does not embrace, yet the modes in which it furnishes this covering

covering to the several viscera, are so diversified, as to merit a division into different classes.

Thus, for example, the abdominal cavity contains certain parts, over which the peritoneum is only spread in such a partial and simple manner, as to invest but one of their surfaces; this observation may be applied particularly to the kidneys, the *intestinum rectum*, the *vesica urinaria*, and in some measure also, to the pancreas and gall-bladder.

There are also other viscera, which, notwithstanding their attachment and adhesion to the surrounding parietes of the abdomen, yet project also to a considerable distance into the abdominal cavity itself, and derive from the peritoneum a covering, which invests, by far, the greater part of their external surfaces: of this description are the liver, the spleen, and even the stomach and female uterus, to which we may add, finally, the testes of a male foetus, previously to their descent into the scrotum.

Considerably different again, (in point of peritoneal covering), from both the foregoing classes of viscera, is the whole of the intestinal tube, except that portion which is denominated *intestinum rectum*. This tube passes through the abdominal

cavity in such a manner, as to carry along with it, two remarkably broad processes of the peritoneum, namely the *mesentery* and *mesocolon*, to which it adheres in a state of suspension: under the same class with the two preceding processes, may we also arrange those singular peritoneal productions, denominated the broad ligaments of the uterus.

§ 405.

But finally, the most extensive of all is that peculiar continuation of the peritoneum called the *omentum*. This production is a large empty sac of a very delicate texture, that hangs in a depending position from the great curvature of the stomach; it is spread over the region of the *small intestines* in particular, nicely adapts itself to their irregular convexities, and dips down, in some measure, into their numerous interstices.

§ 406.

Besides the blood vessels by which the omentum is painted, it is also marked by numerous *striae* or *broad lines* of adipose substance, which meet, intersect, and thus form a variety of reticular intertextures, from whence the membrane has received the name *vernaculum*. In persons disposed to obesity this adipose substance encreases now and then to such a size, as to become not only troublesome but even dangerous: it is also this
adipose

adipose portion that affords origin to that oily halitus by which the omentum is constantly surrounded and moistened.

§ 407.

It has been the opinion of certain celebrated characters, and a further attempt was made by the illustrious Haller to prove, that the fat contained in the omentum is destined to be taken up by absorption and conveyed to the liver, for the purpose of supplying the bile with its oily portion, &c. With respect to the truth of this opinion, however, I must still be permitted to entertain and express a serious doubt, having never yet been convinced that sound, uncontaminated, bile contains any oil; nor have I ever been able to discover any orifices subservient to such an absorption, not even in frogs themselves, where Malpighi alleged, and even attempted to prove, their existence; much less in that part which is the subject of our present consideration, namely, the omentum of man.

§ 408.

What appears, from the nature and situation of the part, as well as from the concurring belief of all physiologists of the present day, to be a much more unequivocal use of the omentum, is, to lubricate the intestines, and by that means aid and

facilitate their perpetual motion. The same appear also to be the use and destination of certain simular, but small, adipose *bursæ*, by which the *colon* and *rectum* are invested.

The omentum also further serves to prevent the occurrence of an adhesion between the intestines and peritoneum, by which the whole office of the *primæ viæ* would be subverted.

§ 409.

That this adipose curtain is destined to serve as a defence against cold, (though an opinion very generally received), appears, notwithstanding, to rest on evidence of a more questionable nature: the omentum of a man in perfect health, which ought by no means to be burthened with an accumulation of fat, is indeed, but very illy calculated to answer such an intention.

When we consider, in the mean time, the singular structure of the two *omenta*, more especially of that denominated *omentum parvum* or *gastrohepaticum*, it appears sufficiently probable, that besides the uses already enumerated, the latter is still destined for another, of, perhaps, even *supreme importance*, which is as yet unknown to us, and which future researches in comparative anatomy will be alone able to develop.

S E C T.

SECT. XXXIII.

OF THE FUNCTIONS OF THE INTESTINES.

§ 410.

THE intestinal tube itself (before which the omentum is spread, and into which we have already seen the chyme conveyed, in order to be further elaborated and sufficiently fitted for the separation of chyle), is divided into two leading portions, namely, the *small* and *great*; of the functions of which we will now treat separately and in order.

§ 411.

The *small* portion of intestines is again subdivided into three parts, namely, the *duodenum*, *jejunum*, and *ileum*.

The duodenum derives its name from the circumstance of its length.

The jejunum from that of its general habit, because, in a recent corpse, it appears collapsed and empty as it were, even although it contain at the same time a quantity of pulpy chyme. In the third division, called *ileum*, the chyme deposits its fæces, and suffers an evolution of its air, which

had been hitherto fixed, so that this last of the small intestines, being at the same time the longest, and deriving its name from its circumvolutions, appears more turgid, somewhat inflated, and marked here and there with small bubble-like eminences, after the manner of the large portion of this tube.

§ 412.

The coats of the small intestines are perfectly similar to those composing the stomach, of which we have already spoken (§ 359.)

The *external* is a production of the mesentery.

The *muscular* coat consists of two orders of fibres, to wit, *longitudinal*, which are interrupted in their course, and run rather *externally*, especially on that side of the intestine that looks in a contrary direction from the mesentery; and more *internal*, *annular*, or *falciform* fibres, which are calculated to contract or narrow the diameter of the tube; whereas the former are intended to diminish its longitudinal extent. On both the preceding orders of fibres depends that exquisitely energetic and pertinacious *irritability* of the intestines, of which we have spoken on a former occasion (§ 306.)

The

The *nervous* coat consists of compacted cellular membrane; and may, by a very simple mode of treatment, especially by blowing into it, be again reduced to a spongy, foam-like tissue: throughout this coat a variety of blood-vessels, detached from the mesenteric, are distributed in the form of arborets or branching shrubs, of inimitable elegance and beauty. As in the stomach, so likewise in the intestines, the nervous coat is the principal seat of tenacity and strength.

Finally, the internal coat (which merits more unequivocally, in the small intestines, than in any other part of the alimentary canal, the name *villous*), is continued here and there, in conjunction with the internal surface of the preceding membrane, into wave-like productions and rugous folds, that in the intestines, when inflated and dried, exhibit a falciform appearance, and are denominated *valvulæ Kerkringii*.

§ 413.

Of the *villi* themselves, an immense number overspread, in the closest order, the whole internal surface of the small intestines: their subtle and exquisitely elegant vascular structure, was first discovered and demonstrated by the labours of the indefatigable Leiberkuhn. While the intestines are destitute of chyle, the *villi* may be compared
in

in some measure to small purses hanging in a loose and flaccid position, and consisting internally of a soft spongy texture; but when they become turgid, in consequence of the absorption of this milky fluid from the intestinal canal, their figure undergoes such a striking change, as to bear no small resemblance to the *phallus esculentus* *.

§ 414.

Those *villi* are surrounded, at their bases, by an infinitude of *small glandular follicles*, which are lodged principally in the nervous coat, and communicate by very minute orifices with the intestinal cavity, into which they discharge a mucus that serves to line and lubricate the whole internal surface of that tube.

These minute glands are commonly supposed to consist of three orders. *First*, the Brunnerian or larger glands, which are separate from each other, and situated principally on that part of the duodenum, which lies next to the pylorus.

Secondly, the Peyerian, which are considerably smaller, planted in clusters, and lodged, in particular, on the other extremity of the small intestine,

* A species of *fungus*, denominated *phallus*, from its striking similitude to the male penis.

tines, which looks towards, and is contiguous to, the valve of the colon.

And, *lastly*, the glands of Leiberkuhn, the most minute of all, of which about eight are said to belong to each *villus*.

It ought to be observed, however, that this division of the sources of mucus appears to rest on very equivocal evidence. For if I be not greatly deceived, both the Brunnerian and Peycrian glands, as commonly exhibited in plates, are the result of a vitiated and diseased state of the intestinal tube. I am induced to entertain this opinion from having never been able to discover, in the found small intestines of subjects carefully examined in different periods of life, the smallest vestige of such fungous papillæ, perforated with orifices; whereas, on the other hand, I have frequently seen, in cases of *aphtha*, almost the whole intestinal canal planted with countless numbers of them, partly standing alone, and partly arranged in crowded clusters. From considering the foregoing circumstances, I feel a confidence in concluding, that none can be accounted true muciferous glands, except those extremely minute miliary bodies, which, on gently separating the *villous lining*, may be readily detected on its *averted surface*, but
cannot,

cannot, without great difficulty, be distinguished on the side next to the eye.

§ 415.

It has been incontrovertibly established, not only from that well known experiment first instituted (if I mistake not) by Pechlin, but also from several others, that as the stomach, so in like manner the cavity of the small intestines, is supplied with a constant influx of a liquid, denominated, from the place into which it is discharged, *intestinal juice*. It appears probable that this fluid is similar in its nature to the gastric liquor, although a more accurate investigation of it is, certainly as yet, a desideratum in physiology: neither can I venture to say any thing decisive respecting the *quantity* of this liquid secreted: I am, however, fully of opinion, that Haller has been too profuse in his estimate, where he alleges, that this secretion amounts to eight pounds in the space of twenty-four hours.

§ 416.

Further, it is also common to the intestines with the stomach, to be agitated by a *similar*, but far more *lively* and vigorous *peristaltic motion*, which, in particular, while the chymous pulp is advancing, enward, throws the same into gentle commotion,
by

by a wavy and progressive constriction, and thus propels it forward from the duodenum towards the great intestines. For although we cannot absolutely deny the phenomenon of an anti-peristaltic commotion, in consequence of which the intestines are subjected to a retrograde action, it must, notwithstanding, be acknowledged, that this, in a healthy subject, is much feebler than the former, that it occurs more rarely, and possesses a more precarious and short-lived existence.

§ 417.

In consequence of the co-operation of those energetic causes, hitherto enumerated (viz. both the *principles* of *motion*, of which we have just spoken, and likewise the *solvent* and *alterative* powers of the inquiline humours that are every where blended in abundance with the chyme), the following remarkable changes are produced in this heterogeneous mass:—in the jejunum it exhibits the appearance of a more liquid pulp, possessing a colour somewhat grey, and an odour slightly acid: after its entrance into the ileum it begins to separate into two portions; these are, *first*, the *feces*, marked by a pale yellow colour, inclining more or less towards a brown, and possessing a feid odour; and, *secondly*, a white milk-like fluid, denominated *true chyle*, which floats on the surface of the feces, and is separated from them by the
action

action of the hepatic liquor or bile. This chymous emulsion, designated by the name of chyle, is destined to be received by *absorption* into the *lacteal vessels*, through which mazy tubes we will accompany it farther in the *following section*; and shall, in the mean time, close the *present*, by tracing, in as brief and intelligible a manner as possible, the route pursued by the residuary fæces.

§ 418.

These, therefore, after having become more and more inspissated, in consequence of a tedious course through the ileum, are obliged at length to pass the valve of the colon, and thus enter the tract of the *great intestines*; for which purpose the neighbouring extremity of the ileum is furnished, and lubricated internally, by a more copious quantity of mucus, destined to destroy the friction of the fæces, and consequently facilitate their transition through the foregoing valve.

§ 419.

The *valve of the colon* (denominated very justly in honour of its real and illustrious discoverer, *valvula Fallopii*), is a short continuation or process of the *ileum* projecting into the cavity of the *great intestinal portion*, by which it is surrounded and closely embraced: the more exterior *labia* of this *process* are so constituted, by means of a more prominent

prominent or extensive ruga of the *great intestine*, as to consist not only of its internal and nervous coats (as is the case with the greater number of such plicæ), but to contain also in its composition some fibres from the muscular coat. Hence the function of this valve appears to be twofold, to prevent the premature passage of the fæces from the small into the great intestines, and also to obstruct their regurgitation from the latter into the former.

§ 420.

The great intestinal portion, which in like manner with the small, is also divided into *three sections*, begins from the *cæcum* (to which is appended the *vermiform process*, a part indeed of equivocal use in the economy of an adult subject), and constitutes collectively a canal so capacious, as to admit the inspissated fæces to be gradually collected and retained in its cavity, till a convenient opportunity for their evacuation.

§ 421.

As the *great* is superior to the *small* portion of the intestines in diameter, so it likewise exceeds it in the thickness and strength of its coats. The muscular coat, in particular, possesses this peculiarity, that its longitudinal fibres (if we except the lower part of the rectum) are collected into three fasciculi

fasciculi or bundles, called *ligamenta coli* ; and the colon itself is thus divided into distinct segments of a vesicular or cystiform appearance. The internal coat in the *great*, is not of such a beautiful and elegantly floccose appearance as in the *small* intestines, but possesses a nearer resemblance to that which invests the cavity of the stomach.

§ 422.

The peristaltic motion appears to be less vivid and active in the great, than in the small intestines. On the other hand, the *abdominal pressure* is considerably greater on the former than on the latter, in as much as the whole *colon* is subjected to its immediate action and influence.

§ 423.

The inspissated and hardened fæces contained in the large intestines, are protruded slowly onward, till having at length reached the rectum, they excite, by their stimulus on the internal surface of that tube, a propensity to an evacuation. For the purpose of facilitating this evacuation, ample and wise provision is made, partly by a defect or interruption in the transverse rugæ, but more especially by a profuse quantity of mucus, that lubricates the internal surface of the rectum near to its extremity.

The evacuation of the fæces is, however, principally accomplished by a downward direction of the abdominal pressure, overcoming the resistance of the coccyx and both the sphincters, the interior of which is a very singular fasciculus or bundle of annular fibres, but the exterior, a genuine cutaneous muscle: these ends being quite completed, there succeeds an entire remission of the abdominal effort, the intestine is retracted by the *levator ani* in particular, and finally closed again by the contraction of the sphincters.

SECT. XXXIV.

OF THE FUNCTIONS OF THE ABSORBENT SYSTEM.

§ 424.

FROM observations delivered in a former section it is sufficiently evident, that the chyle, which we left in the *intestinum ileum*, completely disengaged from its fæces, is a compound of several different humours. Although it be almost literally impossible to calculate, with accuracy and definitude, the precise quantity of *inquiline humours*, such as saliva, gastric juice, pancreatic juice, intestinal juice, bile, &c. that is mixed and blended

with the chyme, it appears, notwithstanding, a matter of the highest credibility, that these several humours, taken collectively, very far exceed, in quantity, the other constituent part of the chyle, which is derived immediately from alimentary substances, recently taken as nutriment. Hence we may derive a solution of that problem in physiology, by what means alimentary matters, though of the most different and even opposite kinds, may, notwithstanding, be converted into the same assimilated, homogeneous, and milk-like chyle, equally adapted to the *nature*, and calculated to serve as the *nutriment*, of animals?

§ 425.

The *channels* through which the chyle must flow, in its passage from the intestines to the *mass of blood*, (the reservoir destined for its ultimate reception), constitute a part of the *absorbent system*, which we have hitherto mentioned only occasionally, and in a very cursory manner, but will now assume as the professed object of our present attention. This system is divided generally into four parts, viz. lacteal veins; lymphatic veins; conglobate glands; and finally, the thoracic duct, each of which shall constitute a subject of exclusive consideration.

§ 426.

With respect to the nascent origin of the lacteals from the intestines, there exists scarcely a doubt, but that this is constituted by the innumerable *villi* of the internal intestinal coat, of which we have already spoken. It is, however, still a matter of controversy, whether the lacteals originate immediately from those villi themselves, or only preserve a more distant intercourse and communication with them, by means of interjacent cellular substance. As far as my information has extended, no one has hitherto been able, more than myself, to trace the evanescent radicles of the lacteal vessels to the villi themselves, with such clearness and definitude, as to discover an immediate and unequivocal connection between the parts; on the other hand, the lacteals appear here and there, throughout the coats of the intestines, to form trunks of considerable size, immediately after their origin, and, (if a conjecture be allowable), to absorb from the cellular substance of the adjacent parts, that chyle which had been originally taken up from the cavity of the intestines by means of the villi themselves. This phenomenon I think I have frequently observed, in young puppies, into which I had poured, according to the celebrated experiment of Lister, a solution of Indian blue, one or two hours before subjecting them to the operation of *live-dissection*.

§ 427.

Those trunks, of which we have just spoken, frequently run the distance of several inches, and sometimes even wind about in angling or meander-like directions, immediately under the external coat of the intestine, previously to their entrance into the mesentery.

§ 428.

During their passage through the mesentery, these trunks make frequent entrances into small *mesenteric glands*, which may be divided into two different *series* or *orders*. Those of the first order are situated in the vicinity of the intestinal tube, and resemble, in their appearance, small beans lying separate from each other. The glands of the other order, lie nearer to the receptacle of the chyle, are superior in magnitude, and planted in collective clusters.

§ 429.

Both the foregoing kinds of glands appear to be in reality nothing else, than round compacted convolutions of the lacteal vessels themselves, covered and interspersed with an infinitude of minute blood-vessels: their destination appears to be, to retard the progressive motion of the *chyle*, in order, perhaps, that, by such delay, it may be more fully and perfectly animalised and matured, previously

ously to its entrance into the thoracic duct, and subsequent admixture with the circulating volume of the blood.

§ 430.

It has been proposed as a physiological question, whether or not the *large*, possess also lacteal veins, in common with the *small* intestines? The affirmative of this has been zealously advocated, and its defence attempted by arguments drawn from the influence and efficacy of specific enemata, of enemata composed of nutrimental substances, of inebriating substances, &c. and also from the following well known circumstance, viz. that the longer inspissated fæces are retained in the large portion of the alimentary canal, the more indurated and insucculent they are uniformly found. But although these arguments do not satisfactorily demonstrate that any genuine chyle is absorbed from the fæces after their transition over the valve of Fallopius, they furnish, notwithstanding, additional evidence in confirmation of that, which has indeed been long since established on the testimony of the sense of vision itself, namely, that the great intestines abound with a sufficiently plentiful apparatus of lymphatic veins, perfectly similar to the lacteals both in their structure and functions: in testimony of this entire similarity, it may be proper to observe, that when the intestines are destitute

of chyle, the lacteals of the mesentery are then engaged in the absorption of lymph.

§ 431.

Another question, more important and difficult of solution than the former, is, whether or not the whole of the chyle, absorbed from the cavity of the small intestines, be conveyed to the blood through the same *public*, and *royal* route, as it is termed, or whether there do not exist certain secret channels, through which it may glide surreptitiously onward, to mingle its streamlets with the general current of circulating blood?

It must indeed, be confessed, that most of the arguments, by which physiologists have endeavoured to prove a private absorption and conveyance of chyle through the sanguiferous veins, do not appear to rest on a very solid foundation: thus the assertion of Ruysch, that on the approach of old age the mesenteric glands become so indurated and constricted, as to be rendered unfit for performing their functions, has been long since refuted, and it has, on the other hand, been satisfactorily demonstrated that, different affections of these glands, such as swellings, &c. very erroneously pass under the common name of *obstructions*, while, at the same time, their vessels remain in a state sufficiently pervious to afford a very easy entrance

trance and transition to injections of quick silver. That well known phenomenon, from which it is ascertained, that tepid water, thrown into the inert mesenteric veins of a dead subject, transfuses into the cavity of the intestines, appears to contribute but very little towards the satisfactory elucidation of any function of the human body while in a living state; much less can we repose confidence in the evidence derived from that *bicrural* and *two branched* tube of copper, which was invented by Lieberkuhn, for the purpose of confirming the same opinion. As to the assertion, that chyle has been unequivocally detected in the red veins of the mesentery, it appears to me to stand in need of farther evidence for its unquestionable confirmation; on the whole, I have never yet been convinced, that those veins convey any thing else than blood very highly charged with phlogiston, destined for the secretion of bile.

§ 432.

Finally, the ultimate trunks of the lacteal veins, (with certain other tubes very similar in appearance and function, which are formed by the confluence of a great number of minute lymphatic vessels), unite and constitute by their junction, the *receptacle* or *cistern of the chyle*, which is a name given by physiologists to the inferior and larger

portion of the *thoracic duct*, called also the *duct of Pecquet*.

§ 433.

This duct is a membranous canal, of a delicate appearance and texture, yet sufficiently robust and strong, more or less circuitous in its course, and not unfrequently subject to very striking diversities with regard to the direction in which it runs, and the divisions it occasionally undergoes: it is equally destitute of muscular fibres and nerves, is furnished here and there with small valves, and, after having passed over the *left subclavian vein*, is again reflected towards, and finally inserted into, the *same*, and, at the very point of insertion, has its entrance guarded by a valve of a peculiar structure.

§ 434.

The powers which produce and continue the onward motion of the chyle, both in the lacteal veins, and through the thoracic duct, are to be attributed, indeed, principally to the contractility of these vessels themselves, but, in part also, to the valves with which they are furnished, to a propulsive *vis a tergo*, and to the uninterrupted pulsation of neighbouring arteries.

§ 435.

§ 435.

It appears probable, that the principal destination of the valve, which is fixed, as has been already observed, in the entrance of the chyloferous duct into the subclavian vein, is not so much to obstruct the lateral passage of blood into this duct, as to regulate the necessary discharge of chyle into the vein, and prevent its admission in any other manner than by a slow and gradual stillicidium.

By this means, adequate provision is made against the simultaneous entrance of too large a quantity of recent chyle, into the mass of blood. Such an excessive influx of this crude fluid would necessarily stimulate the *parietes* of the heart to exertions too violent and laborious, and would be blended and assimilated by the same, with the utmost difficulty, and in an imperfect manner; that this would be the result, we judge from the nature of recent chyle, which is a compound of heterogeneous elements, derived not only from the *primæ viæ*, by means of the *lacteal*, but also from all the other parts of the body, through the avenues of the *lymphatic vessels*.

§ 436.

The *lymphatic veins* themselves, which constitute a third part of the absorbent system, and bear
a very

a very close resemblance to the lacteals, both in structure and in function, are so considerable, in point of extension, as to pervade, perhaps, every part of the human body; but originate, in particular, from the common external integuments, from the pleura, the peritoneum, and viscera, contained in the thorax and abdomen.

§ 437.

The manner in which they arise, is similar to the origin of the lacteals from the intestines, of which we have already spoken. Thus each radicle of each lymphatic vessel, is destined to absorb from a neighbouring portion of cellular membrane, (as from a territory of its own), the moisture it contains, and propel it onward to the general cistern of the chyle.

§ 438.

These *lymphatic vessels* are furnished in their course, sometimes more frequently, sometimes more rarely, with valves situated in *bigæ* or *pairs*. By far the greater part of them enter conglobate glands; those in the vicinity of each other frequently anastomose; and such of them as overspread the surface of certain viscera, as that of the lungs, the liver, &c. form exquisitely elegant reticular expansions.

§ 439.

To pass silently over certain other aids, sufficiently evident from former observations, the function of the lymphatics is greatly promoted by their remarkable contractility, and the *strength* of their delicate coats, which is sufficient, in processes for anatomical preparations, to resist the pressure from a ponderous column of quick silver: this function is also further aided, especially in the joints, by *muscular motion*, in consequence of which, the lymphatics being compressed and closely embraced on all sides, have their tone remarkably augmented.

§ 440.

With respect to the terminations of the lymphatics, various controversies have lately existed among physiological writers. Thus, while some contend, that all those vessels unite in the thoracic duct, (in like manner as the sanguiferous veins unite in the *venæ cavæ*), others, on the contrary, exempt from this general confluence, at least the lymphatics of the right arm, and right side of the neck, which they allege are not inserted into the same duct, but into the right subclavian vein: others again assert that in the conglobate glands, the lymphatics communicate immediately with sanguiferous veins; and lastly, others maintain (not indeed without an appearance of probability) that
certain

certain lymphatic vessels *, actually exist, which form a direct and free communication between the intestinal tube and uropoietic organs.

§ 441.

Seeing therefore, the lymphatic vessels are extended far and wide throughout almost the whole system, and, especially, in as much as an immense profusion of them originate on the cutaneous surface of the body, and may consequently absorb such fluids as are applied from without, it is sufficiently evident, that the lymph, when recently absorbed, must be, indeed, a liquid composition extremely heterogeneous and diversified as

* For a great number of truly important observations and highly interesting speculations on this subject, the reader is referred to a short treatise, written by Charles Darwin, "On the retrograde motion of the lymphatics," and published at Litchfield in the year 1780, a considerable period of time after the premature death of its ingenious author. This young philosopher and physician appears to have been peculiarly formed by nature, and happily finished by education, to shed unequivocal light on subjects of a dark and difficult nature in the science of medicine. He experimented with accuracy and definitude, he observed with the utmost attention, and he speculated with the highest ingenuity and force. Unhappily for the *healing art*, and (perhaps I may add) for *science* in all its various branches, this amiable young philosopher was hastily summoned away, ere yet his mind was perfectly expanded, or his plenitude of merit announced to the world.

to its nature and elementary parts: this diversity is fully ascertained and established, by a more careful and accurate examination of dead subjects, where, for instance, the liquid contained in the absorbents of the liver and spleen, appears to be evidently different from that discovered in those which run to the uterus.

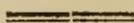
§ 442.

Of the *conglobate glands*, (which constitute the last branch of the lymphatic system), the principal use and destination appear to be, to assimilate to the animal nature this subtle and heterogeneous fluid, especially that portion of it which is absorbed by the lymphatics of the skin: this assimilation they accomplish by retarding and in some measure obstructing the motion of the lymph, and perhaps also by the addition of a new fluid, derived from the minute arteries, with which they very plentifully abound. Hence a wise and adequate provision is made, to prevent the *humours*, while in too crude a state, from effecting a premature mixture with the blood, and thus the heart is guarded in perfect security from their noxious impressions.

§ 443.

With respect to those other glands of the same nature, which are minutely dispread throughout
by

by far the greater part of the system, and planted here and there in collected clusters, as in the groin, beneath the axilla, &c. they bear, in every respect, the most perfect resemblance to the mesenteric glands, of which we have already spoken; like them they are composed, in a great measure, of the mazy convolutions of absorbent veins; like them they are furnished with a vast profusion of minute blood vessels; and finally, they are subject to be readily invaded by the same diseases that attack the glands of the mesentery.



SECT. XXXV.

OF SANGUIFICATION.

§ 444.

IT is scarcely necessary to observe, that by the term *sanguification*, we mean the assimilation of *chyle* to *blood*, and the constant and uniform restitution made by means of the *former*, for the equally constant and uniform loss which is sustained by the *latter*.

§ 445.

For on this *principle* depends that division of all the humours of our body, into the three classes

(§ 4.

(§ 4. 5.) of *crude, sanguineous, and secreted*; viz. that the middle class embrace the whole circulating volume of blood, from which the different secreted humours are derived in constant streamlets, and to which the countless channels of the absorbent system convey their chyle, and the infinitude of lymphatic tubes return their absorbed fluids in currents equally constant and uniform.

§ 446.

Seeing the blood is an animal humour of so very singular and exclusive a kind, as to be wholly dissimilar to every other fluid yet discovered in any department of nature, it is a proposition sufficiently self-evident, that there must be a variety of assistant powers which contribute, by their joint co-operation, to incorporate and assimilate with the blood, the heterogeneous and adventitious humours, which it is constantly deriving from the thoracic duct.

§ 447.

The process of sanguification we may consider, then, as first commencing under the action and influence of those mazy circumvolutions (frequently spoken of already), which both the lacteal and lymphatic veins exhibit occasionally in their courses (more especially in the mesenteric and other conglomerate

globose glands), and which are, at the same time, furnished with considerable quantities of what may be called *animal* and *inquinine contagion*.

§ 448.

It is necessary further to consider, that a great part of the lymph, which enters the subclavian vein (after having first effected a mixture with the intestinal chyle in the thoracic duct), is derived from the interior recesses of the viscera and other soft parts of the body, and was formerly secreted from the blood itself; from whence it necessarily follows, that such portion of the lymphatic fluid must doubtless possess, already, the animal nature entire, and be very readily miscible with the mass of blood to which it is returned.

§ 449.

To these we may add another circumstance, of which we spoke on a former occasion, namely, the slow and stillicidious transition of the *chyle* into its reservoir, the *blood*—that fluid not being admitted to pass through the ultimate valve of the thoracic duct into the subclavian vein, in any other manner than by drops, in order that those minute portions may, by this means, be more intimately mixed and incorporated with the circulating blood.

450

The internal structure of the heart itself appears also to contribute, not a little, towards the important process of sanguification. Thus, by means of those astonishing muscular papillæ, with which the ventricles of the heart are plentifully furnished, the blood and chyle (having recently met together), are thoroughly agitated, and brought into a state of more intimate combination.

§ 451.

That the *lungs*, receiving the blood, recently impregnated with chyle, perform, by the function of respiration, an important part in the further assimilation of this crude fluid, will appear sufficiently evident to any one who considers the astonishing vascular structure of these viscera (§ 136.) in conjunction with the equable alternate motion to which they are perpetually subjected, during the continuance of human life.

§ 452.

The remaining part of the process of sanguification is finally completed by the more extensive circuitous journey of the blood throughout the whole body, and by those powers which contribute towards the continuance of the same, more especially *muscular motion*, &c.

§ 453.

But although potent provision be made, by such powerful and diversified *apparatus*, for blending and intimately incorporating the chyle with the blood, it appears, notwithstanding, that there exists a certain similitude between the constituent parts of those two fluids. It is very commonly asserted, that a great many hours must elapse before the chyle can be completely divested of its own milky colour, and perfectly assimilated to *that* of the crimson fluid into which it is destined to be converted: in testimony of the truth of this assertion, medical philosophers usually adduce (besides other arguments) the following singular pathological phenomenon, namely, that several hours after the close of digestion, genuine chyle has been frequently observed to flow from an orifice made in a vein of the human body: this phenomenon I have indeed had an opportunity of observing myself; but it was at the same time extremely evident, that the blood was then highly charged with phlogiston (a condition of this fluid very unfriendly to the regular assimilation of chyle), so that from hence scarcely any inference can be drawn relative to the *healthy state* of the system, which is alone the exclusive subject of the science of physiology.

SECT: XXXVI.

OF NUTRITION.

§ 454.

BESIDES *that function* (which we attributed to the blood in a former section) of distributing the element of *fire* throughout the whole body, and in *its* place waiving that of *phlogiston* back to the lungs, two of its primary and leading offices appear to be, to convey to the body nourishment, and to the secretory organs the matter of those peculiar fluids which they are severally destined to extract. Of this twofold function we will next treat; and *first* of the function of *nutrition*.

§ 455.

Nutrition is the supreme privilege of nature. It is a common and leading prerogative of all organized bodies, whether animal or vegetable, by which they are instantly discovered, on first view, to surpass, in an immeasurable degree, all machines and automaton constructed by human artifice: because on none of these latter has any artist ever been able to confer a power (I will not say of actual *growth*, of progressing toward *maturity*, and of acquiring gradually higher and higher

degrees of *perfection*), but not even of preserving themselves in a state of *stationary existence* by their own inherent powers, nor of repairing the gradual losses to which they are subjected by attrition, by incidental casualties, &c.

§ 456.

Nutrition is that faculty of our bodies, on which all the sublime and astonishing functions of our nature depend. By means of this faculty we increase in magnitude from the earliest dawnings of our existence, we advance through the expanding period of youth, and finally arrive at our *acme*, or point of complete maturity. It is also through the instrumentality of this same faculty that a competent remedy is applied, and sufficient restitution made, for that uniform waste and loss of the body, by which (while in a living state) it destroys and in some measure consumes itself, by its own necessary action.

§ 457.

With respect to the nature and mode of this *wasting* or loss, various controversies have existed among physiologists. The more immediate point of disputation has been, whether such waste occurs in the solid parts of our bodies, or whether it be not more probable, that those parts, when once formed and completed, remain stationary, without
being

being subject either to vitiation or change? which latter is indeed an opinion embraced and taught by several characters of the utmost acumen and ingenuity.

§ 458.

With respect to some particular solid parts of the body, such, for example, as the epidermis, the nails, &c. there exists indeed not a shadow of doubt, but that they are gradually destroyed and again repaired; and with regard to the destruction or waste and subsequent reparation of the bones themselves, the testimony will appear equally plain and conclusive, to any one who may consider with attention the result of the well known experiments made by feeding warm-blooded animals, for some time, on the root of the *rubia tinctorum*, or who may take the further trouble of contemplating attentively the phenomena exhibited by certain large plain bones, especially those of the cranium, which in extreme old age become remarkably attenuated, or diminished in thickness, in consequence of the scanty nourishment with which they are supplied at that period of life.

§ 450.

Upon the whole, if I be capable of judging rightly, those solid parts appear to be not only gradually consumed, and again repaired, by the

faculty of nutrition, but possess also a *vis reproductiva*, or power of re-production. This latter is indeed a surprising faculty, destined not only to make restitution for the uniform removal of minute atoms by the necessary action of the animal economy, but also to repair the incidental loss of larger parts (suffered in consequence of external injuries, wounds, &c.), by a perfect restoration of the substance of which the body has been thus forcibly deprived. That such a power does unequivocally reside in the bones, and a few other parts, of which we have just spoken, is with me too well ascertained and substantiated to admit of a doubt.

§ 460.

But on the other hand, from a variety of observations and experiments which I have made both on man and other warm-blooded animals, this *power of reproduction* appears to reside in scarcely any other solid parts of the body than *such as are endowed with contractility alone, without possessing at the same time any of the other vital energies, such as irritability, sensibility, or finally, specific life.*

§ 461.

Of those parts of the system therefore (which possess the more exalted kinds of vital energy), the staminal basis appears to me to consist of a *perennial*

rennial parenchyma, which is subject neither to genuine mutation nor decay, but only liable to certain *viciſſitudes* in point of bulk, that are produced in the following manner, namely, when the proceſs of nutrition is conducted with ſufficient activity and vigour, the cellular interſtices of the parenchyma, being uniformly filled with the rich and plaſtic lymph of the blood, are, of courſe, diſtended, and the parenchyma neceſſarily enlarged; but when, on the other hand, nutrition goes on leſs favourably, theſe ſame interſtices, being in a great meaſure deprived of this nutritious lymph, fall into a ſtate of collapse, and the parts become conſequently diminished in ſize.

§ 462.

With reſpect to this plaſtic lymph (of the dignity and importance of which we have ſpoken fully on a former occaſion), as it aſſumes with great facility the appearance and nature of genuine cellular membrane, ſo it appears to conſtitute generally the principal nutritious matter of the whole ſyſtem, and is conveyed to every part of the body by means of that infinitude of minute blood-veſſels, to which we have ſo often called the reader's attention.

§ 463.

During the time of the body's advancement in growth, it appears to possess certain peculiar or specific powers, by the aid of which the lymph, being deposited from the evanescent extremities of the sanguiferous vessels, into the surrounding cellular membrane, is duly arranged, and completely assimilated to each particular portion, and kind of parenchyma. To the head of these specific powers, must we in part refer that particular law of affinity, by means of which the *partes similes* of the system attract and appropriate to themselves, the homogeneous *elements* of the nutritious lymph, more especially such of them, as possess reciprocal and kindred propensities; and to the same head may we also in part refer that *nisus formativus*, of which we will have occasion to speak more fully hereafter, and to which must be attributed, the just and specific application of the rude, and hitherto formless, elementary matter, and its subsequent organisation and arrangement into the form and figure of its peculiar destination.

§ 464.

It is, I presume, from the joint co-operation of both the preceding powers, that we must principally derive the nutrition of those parts of the body, which are not proximately supplied with any
 blood

blood vessels at all; such as the nails, hairs, &c. and which are, notwithstanding, generated at first, by a very powerful and truly infallible *nifus* or exertion, are afterwards advanced in magnitude, and regularly supported by nutriment throughout the whole of life, and, finally, if by accident removed, are again readily restored by the astonishing efforts of the *vis reproductiva*.

§ 465.

Although the preceding appears to be a general *breviate account* of the process of nutrition, yet, on the other hand, it is evident that there exists, in different individuals, a great many varieties, with regard to the degrees and modes in which this function is discharged. Thus, for example, in proportion as a more lax or more close *apposition* and *union* of the nutritious matter are effected, the texture of the parts themselves is rendered more dense or delicate, and hence also seems to originate the difference between the specific weight of human bodies; in which respect it is well known, not only that man differs from man, but even nation from nation: in testimony of this truth it may be sufficient to adduce even a solitary example from among certain northern tribes, namely, the Jukatæ, the Buratæ, &c. people highly conspicuous on account of the remarkable and truly singular levity of their bodies.

SECT.

SECT. XXXVII.

OF SECRETION.

§ 456.

BESIDES those juices destined for the important process of nutrition, there are also in the animal system other humours, of a very different order and character, which are extracted for various purposes from the exuberant fountain of the blood. These humours owe their existence to the process of secretion, than which no function is less understood by physiologists; a *truth* mentioned as a subject of just regret, both by the immortal Haller and other preceding writers.

§ 467.

The secreted humours, appear, in one point of view, to be so extremely diversified in their natures, and, in another, to bear so striking an affinity to each other, that it is not possible to reduce them to any, save highly arbitrary, *classes*. If, however, in treating of these humours, we found our divisions of them on the less and greater changes to which their elementary parts, (con-
tained

tained in the mass of blood), are subjected in the secretory organs, they may be aptly enough enumerated in the following order.

First, *the milk*, a fluid which we think proper to place at the head of our *cenfus* or enumeration, because it may be considered, in some measure, as renovated chyle, and appears to be secreted, by the most simple process, from the blood, to which the chyle had been recently united.

Secondly, the *aqueous fluids*; such, for example, as the humours of the eye, and the tears: to the same head must we refer in like manner, the sweat; and also, (if our opinion be not unfounded), that halitus which is contained generally in the interstices of the cellular membrane, as well as in the cavities of the thorax and abdomen: this vapour appears to differ but very little either from the liquor of the pericardium, or from that subtle halitus by which the ventricles of the brain, and the pituitary sinuses of the cranium are preserved in a state of perpetual humidity.

Under the same head of aqueous fluids, it is likewise common to arrange the *urine*, although this is doubtless a liquid possessed of some singularly striking and peculiar properties.

Of a less compound nature are the *salivary* humours, which, in office, are subservient to mastication, to digestion, and to chylicification.

Thirdly, the *mucagenous fluids*, which invest and lubricate the cavities of most of the viscera, that are destined to the performance of the natural and genital functions, and also the internal surfaces of all the aerial avenues belonging to the system, such as the *nares*, the *larynx*, and the *aspera arteria*.

Of a nature not widely different from the foregoing, is that portion of mucus which covers the internal segment of the eyeball; as well as that which is spread immediately beneath the epidermis.

Fourthly, the *adipose humours* are, in particular, (besides the common fat itself), the medulla of the bones, and the smegma or oily covering of the skin, to which may be added the *cerumen aurium*, or waxlike substance investing the external avenues of the ears.

Of a nature nearly related to the foregoing, is that unctuous secretion, so evident on the *glans penis* of the male, and about the *rima* or *os externum*, in the genital organs of the female.

Under

Under the same class may we also arrange that oily substance, with which the glands of Meibomius furnish and anoint the eyelids.

Fifthly, what are commonly denominated by physiologists *gelatinous fluids*, examples of which we have in the *liquor amnii*, and *unguen* of the joints. Respecting the nature of these fluids, however, we are not yet possessed of a sufficient number of well authenticated facts to give birth to unequivocal and satisfactory conclusions: a similar observation may also be made, respecting that uninvestigated and anonymous humour, which the female uterus discharges during the ardent glow of the venereal orgasm.

We remain also as yet, in a state of equal uncertainty respecting the nature of that fluid, which is lodged, during the first months after conception, between the chorion and amnios; of that which is contained in the umbilical *vesicula* or *pouch* of the embryo in its tenderest state; and also of that which is interposed between the three vessels that constitute the umbilical cord.

The liquid enclosed in the *vesicula graffiana* of the female ovary, and also the liquor of the prostate gland, appear to be of a truly *serous* or *albuminous* nature.

Sixthly, the *male semen* appears to be a *humour* so remarkably singular in its nature, as not to admit of classification, nor even of comparison, with any other.

And lastly, with regard to the *bile*, there is equal room for the admission of a similar observation.

§ 468.

That the foregoing secreted humours, so extremely diversified in their natures and habits, can neither be derived from the mass of blood by the same individual process, nor by organs of the same kind, is a proposition too self-evident to stand in need of, or indeed leave room for, any farther confirmation. Among these humours, there obviously exists this memorable variety, namely, that while some of them are secreted and conveyed from the blood through a *shorter route*, others again, are more elaborately prepared, by being carried onward through tubes of greater longitudinal extension.

§ 469.

Of all the modes of secretion, *that* must doubtless be considered as the most simple, in which the secreted humour appears to transude immediately through the coats of the arteries, by what physiologists

ologists call *diapedesis*. Instances of this mode we have in the secretion of the fat, and of the medulla residing in the bones, &c. ; and, finally, it appears to be by a modification of the secretory process, not greatly dissimilar to the foregoing, that the gastric liquor, the intestinal liquor, &c. are prepared and discharged into the cavities of their respective viscera.

§ 470.

The mechanism of secretion appears to be more compound, where that process is performed by means of *glands*, under which denomination we generally include even *follicles* and *cryptæ* themselves ; such, for example, as are easily discoverable in the fauces ; and which physiologists generally designate by the name of *glandulæ simplicissimæ*.

We bestow, with propriety, the denomination of secreting glands, on those bodies which, (to distinguish them from the *conglobate*, belonging to the lymphatic system), are called *conglomerate* ; examples of which we have in the salivary glands, in the pancreas, in the lachrymal glands, and in the *mammæ*, or breasts of females. The foregoing glandular bodies are furnished with excretory ducts, which are composed of tubes or canals running immediately from their larger lobes : these lobes,

lobes, on being submitted to farther examination, are found to be made up of smaller lobules, respecting the internal structure of which, there formerly existed very warm controversies in some of the most celebrated schools of medicine. Malpighi considered the small miliary globules, which may be readily demonstrated in the greater part of them, to be nothing else than genuine *acini* or *kernels*, containing, each one, a minute cavity in its centre. While Ruyfch contended, on the other hand, that those hypothetical excavated kernels were nothing more than globular convolutions of extremely fine blood vessels; which latter opinion, is doubtless founded on by far the most unequivocal and substantial testimony, as we readily learn from well conducted anatomical investigations, more especially from successful injections, and the assistance of glasses.

§ 471.

Nor does this structure (if indeed we keep out of view the peculiar parenchyma of each particular viscus), differ much from, but appears rather to shed a considerable gleam of light on, the structure of certain other secreting viscera, particularly on that of the liver and kidneys, in which late experimenters have been able to demonstrate, with the utmost perspicuity, certain spherical bodies entirely similar to the globular convolutions of

Ruyfch, or the kernel-like substances of the celebrated Malpighi. For, in what is called the cortical portion of those viscera, minute ramifications emerging from the sides of the small capillary arteries, become presently convoluted, in such a manner, as to form little vascular balls, which thus appear to hang by those ramifications of which they are composed, like so many small berries or grapes supported by their footstalks. From these minute vascular balls originate *first*, that very subtle and colourless order of vessels immediately destined for the business of secretion, (respecting the origin of which, from the evanescent terminations of arteries, we transiently spoke on a former occasion, (§ 79. 81.); and *secondly*, the incipient radicles of veins, into which the minute arteries are themselves continuously reflected, and which conduct back to the venous trunks, the residue of the blood now deprived of those elementary particles necessary to constitute the fluid recently secreted.

§ 472.

Finally, certain other parts of the body, appropriated entirely to the business of secretion, are distinguished again by different and remarkably peculiar, species of organization; thus the male testes, for example, are wholly composed of nothing else than close and mazy convolutions of very lengthy and numerous blood vessels, &c.

§ 473.

We come now to the consideration of the peculiar causes, by the operation and efficacy of which *those* determinate and specific humours are secreted in *these* corresponding determinate and specific organs: this is indeed the *Gordian knot*—this is by far the most difficult point of disquisition in the whole doctrine of secretion—that point which numerous doubts and difficulties yet invest.

§ 474.

It appears indeed to be a truth ascertained and established beyond the faintest shadow of a doubt, that the leading, and what may be called the proximate cause of most of the secretions, must be sought for in the internal structure of the secreting organs themselves: under this head we must particularly consider, in the conglomerate glands and other secreting viscera, not only the peculiar distribution and direction of the extreme blood-vessels, from which the humours are secreted, but also the *parenchyma*, so uniformly proper to each secreting viscus, that in many of them it can be instantly known and distinguished at first sight from all other kinds or species of flesh (§ 27).

§ 475.

It is also an opinion extremely probable (in support of which we have advanced, on former occasions,

occasions, several arguments not easily refuted), that the secreting viscera, besides their peculiar parenchyma, possess also what we have taken the liberty to call a *vita propria*, i. e. a specific or exclusive kind of vital energy, essentially different from what we denominated the three *common energies*, namely, contractility, irritability, and sensibility.

§ 476.

But further, if my views of the subject be in any measure just, the *absorbent system* appears to contribute also a very important part towards the promotion of the several secretions: thus, from each of the secreting viscera certain appropriate branches of this system absorb and re-convey to the blood-vessels larger or smaller portions of each of the several humours to which these viscera give origin; the uniform consequence of which is, that the blood becomes literally impregnated with the contagion of every humour secreted in the different parts of the body, e. g. with *bile* from the liver, with *semen* from the testes, &c.

Thus there appears to exist, in the system destined for the business of secretion, a perpetual routine or circulation, so that the elementary parts of the humours already secreted being incessantly conveyed from the secreting organs

themselves, are united afresh to the mass of blood, and on their subsequent return to their *parent organs*, in conjunction with the sanguineous current, are again more easily attracted by the secreting vessels, in consequence of a peculiar law of affinity, and have also a power of drawing along with them those parts of the blood that are most homogeneous in their nature, and for which they consequently possess the highest degree of attraction.

§ 477.

To facilitate the secretion of *certain humours* of the body, adequate provision is made by the production of specific qualities, in those particular portions of the blood from which they are to be proximately derived: thus the bile is secreted from the blood of the *vena portarum*, a portion of fluid highly impregnated with *phlogiston*, furnished in profusion by the abdominal sources, from which this blood immediately originates.

§ 478.

I pass in silence over certain other co-operating aids, which act in subservience to particular secretions, as *congestion* and *derivation*, so evidently efficacious in the secretion of milk, with other instances of a similar nature.

§ 479.

Among the humours thus secreted by the organs which we have just described, and by the powers or causes just enumerated, it may be observed that the following difference afterwards exists, namely, while some of them drop immediately from their secreting organs into the places of their ultimate destination, in which they are to perform their specific functions, others again are conveyed to appropriated receptacles, in which they are retained for some time, and thus farther matured previously to their final elimination from the system: of this last description is the milk which stagnates in the lactiferous ducts, the urine, the bile, and the semen masculinum, which are subjected to retention in their vesicular receptacles, and finally, the *serum* contained in those vesicles which were first discovered by de Graaff in the ovaria of the female.

SECT. XXXVIII.

OF THE URINE.

§ 480.

BESIDES the nutritious juices and the secreted humours destined for further services in the animal economy (§ 4.), the blood furnishes also materials for the formation of certain useless and superfluous liquids, that are intended to be entirely eliminated from the system, and are from thence vulgarly called *excrements of the second digestion*. These excrementitious liquids are of two kinds, one of which is exhaled by the process of perspiration, and has already engaged our particular attention; the other is the *urine*, a liquid secreted in those glands denominated kidneys.

§ 481.

The kidneys are two viscera situated behind the peritoneum, on each side of the spine, and in the upper part of the lumbar region: Although their figure is generally somewhat flattened, yet it is proper to observe, that both in this respect, and also in point of number, they are subject to more varieties than any other viscus belonging to the human body: they hang by vessels commonly called
emulgents

emulgents (remarkably large in proportion to the magnitude of the parts on which they are distributed), and are cushioned round by fat of a sebaceous consistence (§ 38).

§ 482.

They are invested by a proper membrane, of an elegant vascular structure: each one of them, especially during the period of infancy, appears to be composed of about eight, or somewhat more, kidney-form lobes or subdivisions; each of which consists again (according to an opinion formerly entertained and taught by Ferrein), of about seventy or eighty fleshy *radii*, which that physiologist called white pyramids.

§ 483.

If the kidney be dissected or divided from its convex *dorsum* towards its concave *pelvis*, it exhibits in its composition two kinds of substance; one forming its circumference, and therefore denominated its *cortical*, the other constituting its centre, and hence called its *medullary*, portion.

Each portion abounds with sanguiferous arteries and veins; besides *which*, the external cortex is also furnished with an additional order of very minute colourless vessels, destined to *secrete* the urine: while the medulla contains also vessels of

a similar description, intended to *carry it onward* when secreted.

Those secretory ducts originate, in the manner already described (§ 471.), from the small globular convolutions of capillary arteries that are every where interspersed throughout the cortex of the kidney: those ducts constitute indeed by far the greater portion of the cortical substance of the kidney, and may be very easily distinguished by their singular meanderings and intricate mazes, from the small conducting tubes of Bellini; in which they finally terminate. These *tubuli Belliniani* (as they are frequently termed) pass by a direct route from the cortical, and enter the medullary substance, of which they constitute by far the greater part; and uniting afterwards by reiterated coalitions into a small number of narrow trunks, finally perforate, by their extreme orifices, in a sieve-like manner, the several *papillæ* contained in the renal pelvis.

§ 484.

The *papillæ* correspond for the most part to the number of lobes, of which we already said each kidney is composed. The urine that is secreted in the colourless vessels of the cortex, and afterwards conducted through the *tubuli Belliniani* of the medulla, these *papillæ* discharge into their
corresponding

corresponding *infundibula*, which form by their subsequent confluence the common *pelvis*.

§ 485.

The *pelvis* is continued into the *ureters*, which are membranous canals, exquisitely sensible, and defended internally by a complete investiture or lining of mucus; they are capable of extreme dilatation; in man they are here and there uneven in the width of their cavities, and are at length inserted into the posterior surface, not far from the neck of the urinary bladder. This insertion is effected in such a manner, that the *ureters* do not immediately perforate the *parietes* of the urinary cyst, but descend a short distance between its muscular and nervous coats (which are here possessed of more than ordinary thickness), and open finally into the cavity of this organ by oblique orifices. By means of this structure, adequate provision is made to prevent the urine, that has once entered the cavity of the bladder, from being forced to return again into the *ureters* by an inverted or retrograde motion.

§ 486.

In an adult subject, the urinary bladder is in general sufficiently capacious to contain about two pounds of urine; its *fundus* or bottom, which in the fœtal state terminates in the *urachus*, and also
its

its posterior side, are invested by the peritoneum ; as to its remaining membranes or coats, they bear a general resemblance to those of the stomach, of which we have already spoken.

The *muscular* coat consists indeed of interrupted bands of fleshy fibres, that surround the cyst, forming at the same time various irregular decussations or interfections, which are different in different subjects : this muscular coat physiologists denominated *detrusor urinæ*, while they designate by the name of *sphincter vesicæ*, those orbicular fibres that partially surround the neck of the bladder, though they are very inconstant and irregular, both with respect to their figure and origin.

The *nervous coat* bestows on this membranous viscus also the principal part of its strength and firmness.

Finally, the *internal* coat, which is considered by physiologists as a process or continuation of the epidermis, is defended by a complete covering of mucus, especially round the neck of the bladder.

§ 487.

Besides those public and well known routes of the urine, of which we have already spoken, it appears probable from several phenomena, that there

there exist also certain secret avenues, which lead immediately from the intestines to the uropoietic organs. For the speedy discharge of certain drinks from the urinary emunctory, so frequently imbued with the odour, tinged with the colour, and characterized by other specific qualities of the aliments recently taken in, will scarcely admit the belief, that these liquids had performed, in so short a time, the customary long and circuitous route through the thoracic duct and sanguiferous system: to the foregoing circumstance we may add an account we have read, of the urine having been found covered with *oil*, that entered into the composition of an enema, which had been previously and recently thrown into the intestinum rectum. It is, on the other hand, a circumstance well known to physiologists of the present day, that very striking and numerous anastomoses occur between the lymphatic vessels of the intestines, and those of the kidneys. Lastly, it is now unequivocally ascertained and confirmed by live dissections, that if both ureters of a dog be tightly enclosed in ligatures, and his *bladder* perfectly evacuated of its contents, this latter organ will, notwithstanding, in the term of three hours afterwards, contain a certain quantity of urine; while at the same time the usual avenues of this fluid, namely, the ureters, are completely obstructed, as is evident from this circumstance, that above the
ligatures

ligatures these tubes suffer vast distention from the accumulated urine.

§ 488.

But through whatever avenues the urine has been conveyed to the bladder, its gradual accumulation in that organ excites an uneasy sensation, which becoming urgent and troublesome (§ 331.) potently solicits its final elimination, through an emissary or sewer destined for that particular purpose, namely, the *urethra*. This excretory canal is subjected to a variety in its conformation, founded on the diversity of the sexes, of which we will speak more amply when treating professedly of the sexual functions.

§ 489.

In order to evacuate the bladder, it is necessary to overcome the contraction of its sphincter, by the exertion of its own *detrusor* (of which we formerly spoke) (§ 486.), aided by the co-operation of the abdominal muscles, and those subservient to the process of respiration; to which, in males of the human species, we may add, lastly, the action of the *musculi acceleratores*, which forcibly ejaculate, *per saltum*, as it were, even the residuary drops of urine that may be occasionally lodged in the bulb of the urethra.

§ 490.

As to the *nature* of the *urine* itself, it is subject indeed, to an infinitude of varieties generated by the circumstances of age, and season, but, above all, by the longer or shorter term of time, subsequent to the previous use of food and drink, the discharge of this fluid occurs; to which may be also added, the quality of the aliment previously used, &c. In general, however, when we examine the urine which is discharged by a healthy human adult, immediately after sound and tranquil sleep, we discover it to be a watery liquid, of a nidorous smell, and citron colour, containing in its aqueous medium, (as in a common vehicle) various elementary substances, especially *earthy* and *saline*, which bear different proportions to each other in different individuals, and even in the same individual at different times and under the influence of different circumstances. Of the terrene elements the most abundant is, in general, calcareous earth, which is not unfrequently found in the urinary passages under the form of *calculi*, but which is, notwithstanding, extremely variable and inconstant in its quantity. Of all the saline matters, that most worthy of being mentioned, is the *essential* and *native salt* of urine—called also, *microcosmic salt*, *fusible salt*, &c. This saline substance contains, in a greater proportion than any other

other part of the human body, the celebrated phosphoric acid chemically espoused to the volatile alkali.

SECT. XXXIX.

OF THE DISCRIMINATION OF THE SEXES IN
GENERAL.

§ 491.

THOSE functions of the human body, in the consideration of which we have been hitherto engaged, are indeed possessed, and exercised in common, by the individuals of each sex: with respect to the mode, however, in which some of them are performed, there occur between the two sexes no inconsiderable degrees of difference. Of this difference, it may be proper briefly to enumerate the leading points, previously to our entrance on the consideration of what are denominated the *sexual functions*.

§ 492.

To speak, then, in general terms, each sex possesses and exhibits its *own peculiar habit*, which differs considerably from *that* of the other. In
the

the human subject after birth, this difference of habit is distinctly observable; but during the tender foetal state, is scarcely to be distinguished, unless by more close and pointed attention; neither indeed, in this state, can the external organs of generation themselves be discriminated, on a transient and superficial view, owing to the extraordinary magnitude and prominency of the female clitoris, and the very diminutive size of the male scrotum.

§ 493.

During the period of infancy this difference of the general habit, depending on the diversity of sex, makes only a slight impression on the observer; but becomes gradually more and more obvious and striking till the full completion of the years of *puberty*, at which period, the general conformation of the female body, its tenderness, its softness, and the usual inferiority of its stature, contrasted with the athletic and robust body of the male, exhibit this general *habitual* difference in the most striking point of view.

§ 494.

Similar to the difference that occurs between the *external habits* of body, that characterise the two sexes, is that which is observable in the bones
them-

themselves. These solid portions (all other circumstances being alike) are evidently much more smooth and round in females than in males; the cylindrical bones, in particular, are more slender and delicate, and the plane ones more attenuated or thin, in the former, than in the latter sex; not to mention the peculiar diversities of certain remarkable bones, particularly those of the thorax and pelvis, with the clavicles, the femora, &c.

§ 495.

With respect to the soft parts of the body, we may observe in general, that in females, the cellular membrane is more lax, more pliable, and consequently more readily dilatable in the state of pregnancy: while the skin is more tender, fair and beautiful, in consequence of the immediate substratum of fat.

The hair of the head is generally of a greater length in *females* than in *males*, while at the same time, certain other parts of the body which in the latter are rough and hairy, are in the former either perfectly smooth, as the chin and breast; less hairy, as the perineum; or planted with only a very tender and soft down, as the arms and legs.

§ 496.

When speaking of the diversities of particular functions, we must not silently pretermitt the pulse, which (other circumstances being alike) is more frequent in females than in males, (§ 109). In the former, the *thorax* is subjected to a greater degree of motion, (especially at its superior part,) than in the latter; the *os hyoides* is much smaller, the larynx is less capacious, and hence the voice more shrill.

§ 497.

With regard to the animal functions, it is necessary to observe in general, that in females the mobility of the nervous system is much greater than in males, the irritability is more exquisite; and the propensity to commotions of the mind, more prompt and spontaneous.

§ 498.

As to the natural functions, the appetite for food is weaker in the female, than in the male sex; while, on the other hand, the increase of the body is more rapid in the former, and the state of puberty and mature growth attained at an earlier period.

§ 499.

But by far the greatest and most important distinction of the sexes is derived from the genital functions themselves, the male being furnished with a power of *fœcundation*, and the female with that of *conception*. A farther investigation of these powers shall engage the greater part of our attention, throughout the remaining pages of this work.

 SECT. XL.

OF THE GENITAL FUNCTION OF THE MALE SEX.

§ 500.

THE genital liquor of the male is prepared by the *testes*, two bodies suspended in the scrotum by their *spermatic cords*, and (besides the lymphatic veins with which they abound in profusion), composed chiefly of *three* kinds of vessels.

These are *first*, the *spermatic artery*, which in proportion to its slender diameter is said to be the longest of all the arteries belonging to the human body :

body: it in general conveys the blood immediately from the abdominal portion of the aorta itself, to the body of the testis.

Secondly, the *ductus deferens*, which carries to the *visculæ seminales*, the semen when once secreted from the arterial blood.

And, lastly, what is commonly denominated the *pampiniform plexus of veins*, the function of which is to receive and convey to the cava or emulgent vein, the blood that remains after the process of secretion is accomplished.

§ 501.

The testes are not, from the time of their earliest formation, suspended in the scrotum, as represented in the above description: thus in the male foetus, while yet in a very tender and immature state, those glandular bodies occupy indeed a very different situation, the reason and successive changes of which were first accurately investigated and detailed by Haller, at Gottengen in the year 1749, but were afterwards explained by other writers on principles so different from each other, as to have given rise to various controversies of some weight and importance. Of the situation and changes of the testes in the foetal state, I am prepared to lay before the reader a brief, though

comprehensive account,—the spontaneous result of numerous observations made on nature herself, during a remarkable series of dissections of male embryo's, in which I engaged for the express purpose of shedding light on this subject so interesting to physiologists.

§ 502.

On opening the lower abdominal region of an immature foetus, we discover in each groin, near what is called the ring of the oblique muscles, a very narrow orifice in the membrane denominated peritoneum; this orifice is the threshold to a strait avenue or alley, as it were, that leads through the abdominal ring itself, and terminates afterwards in a peculiar bullous or bubble like sack: this sack extends without the abdominal cavity, looks towards the scrotum, is interwoven with cellular fibres, and destined for the future reception of the testis.

§ 503.

At the very posterior margin of this small abdominal orifice, the peritoneum sends off another process, which mounts upwards, and in the tender foetus represents, in the greater part of its course, a longitudinal fold: from the basis of this process a slender cylinder, or rather inverted cone ascends, and forms at its summit, which regards
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the inferior margin of the kidney, a small blister or sack-like termination; in this sack the testis and epididymis are enclosed; so as to resemble, at first sight, a small berry resting on its footstalk, and appear, at the same time, to hang loosely into the abdominal cavity somewhat like the liver or spleen (§ 404).

§ 504.

The vessels which are afterwards to constitute the spermatic cord, are, at this very early period, seen running behind the extremely tender and pellucid peritoneum, so that the spermatic artery and vein run in a descending direction along the sides of the spine, while the *vas deferens* bending somewhat inwardly towards the neck of the urinary bladder, stretches along the loose cellular membrane, which is situated behind the peritoneum, and both enter the body of the testis in that peritoneal *plica* or fold of which we have already spoken.

§ 505.

From about the middle stage of pregnancy, the testes begin to sink downward by degrees, so as gradually to approach the narrow orifice of the peritoneum, which has been already mentioned. At the same time, the foregoing peritoneal fold, with its cylindrical attachment, are wrapped up

by degrees, till the testis finally rests on the very mouth of the preceding canal.

§ 506.

When in the foetus, now advanced to a higher stage of maturity, the testis is fully prepared for a final descent, the orifice, hitherto so contracted or narrow, suffers such a remarkable dilatation, that the testis is at full liberty to enter with facility the opening that leads out of the abdomen as well as the ring by which this opening is surrounded, to pass onward through the whole length of the canal, and thus plunge headlong, as it were, into the blister-like sac of which we have already spoken. The testis having finally accomplished its descent, the peritoneal opening is soon after closed in the most complete manner, and even subjected in a short time to a perfect adhesion of its sides, so that in the stage of *infancy*, scarcely a wreck of it is left, to point the enquirer to the place of its former existence.

§ 507.

The more gradual and slow the movement of the testis (while yet in the abdominal cavity) towards the orifice of its egression, the more sudden and instantaneous appears to be its act of transition through the abdominal ring. For in the dissections of mature foetuses, it is by no means
uncom-

uncommon to discover the testis either as yet incumbent on the peritoneal opening, or else stationary in the groin, after having recently passed the abdominal ring: but once only was I so fortunate as to have an opportunity of observing the right testicle of a twin-fœtus (of which a complete drawing has been given), at the very moment of its passage through the abdominal ring: the gland appeared to have been very tightly embraced and strangled, as it were, by the surrounding parts, and was apparently in complete readiness to emerge from the abdomen into its destined sack; a transition already accomplished by the left testicle, that had just escaped from the ring, the orifice of which had again resumed its former impervious state.

§ 508.

This remarkable descent of the testes along the groins, does not appear to be exclusively confined to any particular period of time: it occurs for the most part, however, about the last month of pregnancy: although these glandular bodies are not unfrequently found either in the abdominal cavity itself, or in the superior part of their inguinal route, even in infants after birth. For the testicle, after its entire escape from the abdomen, has still a further stage of its journey to perform, namely, its final descent along the groin into the

scrotum, in company with the small sac by which it is enveloped.

§ 509.

That the foregoing is indeed a true account of the progressive movement of the testes in their descent from the abdomen into the scrotum, I have had sufficient opportunities of ascertaining from repeated observation. To develop the *causes* and *energies* by which this astonishing descent is accomplished, appears to be indeed attended with difficulties of the utmost magnitude. For I am daily more and more convinced, that neither of those powers to which this descent has been hitherto ascribed (such, for example, as the action of the cremaster muscle, the action of the diaphragm, or the contractility alone of that cellular and tendinous intertexture, which adheres to the processes of the peritoneum, and is usually denominated *gubernaculum Hunterii*, &c.), is sufficient to explain a movement of such extreme singularity, especially that part of it relating to the immediate transition of the testis through the narrow abdominal ring, to which the reader's attention has been so frequently solicited: while I am impressed, on the other hand, by a thorough conviction, that this whole process exhibits the most unequivocal and striking example of what we have denominated *specific life*, without the peculiar operation

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tion and aid of which, it is scarcely possible to solve the several phenomena of a transition so extremely singular in its nature, and so widely dissimilar to all other movements and functions that occur in the whole animal economy.

§ 510.

The involucria by which the testes are invested, after their final completion of the foregoing route, may be aptly enough divided into *common* and *proper*.

The only involucrum common to both these glandular bodies is the *scrotum*. This is a sac, consisting of a tender portion of cutis expanded over a thin substratum of fat, and possessing a peculiarity that does not reside in any other part of the common integuments of the body, namely, a power of changing, in a very remarkable degree, its usual habit and appearance: thus, it sometimes depends loose and flaccid, and again (especially under the impression of the venereal œstrum, or in case of exposure to cold), becomes constricted and rigid, as it were, and is then particularly marked by furrows and diversified rugosities.

§ 511.

Of those involucria which are proper to each testis, that placed immediately beneath and within
the

the scrotum, is called the *tunica dartos* : this coat possesses a very peculiar and vivid *contractility*, by which Winflow, Haller, and other celebrated characters have been so far deceived, as to bestow on it the nature and energy of a muscle.

§ 512.

This is succeeded (after a voluminous and soft stratum of cellular membrane), by three separate *vaginal coverings*, which were first accurately traced and distinguished by the ingenious and indefatigable Neubauer.

Of these vaginal coats, the exterior is *common* to the testicle and spermatic cord, and has the cremaster muscle attached to it by separate bundles of fibres.

But the two interior are *proper*, one to the spermatic cord, and the other to the testis itself; of these the latter adheres, for the most part, by its fundus to the common tunic, while its internal surface is moistened by a lubricant fluid, somewhat after the manner of the pericardium.

§ 513.

The *origin* of those vaginal tunics which has given rise to such a variety of controversies among physiologists, can, (if I be not greatly deceived),
be

be without difficulty ascertained, from what has been already said, when treating of the descent of the testes.

Thus, the *tunica communis*, for example, originates from the descending (§ 502.) blister-like sac or process of the peritoneum.

The *propria testis*, from that production of the peritoneum, which mounting upward in the form of a cylinder (§ 503.), invests the testis itself from its earliest formation.

And, finally, the *propria funiculi*, from that fold of the peritoneum, of which we have already spoken, and the short cylinder in which it terminates previously to its embracing the testis itself.

§ 514.

Immediately to the testis itself the *tunica albuginea* is very closely attached, somewhat after the manner of a cortical covering. From this tunic, blood-vessels pass into the *pulp* or body of the testicle, which consists indeed entirely of innumerable vessels, about a span in length, wound up into small conglomerate lobules: these vessels, of which the substance of the testicle is composed, are both sanguiferous and secreting, the latter of which

which conduct the semen, when prepared, through the vascular net-work of Haller, and the *vasa defferentia* of Graaf, into the beginnings of those cones that form the epididymis.

§ 515.

That body which ranges along the side of the testis, namely, the *epididymis*, consists indeed of a single vessel, about thirty feet in length, which at one end (that for instance denominated its head), is distinguished into about twenty small rolls or cones, and at its other (inferior) extremity, called therefore its tail, increases gradually in thickness, and thus forms by its continuation the *vas deferens*.

§ 516.

The two *vasa defferentia* ascending towards the neck of the urinary bladder, and forming a junction beneath, or near to, the prostate gland, are from hence bent backward, and expanded into the *vesiculæ seminales*; in such a manner, however, that these vesiculæ, and the *vasa defferentia* themselves, open by two common orifices into the urethra, just behind the *caput gallinaginis*.

§ 517.

Finally, the *vesiculæ seminales* themselves, are attached to the posterior surface of the urinary cyst,

cyft, near to the inferior extremity, or neck, of that organ : they are imbedded in a profufe quantity of fat, and from their diversified flexuofities and numerous blind *appendiculæ* that shoot off fomewhat in the form of ramifications, refemble, in their general appearance, two small intefines.

These *vesiculæ* confift of two coats, almoft of the fame kind with thofe that enter, as formerly mentioned, into the compofition of the gall bladder ; thus, the firft or external coat is more robuft, and fimilar in its nature to fuch as are commonly denominated *nervous* ; while the fecond or internal abounds with minute cells and pits, and is every where divided, by means of projecting eminences, into minute purfe-like cavities, perfectly fimilar to thofe that are fo conspicuous about the neck of the gall-bladder.

§ 518.

In thofe organs and veffels hitherto enumerated and defcribed, there is, even from the earlieft years of puberty, a certain fluid fecreted flowly, and retained in fmall quantity, namely, the *femen mafculinum* ; a liquor extremely fingular in its nature, and of the utmoft dignity and importance in the animal economy : it exhibits to the eye a milky colour, emits an odour entirely peculiar, poffeffes a mucoid vifcofity, and is of
fuch

such remarkable specific gravity, as to surpass, in this respect, all other secreted humours belonging to the animal body.

§ 519.

A peculiarity of this fluid, which must not be passed over in silence, is, (as was first observed by Lud. Ham at Dantzic, in the year 1677), that it is peopled by a countless multitude of microscopic animalculæ, belonging to the same order with those called *infusoria*, and possessing different figures, as they appear in the seminal fluids of different animals. In man (and also in the male ass) the *seminal animalcules* exhibit oval figures, furnished with tails of extreme minuteness: these animalcules are said not to be found in any, save found and prolific semen, so that they appear to constitute a certain *adventitious* criterion of the fertilizing maturity of this important fluid: we have called the criterion derived from these animalcules *adventitious*, and presume it is scarcely necessary, at this enlightened period, to repeat, that they should not be accounted the reservoirs of the fecundating principle, much less should they be considered as the germs of future *homunculi*, since so many, and such weighty arguments and observations have been lately advanced in support of a different doctrine.

§ 520.

This genital liquid being gradually collected in the vesiculæ, which we have already described, is there retained till a future act of excretion. By such retention it suffers changes very nearly resembling those to which the bile is subjected in consequence of a state of stagnancy in its cystic reservoir; thus, being gradually robbed of its aqueous portion, it is more and more inspissated and approximated, as it were, towards a state of concentration.

§ 521.

For as the testes generally, together with the cords by which they are suspended, abound with an astonishing assemblage of lymphatic vessels, which serve to re-convey from thence to the blood a portion of fluid, impregnated with the spermatic contagion, and by this means aid and facilitate the further secretion of semen, on the principle, and in the manner formerly laid down (§ 476.), so are the *vesiculæ seminales* themselves also provided with vessels of the same kind, which by absorbing the subtle, though inert water, render the residue of the seminal fluid more active and efficacious.

§ 522.

§ 522.

On this subject I doubt much whether or not, in a healthy man, any genuine semen be ever absorbed from the vesiculæ feminales:—more still, whether or not, as is sometimes alleged, semen thus absorbed could be carried immediately into the neighbouring sanguiferous veins:—but most of all, whether or not such a feminal absorption (admitting its real existence) could possibly act as an antidote against excessive venereal propensities, since it appears evidently, on the other hand, that this same absorption would necessarily operate as an exciting cause of unbridled and almost infuriate lust: in quest of testimony to establish the truth of this latter proposition, we need only attend to the *phenomena* of such animals as experience the venereal propensity only at stated seasons of the year, and compare them with the constitution of those that have been reduced to the state of castration.

§ 523.

To me indeed it appears probable, that, for the purpose of moderating libidinous desires, man is endowed with a far different prerogative (not conferred on any other species of animals with which we are hitherto acquainted), namely, that of *nocturnal pollutions*: these *evacuations* I therefore consider among the natural excretions of man

—*evacuations* by which (as they occur at longer or shorter intervals, according to the varieties of temperament and constitution), he is relieved from a troublesome and otherwise urgent impression produced by an abundant accumulation of semen.

§ 524.

It must be observed, however, that the semen masculinum is never excreted in a state of entire purity, but is always blended with more or less of what is usually denominated *liquor prostaticus* (i. e. the liquor of the prostate). With regard to the external habit and appearance of this last mentioned liquid, it bears a very striking similitude to the albumen or white of eggs. This peculiar liquor derives its name from its immediate *birth-place* or source, which is a body of considerable magnitude, and of a singular and very compact parenchymatous texture, situated between the *vesiculæ seminales* and the bulb of the urethra, and is usually designated by the name of *glandula prostatica*. The excretory avenues of this liquor have not yet been satisfactorily investigated and ascertained, unless (as appears probable) they communicate with the duct of the *caruncula seminalis*, the orifice of which opens into the urethra between the two mouths of the avenues leading from those minute vesicles destined for the recep-

tion and temporary retention of the fertilizing semen, (§ 516).

525.

The *urethra* in man is destined as a common conduit or emissary duct, to three different kinds of fluids, namely, the urine, the semen, and the liquor of the prostate gland. It is lined internally with a mucus which originates from an immense number of sinuses, that are every where dispersed throughout its canal. It is surrounded by a substance of a spongy texture, to which are subjoined two other bodies, similar in structure but far superior in size, (called *corpora cavernosa*), that constitute the principal part of the *male penis*; an organ which is terminated anteriorly by the *glans*, and wholly invested by a very tender and pliable portion of skin entirely destitute of all appearance of fat. This skin forms the prepuce by its attachment round the *corona*, or circular base of the *glans*, and plays over this body with a free motion, somewhat like the palpebræ over the ball of the eye. The interior duplicature of the prepuce, having assumed a different appearance, is reflected over the glans itself, (somewhat like the adnata over the eye) and is furnished around the corona, with an immense number of the small glands of *Littrius*, (analogous to the Meibomian glands of the
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the palpebræ) that give birth to a matter of an unctuous but very singular nature.

§ 526.

The male penis, thus organised and constructed agreeably to the preceding description, possesses a faculty of erection, *i. e.* in consequence of an encreased *congestion* and impetuous *effusion* (for congestion alone will not explain the phenomenon) of blood into the *corpora cavernosa*, the penis swells, becomes rigid, and changes its former position, but suffers again a detumescence and collapse by a reabsorption of the superfluous portion of this distending fluid.

§ 527.

When the penis resumes its flaccid condition, it suffers a singularly circuitous flexion, at the place where it originates from the neck of the bladder. In this state it is, indeed, extremely well calculated for the excretion of real urine, but quite unqualified for the emission of semen, as the beginning of the urethra forms now a more acute angle with the small orifices of the vesiculæ seminales.

§ 528.

When a gradual intumescence of the penis commences, there occurs first an effusion of the *liquor*

furnished by the prostate gland, which is oftentimes eliminated unmixed, but scarcely ever along with the urine. Of this liquor the primary destination is, to be ejected, in conjunction with the *seminal fluid* itself; either, that it may, by its albuminoid lubricity, qualify the sluggish tenacity of the latter fluid, and thus facilitate and promote its ejection; or that it may itself contribute, in a certain degree, towards the process of generation.

§ 529.

The emission itself of the male semen is *excited* as well by the immediate impression arising from an abundant accumulation of this fluid in its appropriated receptacles, as by the genuine *sexual instinct*; it is *accomplished*, first, by a very strong *erection* of the penis, which, while it obstructs the passage of the urine, paves as it were, on the other hand, a more direct and ready way for the transition of the semen; to which we may subjoin, as co-operating causes, a certain *spasmodic contraction* of the vesiculæ seminales, a convulsive action of the *levator ani*, and *acceleratores urinæ*, and finally, a general *succussion*, of the whole nervous system, gentle indeed in degree, and transient in existence, but yet of an epileptic nature, and considerably depressing, in its effects, on the energies of the system.

SECT. XLI.

OF THE GENITAL FUNCTION OF THE FEMALE SEX
IN GENERAL.

§ 530.

AS the male organs of generation are naturally calculated to *give*, so are the female to *receive*, and in the two sexes these organs are, in a general point of view, widely different from each other. It must be observed, however, that in the general structure of certain parts, these two kinds of organs exhibit no small degree of reciprocal similitude. Thus beneath the pubes (the structure of which has been already a subject of transient attention (§ 36.) the *clitoris* which lies concealed in the superior commissure of the labia, resembles the male penis in more respects than one, but is not furnished with a urethra, is therefore imperforate, and, (when not of a preternatural proportion,) is remarkably small. It is said, however, that this organ preserves, occasionally, even in adults, the same proportional size, which, as formerly observed, is so extremely conspicuous in the clitoris of the female embryo, (§ 492.) Hence appears, in all probability, to have originated most of those obscene and fabulous stories,

stories, respecting the existence of *hermaphrodites*. This organ consists also, like the male penis, of *corpora cavernosa*, like it, is capable of erection, like it, is invested by a prepuce, and furnishes, finally, an unctuous matter not dissimilar to that of Littrius, (§ 525).

§ 531.

From the clitoris descend the *nymphæ*, acquiring, also, occasionally, an enormous and preternatural magnitude, (which excess has, in like manner, not unfrequently given rise to extraordinary and fabulous reports): they possess, in common with the clitoris the most exquisite degree of sensibility; and appear to give direction to the stream of urine when discharged, as the *orifice* of the *urethra*, (a tube extremely short in the female sex, and, in the most highly finished and perfect examples, ciliated or fringed in a very singular manner), lies hid, as it were, in a fossa formed by their two bases.

§ 532.

Beneath this orifice is situated the *opening* of the *vagina* itself, environed by *cryptæ* of various kinds, such, for example, as the *urethral lacunæ* of Graaf, and the mouths of what are improperly and even absurdly termed, the prostate glands of Casp. Bartholin, &c. with the unguen-like mucus
of

of which, these obscene parts are moistened and lubricated.

§ 533.

Over the very threshold or entrance of the vagina is expanded a weblike production denominated the *hymen*. This is a membrane, the existence of which in an unlacerated condition, is considered as a sure badge of spotless virginity—a membrane bestowed exclusively on the female of the human species, and of which no physical destination has been yet unequivocally ascertained.

The fringes or residual fragments of this membrane, after laceration, are gradually converted into what are denominated *carunculæ myrtiformes*, bodies quite indefinite in point of number.

§ 534.

From the immediate seat of these minute myrtiform bodies ascends, between the urinary cyst and intestinum rectum, the *vagina*, a tube composed of a cellular parenchyma, interspersed with an infinitude of small blood-vessels. At its inferior extremity the vagina is encircled by a muscle denominated *constrictor cunni*; more internally it is lined by a very soft and delicate coat, which is characterised by two extremely elegant *columnæ* or wrinkles, namely, the anterior and poste-

rior; from these columns a fine mucus is constantly discharged, destined to lubricate the cavity of this highly important canal.

§ 535.

The vagina, at its upper and interior end, receives and embraces, finally, the *uterus*, an organ attached on each side to, and thus suspended by, the *ligamenta lata*.

The cylindrical neck of this organ being thus embraced, as it were, by the vagina, is perforated by a narrow canal, which, like that of the vagina, is impressed by a singular apparatus or arrangement of rugosities, designated by the name of *arbor vitæ*: of this canal the two extreme orifices, more especially the superior or internal, are overspread, for the most part, with a quantity of tenacious mucus.

§ 536.

The substance of the uterus is altogether singular in its nature, consisting of a peculiar parenchyma, very dense and compact, and interwoven with an infinitude of blood-vessels (running in serpentine mazes of astonishing intricacy) of which, the veins are wholly destitute of valves. This organ is doubtless furnished, in like manner, with an apparatus of lymphatic vessels: it abounds
with

with a countless number of nerves, through the medium of which, it preserves such an astonishing sympathy with the other parts of the system.

§ 537.

Externally the uterus is invested by the peritoneum, while its minute internal cavity is lined, especially at its *fundus*, by a very soft and tender membrane, of a spongy texture, which, as some physiologists allege, consists of colourless vessels, while others pronounce it to be composed of lymphatic absorbents.

§ 538.

With regard to the muscular texture attributed to this organ by some physiologists, and strenuously denied again by others, I must take the liberty of observing, that notwithstanding the number of uteri which I have examined with the utmost care and attention, both in an impregnated and an unimpregnated state, (in each of which I have had repeated opportunities of examining this organ, not only in a prepared condition, but also in subjects recently dead), I have never yet been able to detect, in them, any portion that exhibited obvious and unequivocal signs of muscularity. On the other hand, I am daily more and more persuaded, that the uterus, possessing no muscular fibres, is destitute also of true irritability (§ 307),
and

and owes entirely to a *vita propria*, or specific life (§ 47.), all its peculiar motions and functions, which cannot, indeed, with the smallest semblance of propriety, be derived from any of those energies that are common to what we formerly termed the *partes similes*, or similar parts of the body (§ 43, 46). So very singular and unaccountable did the motions and functions of the uterus appear to the physicians and philosophers of ancient times, that they were led to consider this organ as a smaller animal contained within a larger.

§ 539.

From the angles on each side of the *lacunar*, or *fundus uteri*, arise what are called the *Fallopian tubes*. These are two very narrow and tortuous canals, that run in the superior duplicature of the *ligamenta lata*: they are similar in texture to the vagina itself, except, that being internally destitute of valves, they are lined with a kind of spongy flesh, of a very soft and tender consistence.

§ 540.

The extreme orifices of these tubes, that regard the abdominal cavity, besides being much more capacious than those which open into the uterus, are also edged round by fringe or finger-like *fimbriae*, of a truly singular and elegant structure.

The

The offices which these fimbriæ are destined to perform, in the business of conception, appear to be indeed of no small degree of importance; thus being rendered, during the venereal orgasm, equally turgid with the tubes themselves, they evidently embrace, in this state, the *ovaria* that are situated in some measure beneath them.

§ 541.

The *ovaria* themselves, or the *female testes*, as they were called previously to the time of Steno, besides a tenacious and somewhat tendon-like involucre, consist also of a dense and decussating cellular membrane, which incloses in each ovarium about fifteen of those minute bodies denominated the *ovula*, or little eggs of Graaf: these *ovula* contain each a small vesicle, or rather drop of serum, faintly yellowish in its colour, and of an albuminous nature, which, if the recent ovarium be immersed in boiling water, is reduced, like the genuine white of eggs, to a state of complete coagulation.

§ 542.

An albuminoid drop of this kind appears to be indeed the principal fluid which the female contributes towards the process of conception; for it appears extremely probable, that, throughout the progressive course of what are termed the prime

or

or better years of life, these small drops arrive at complete maturity in gradual succession, so that each one, in its turn, looks as it were through the involucre, by which the ovarium is enveloped, till it is able finally to burst the parietes of its prison, and thus be received by the abdominal orifice of the Fallopian tube.

§ 543.

But besides this minute albuminous drop that thus bursts from the volume of the ovarium, it appears that there occurs also, during the venereal œstrum, an effusion of another liquor, which ancient physiologists very improperly and erroneously denominated the *female semen*. Respecting the nature, however, the sources, and the universal presence of this humour, we are able to propose nothing more determinate or satisfactory than we can advance with regard to its destination and uses.

SECT. XLII.

OF MENSTRUATION.

§ 544.

A VERY frequent and highly important function of the uterus in the female of the human species is, to discharge *monthly* a tributary effusion (called therefore *catamenia*), during the tedious and momentous term of about thirty years. This is a painful condition of existence, to which nature has not subjected any other genus of her subjects, throughout the wide and diversified range of the whole animal kingdom; so that to use the words of the eloquent Pliny “the only *menstruous* animal in nature is woman.” From this *condition*, on the other hand, painful as it is, nature has not exempted the females of any of the known nations of the globe, but has stamped it with the sacred character of an essential requisite—of a genuine *sine qua non*, in rendering the female sex competent to the propagation of their species.

§ 545.

The commencement of this singular function generally takes place, in our climate, about the fifteenth year of life, and is, for the most part, preceded by various and unequivocal symptoms
of

of plethora, such as congestion and anxiety about the breast, sense of tension and weight in the lumbar region, lassitude or weariness of the limbs, &c. On the first appearance of the catamenia, the genital organs, in the beginning of the attack, usually discharge a humour of a pale reddish cast; this is gradually succeeded by a liquid of a more intensely florid and sanguineous colour, which terminates, at length, in an effusion of genuine cruor or red blood. This spontaneous, though gentle discharge of blood, is kept up for the term of several days, and is, in the mean time, accompanied by a gradual cessation of all those distressing symptoms of which we have just exhibited a partial detail.

§ 546.

From the time of its first occurrence, this *constitutional hemorrhagy* (as it may, with sufficient propriety, be denominated) becomes regularly periodical: thus its future paroxysms return uniformly about the expiration of every fourth week, and at each recurrence, the evacuation continues, at a mean calculation, about six days; during which term, a healthy female is supposed to discharge from eight ounces to an entire pound of blood.

§ 547.

It is proper, however, to observe, that this function is subject, for the most part, to an entire intermission, during the state of female pregnancy, and the term of maternal lactation.

The final *cessation* of the catamenia occurs after their discharge has continued, at stated periods, about the space of thirty years, which term of time is completed, in our climate, about the 45th year of life.

§ 548.

The *sources* of the catamenial discharge have been referred by some to the vessels of the vagina, and by others (with superior weight of evidence on their side) to those of the uterus: for with regard to those examples commonly adduced in support of the former opinion, where women, although pregnant, possessing an imperforated uterus, or distressed by a prolapsus of that organ in an inverted state, have notwithstanding menstruated with uniform regularity, they tend to prove nothing else than the powerful efforts of the *vis medicatrix nature*, which in cases where the main street is obstructed, is (to adopt a vulgar mode of expression) fortunately acquainted with the routes through lanes and alleys. There are on record, on the other hand, numerous *dissections*
of

of females who died during the term of aſtual menſtruation, from which it was unequivocally aſcertained, that the catamenial diſcharge had been wept out of, or diſcharged in a ſtillicidious manner from, the uterine cavity of theſe ſubjects : not to mention the arguments drawn *a priori* (as metaphyſicians expreſs themſelves), from which it appears highly probable, that the end and deſtination of the menſes are, to prepare the uterus for a ſtate of future pregnancy, and render it more fit for the regular nutrition of the fœtus. For the very ſame reaſons alſo this hemorrhagy appears to be attributed, with more propriety, to the *arterial* than to the *venous* veſſels of the uterus.

§ 549.

With regard to the *cauſes* of this periodical and perennial hemorrhagy, they are ſhrouded by ſo thick a curtain of obſcurity, and their inveſtigation is attended with ſuch momentous difficulties, that in the proſecution of this ſubject, we have not a ſufficient power of evidence to conduct us over the arduous mound which divides the twilight-region of *probability* from the more luminous realm of *demonſtration*, and *certainty*.

The proximate cauſe phyſiologiſts ſuppoſe to be a certain topical congeſtion or plethora, to which

opinion, indeed, the symptoms of the impending catamenia, together with the profusion and nature of the uterine blood-vessels fitly enough correspond, and in favour of the truth of which they exhibit a degree of testimony sufficiently respectable.

Among its remote causes it will be proper to enumerate, the erect position of the body (a position that serves as a characteristic distinction between the human species and most other descriptions of animals); to which we must add, the singular parenchyma of the uterus itself, and, finally, the *vita propria* or specific life of that important organ.

With regard to the cause of the periodical recurrence of the catamenia, it will here be better, much better to acknowledge our ignorance, than to indulge ourselves in vague and visionary conjectures, and sportively range through the fair but fallacious fields of mere speculative hypothesis. For I am, indeed, persuaded, that all those periodical phenomena which occur in the animal body, whether in health or disease, (*provided their interval extend beyond the term of 24 hours*) must be ranked with those *latent mysteries* of animal nature, which nothing but time; talents, and industry, will be ever able to develope.

SECT. XLIII.

OF THE MILK.

§ 550.

BETWEEN the female *mammæ* and uterus (the former of which were, by the philosopher Favorinus in his communications to Gellius, elegantly and emphatically denominated, *the sacred fountains that nourish the human race*, there exists such an extremely potent sympathetic connection, that these two organs may be said to be indissolubly associated, or to accompany each other hand in hand, in their phenomena and functions. Thus, during the tender period of infancy, so great is their imbecility and want of action, that they are capable of performing scarcely any function at all: as the years of puberty advance, they begin, at the same time, to acquire vigour and activity, so that on the first eruption of the catamenia, a swelling of the *mammæ* or breasts becomes also evident to the senses. Throughout the subsequent periods of life those two organs are either subjected to simultaneous and similar changes, as when the breasts become turgid and discharge milk during the progress of pregnancy; or experience alternate and opposite affections, instances

instances of which we have in the suspension of the catamenia during the term of lactation, a more copious effusion of the *lochia* when the secretion of milk does not commence at the usual period, &c. And, lastly, on the unwelcome accession of old age, both the preceding functions fail at the same time, so that when the catamenia finally retreat, never again to return, the uterus and mammæ become *equally* flaccid, inert and wholly incapable of their former action. A great variety of pathological phenomena, easily observable in cases of irregular menstruation, in *fluor albus*, and other similar affections, shall be in silence pretermitted, although they furnish the most potent and unequivocal testimony in confirmation of the sympathy now under consideration, namely, that which exists between the uterus and mammæ.

§ 551.

Nor will this intimate sympathetic connection, which subsists between the uterus and mammæ, appear in any measure extraordinary or surprising, when we consider, that all those diversified *sources* of physiological consent, particularly enumerated on a former occasion (§ 54), jointly co-operate in the establishment of such connection between these organs of the female thorax and abdomen.

§ 552.

The anastomosis observable between the internal mammary and epigastric arteries, was formerly esteemed a circumstance of the highest importance in the explication of the foregoing consent. Although physiologists have hitherto attributed by far too much to this remarkable anastomosis, yet that it ought not to be entirely excepted from the number of co-operating causes will appear extremely probable to any one who considers the obvious and wide difference which exists between the diameter of the epigastric artery in a state of pregnancy, and that of the same vessel during the period of lactation.

§ 553.

The two preceding organs, namely, the uterus and mammæ, possess also, in common with each other, this further property, that they both retain and exhibit a friendly affinity or attraction for the chyle, by which means they solicit that fluid to themselves, especially during the term of pregnancy, and thus convert it to peculiar uses.

§ 554.

The female mammæ consists of a placentoid congeries of small conglomerate glands, distinguished by numerous *fulci* into lobes of considerable magnitude, and completely embedded in a mass of adipose

adipose substance. On the anterior part, in particular, a protuberance is formed by a more firm sebaceous cushion, which is covered and protected by a cutis of a very tender and delicate texture.

§ 555.

Each one of these lobes is composed of a number of inferior lobuli, and these again of what are denominated *acini* or *kernels*, in which the incipient radicles of the *lactiferous ducts* originate, and from the extreme *ramuli* or branches of the internal mammary artery extract a chyliform fluid, which they are particularly destined to convey.

§ 556.

These fine filiform radicles uniting successively in their onward passage, terminate finally in leading trunks, corresponding in number to the principal lobes; so that they generally amount, in each mamma, to about fifteen or perhaps a few more. These trunks are frequently dilated into more spacious sinuses, but never appear to be connected by genuine anastomoses.

§ 557.

These trunks terminate in excretory canals of exquisite delicacy and tenderness, which, being collected and closely approximated towards the centre of the mamma, form, by the co-operation

of cellular membrane, the *papilla* or nipple. This projecting papilla being interspersed and minutely pervaded by an infinitude of blood-vessels and nerves of extreme fineness and subtlety, is subject to a very singular species of erection on the accession of certain external stimuli.

§ 558.

The nipple is surrounded by an *areola* or small circle, which is conspicuous, as well as the papilla itself, on account of the singular colour of the *reticulum mucosum* expanded immediately beneath the epidermis or cuticle. This areola is further distinguished by small sebaceous follicles, and likewise by a few minute lactiferous ducts with which it is in some instances pervaded.

§ 559.

The *human milk* which is secreted in the glandular organs hitherto described, is a fluid of a well known colour, somewhat watery, and containing also a small portion of oil: this liquid is sweetish to the taste, extremely mild, and resembles, in its general properties, the milk of domestic animals belonging to the class mammalia, except that it is not, like the latter, subject to coagulation from the action of acids, nor does it exhibit, to the most attentive observation, the slightest vestige of *volatile alkali*.

§ 560.

When coagulated, however, by the influence of spirits of wine, it exhibits the same component elements of which the milk of those other animals already mentioned is known to consist. For besides the *watery* halitus which human milk emits when recently drawn, and yet in a tepid state, its *serum*, separating from the *caseous* or cheezy portion, contains also the sugar of milk, which is composed of the saccharine acid united to a calcareous earth, together with certain additional parts oily and mucaginous in their natures. Lastly, it contains also a *cream* or butter-like portion, the globules of which are extremely various and changeable in their magnitudes, thus vibrating in their diameters from the $\frac{1}{200}$ th to the $\frac{1}{100}$ th part of a line.

§ 561.

The analogy which is observed to exist between chyle and blood, and between each of these liquids and milk itself, renders it sufficiently probable, that this last humour, (which constitutes at present the more immediate object of our consideration), is a species of chyle renovated from the volume of *blood*, or rather separated from this crimson fluid (with which it had just formed a junction) previously to its final and complete assimilation. This opinion, besides other arguments

which might be advanced in its favour, derives powerful testimony from the specific tastes of several kinds of aliment being not unfrequently perceptible in the milk of nurses; and also from the chyle-like habit and constitution of that watery milk, which not unfrequently exudes from the breasts of females during the term of pregnancy, and for a short time after the period of parturition.

§ 562.

The reason why, during the progressive continuance of lactation, this bland food of the fœtus becomes gradually more and more inspissated, rich and oily, must be referred chiefly to the lymphatic veins, with which the mammæ plentifully abound: Thus the more profuse the afflux of *milk*, and the greater length of time this afflux has continued, with the more power and uniformity do these lymphatics absorb its serous parts, and convey them back to the mass of circulating blood, by which means they furnish the most effective aid to the whole process of this secretion (§ 476).

§ 563.

During the first days after parturition, a very profuse secretion of milk occurs, and (provided the mother *lactates*, i. e. suckles her child) is promoted and kept up by the suction of the infant
itself,

itself, until the catamenia return, which had for a long time ceased to flow (§ 547). The existence of milk in the breasts of virgins truly inviolate, in the breasts of new-born infants of each sex, and even in the breasts of men themselves, as well as in those of other male animals belonging to the class mammalia, is a phenomenon which not unfrequently presents itself to our observation.

§ 564.

A profuse quantity, or accumulation of milk in the breasts effectually solicits its own final excretion, whence a spontaneous discharge of that fluid is observed frequently to occur; this discharge is further promoted by the external pressure of the mammæ, as well as by the suction of the tender infant.

SECT.

S E C T. XLIV.

OF CONCEPTION AND PREGNANCY.

§ 565.

HAVING hitherto considered the structure of the genital organs peculiarly belonging to each sex, we come now to treat of those *functions* or processes which constitute the immediate end and destination of these organs, namely, *conception* and the propagation of the human race. In the order and progress of our enquiries into these abstruse and interesting subjects, we will first give a plain and simple narrative of the several phenomena observable in this admirable and truly divine process; and then attempt an investigation of the energies from which these phenomena appear to originate.

§ 566.

It is, in the first place, necessary to observe, that the subjects of the human race have not, like most other animals (all those, if I be not deceived, belonging to the class mammalia, man alone excepted), any peculiar season of the year in which they are unusually prone to venereal enjoyments,
but

but are equally liable to experience, at every period and under every varying temperature, the gentle glow of love's diffusive fires.

§ 567.

When therefore, the female of the human species admits the embraces of the male, and while they are thus mutually enwrapt in the ardour of that animal instinct which far surpasses every other both in the *universality* and the *potency* of its sway, the uterus (if we be not greatly deceived) being rendered turgid by a species of inflammatory orgasm, and animated at the same time by its own specific life, (§ 538.) drinks in, as it were, the *seminal fluid* emitted by the male, and effects a synchronous discharge of *that* which is proper to itself (§ 543); the fallopian tubes become at the same time rigid, and with their fimbriated extremities embrace the adjacent ovaria: in one or the other of these ovaria one of the vesiculæ Graaffianæ is lacerated or burst, somewhat after the manner of an abscess advanced to a state of complete maturity, and the albuminoid liquid which this ruptured vesicula contained, being absorbed by the orifice of the embracing tube, is thus conveyed onward into the cavity of the uterus.

§ 568.

§ 568.

This *liquid* being discharged from the ovary, the external lips of the small and recent wound through which it was emitted, are again united by a fine cicatrix, while the remaining delicate vascular membrane in which the liquid had been enclosed, constitutes what is called *corpus luteum*. This body appears to be at first hollow and filled with a quantity of plastic lymph, that in process of time is converted into a fleshy nucleus, invested by a firm cortex or membrane, which is interspersed by a variety of minute, yet remarkable blood-vessels.

§ 569.

The uterus being thus impregnated, the canal leading through the *cervex* or neck of that organ, especially towards its superior or internal orifice, (§ 535.) is completely obstructed, in such a manner, that according to the common course of nature there is no room left for superfœtation.

§ 570.

The internal superficies of the uterus appears to be invested with a slight inflammatory crust of plastic or coagulable lymph, (§ 19.) which forms the *membrana caduca*, (called also *membrana decidua*), of Hunter.

This

This membrane-like crust physiologists distinguish into two laminæ or layers; one of which, denominated *lamina crassa*, invests the whole internal cavity of the uterus, except the immediate openings into the fallopian tubes, and the internal orifice of the cervical canal; while the other is the growth of a later period, and appears to be generated in the following manner, viz. after the formation of the *ovulum* is fairly commenced, and this minute body begins to strike its roots into the *decidua*, already mentioned, this second lamina begins gradually to expand, and is thus *continued* from the place where those minute roots begin to pullulate, over the remaining superficies of the ovum, whence it has been distinguished by the name of *caduca reflexa*.

§ 571.

Although the *ovulum* be formed itself at an earlier period than the embryo which it is destined to contain, yet the real organization of the former seldom commences earlier than the termination of the first week after conception. For I very much doubt, whether or not, at an earlier period than this, any unequivocal vestige of an organized body has been ever observed in the impregnated uterus of the human subject.

§ 572.

This ovulum, or little egg, is composed of two proper membranes, besides that external *adventitious* covering, which it derives from the *caduca* of Hunter.

The proper membranes are, *first*, an external one, apparently destitute of blood vessels, which forms the *chorion* of modern writers. From the earliest origin of this membrane a great part of its external superficies is beautifully set with knot-like flocculi or minute *piles* of inconceivable elegance, from whence it has been called, *chorion muscosum seu frondosum*, i. e. the *moss-like*, or *leaf-like*, *chorion*. By means of those delicate piles, which constitute the rudiments of the foetal part of the future placenta, the ovulum is inserted (as if by roots) into the *decidua uterina*. (§ 569.)

The other membrane, lying interiorly, is denominated the *amnion*, which is also destitute of blood-vessels, (§ 5.) it is indeed delicate and tender, but yet of remarkable tenacity and strength.

§ 573.

For a few weeks after the first formation of the *ovulum*, its two proper membranes differ very widely from each other in point of size, the chorion exhibiting the appearance of a *larger* bladder,

bladder, to the inside of which the amnion adheres under the form of a *smaller* one, and is attached in particular to that part which is opposite to the centre of the external floccose superficies of the chorion.

The interstice which then exists between the *chorion* and *amnion* is filled with a very subtle chrystaline water, of doubtful origin, and transient continuance.

For when the *amnion* begins, during the first months after conception, to increase with greater rapidity than the chorion, and to gain on the latter membrane in point of magnitude, this chrystaline liquor must necessarily undergo a synchronous, and perfectly correspondent, diminution.

§ 574.

The internal membrane of the ovum, from the earliest period of its formation (§ 570), till the final close of parturition itself, is constantly filled with a fluid, denominated by physiologists, *liquor amnii*. This liquid is aqueous, and of a pale yellowish colour; it emits scarcely any odour, and is to the taste *bland*, with a slight saline impregnation hardly perceptible; physiologists generally suppose it to be a source of nourishment, and compare it to the white of an egg, from which it notwithstanding,

notwithstanding, differs in a very obvious and essential manner, as may be easily demonstrated by an attentive experimental investigation.

The sources of this fluid are as yet doubtful: It is certainly, however, neither derived from the fœtus nor the umbilical cord, as it is not unfrequently found in abortive ovula, which contain neither of these bodies.

The quantity of this fluid is in an inverse proportion to the bulk of the fœtus. Thus the smaller and more tender the embryo, the more profuse is the volume of *liquor amnii*, and vice versa.

Hence we are at liberty to hazard a conjecture respecting the primary use of this liquor, which appears to be subservient, not so much to the nutrition, as to the protection and defence of the minute body of the tender embryo, as yet in a gelatinous state, and, therefore, wholly unable to bear the violence of external injuries. With respect to that small portion of the *liquor amnii*, which has been sometimes (though so rarely as to deserve to be esteemed a preternatural occurrence) found in the stomach of the fœtus, it cannot possibly be destined for the purpose of its *nutrition*, as will be obvious to any one who considers how
2 extremely

extremely inert and empty the chyliferous system of even a more mature foetus appears, how unfit for, and even how averse from, the arduous and important process of chylification. To the foregoing circumstances we might (if necessary) subjoin various examples of foetuses destitute of heads, with diverse other arguments of a similar nature, and tending to the establishment of a similar result.

§ 575.

The *embryo* itself, which (suspended by the umbilical cord, as fruit appended to its foot-stalk), floats in this liquor, begins to be formed about the third week after conception: it appears first under the very simple globe-like figure of a small bean or kidney, to which the rudiments of the extremities are gradually subjoined, the symmetry and specific form farther completed, &c.

§ 576.

According to the usual course of nature, the female of the human species is *uniparous*, and conceives only one foetus at a time. She not unfrequently, however, bears *twins*, the proportion of which to solitary births is, according to the calculations of Suffmilch, as one to seven. In a case of twins each foetus has its own amnion, but they are both enveloped in a common chorion.

§ 577.

That medium, by the aid of which a reciprocal intercourse is preserved between the embryo and mother, are the umbilical cord, and the placenta through which this cord is minutely distributed.

§ 578.

The umbilical cord, which appears to be coeval with the embryo itself, is indeed very strikingly diversified, not only in point of length and thickness, but also with respect to the place of its insertion into the placenta, its varicose protuberances, &c. In general, however, it is formed of the spiral contortions of three blood-vessels, namely, a vein running to the liver of the foetus, and two arteries which originate from the internal iliacs or hypogastrics. These vessels are separated and distinguished from each other by cellular partitions, running in various directions, and have their *lights* or diameters frequently straitened by the small nodes or valve-like bodies of Hoboken.

These vessels are collected and compacted together into a cord by means of cellular membrane, which being filled with a singular and very limpid humour, exhibits the appearance of jelly, but is invested externally by a continuation of the amnion.

§ 579.

§ 579.

At the place where the *fœtus* is attached to this *cord*, the latter is joined by a peculiar body, which originates from the bottom of the *vesica urinaria* (§ 486.), and pursues a middle course between the two umbilical arteries, namely, the *urachus*. This body is, in the human species, pervious, for at least a short space, and afterwards totally disappears; but in other animals belonging to the class mammalia, leads onward to what is called the *allantois*. Of this allantois the human fœtus appears to be entirely destitute, unless we be inclined to designate by this name that mysterious and transient *vesicula umbilicalis*, uniformly observable in the human ovula, between the chorion and amnion, which (if I be not greatly deceived) Isbr. de Diemberbroek first discovered long before it was seen by Albinus or Zinn. But in more modern times it is discovered too frequently, and with too uniform an aspect in unvitiated and fruitful human ovula, (even to so late a period as the third month after conception), to be any longer considered as an accidental, a morbid, or a monstrous conformation of the part.

§ 580.

The blood-vessels of the cord, of which we have already spoken, pass into the *placenta*, which was formerly said to originate from the leaf-like

superficies of the chorion, a membrane attached to, and even inserted in, the *decidua crassa*: Hence we perceive that the placenta is a body composed of two different kinds of substance, received from an equal number of sources. Thus, for example, one kind called the *uterine*, from its immediate apposition to that organ, is derived from the decidua, and constitutes the spongy parenchymatous portion of the placenta; while the other belonging to the foetus, and therefore called the *foetal* part, is derived from the umbilical vessels distributed throughout the chorion.

At this time the increase of the tender ovum is unequal, so that the growth of the smooth portion of the chorion is greater and more rapid than that of the *muscosum* or moss-like; hence it is evident, that the relative magnitude of the placenta to that of the whole volume of the egg, is greater in proportion as the conception is more recent, and less, on the other hand, accordingly as the period of parturition is nearer.

As pregnancy gradually advances, the placenta becomes more and more close and compact in its texture; it is impressed with grooves, and distinguished into lobes on its *external* surface which respects the uterus, but is smooth and highly polished on its *internal*, which, looking towards the
foetus,

foetus, is invell'd or lined by the amnios. With regard to magnitude, thickness, figure, and situation or point of *cohesion* to the uterus, it is subject to a multitude of diversities; it is attached, however, for the most part, to the fundus or bottom of that organ; and is, upon the whole, equally destitute of both sensibility (§ 205.) and genuine irritability (§ 307).

§ 581.

Although all physiologists uniformly concur in this, that the *placenta* is the principal organ through the medium of which the tender foetus is supplied with nutriment, yet various controversies have latterly existed among them respecting the genuine mode of *its* official action, and its reciprocal relation, as well to the uterus as to the foetus. From an attentive and impartial consideration of all the testimony that can be collected on this subject, the result appears to be, that there exists no direct anastomosis between the blood-vessels of the maternal uterus and those of the umbilical cord; but the arterial blood which passes by a continuous route from the uterus of the mother to that portion of the placenta that owes its origin to the decidua crassa, is there absorbed by the incipient radicles of the umbilical veins, that are distributed throughout the moss-like portion of the chorion, and thus conducted into the

venous trunk of the *funis umbilicalis*: while, on the other hand, the blood which is conveyed back from the fœtus by the umbilical arteries, being in like manner effused into the parenchyma of the placenta, is taken up by the venous radicles of its uterine portion, and thus finally re-conveyed into the substance of the uterus itself.

The foregoing opinions receive additional confirmation from the many well guarded but fruitless attempts that have been made by different physiologists to inject the vessels of the umbilical cord through those of the uterus, or, on the other hand, to fill the *vessels* of the latter organ by injections forced through *those* of the former. As a further evidence in support of the same principles, we may mention the difference which is observed to exist between the pulse of the mother and that of the fœtus before their final disengagement from each other; and lastly, it may not be improper to add, as a circumstance tending to the establishment of the same result, the observations which we formerly delivered respecting the difference between the nature of the fœtal and that of the maternal blood (§ 147).

But further, it appears probable that a portion of chyle is also conveyed to the fœtus along with the blood of the mother. For besides the consideration,

ration, that the blood of the mother is not at all times equally pure and unmixed, but, for some hours after every meal, carries along with it, in an unassimilated state, that portion of chyle recently received from the thoracic duct, it has been demonstrated, on a former occasion, that the uterus itself possesses a singular and strong affinity to the chyle and milk (§ 550. 553.); and there are also on record a great variety of observations, from which it appears, that a milky juice has been actually discovered in the uterine portion of the placenta.

§ 582.

During the progressive advancement of pregnancy, while the foetus and fecundines increase so very remarkably in magnitude, it is obvious that the uterus must be also subjected to striking and remarkable changes. Besides the augmentation of its bulk, so extremely evident at first view, those changes respect also its *situation* and *figure*, but affect more especially the *texture* of this singular and important viscus. Thus, in consequence of the uniform and weighty congestion of humours which the gravid uterus is obliged to sustain, it is likewise subjected to extreme alteration, both with regard to the state of its blood-vessels, and

also with respect to that of its parenchymatous portion, throughout which those vessels are interwoven.

On the present occasion it may not be improper to observe, that in proportion as the impregnated uterus advances in magnitude, its bloodvessels lose that mazy and convoluted appearance, for which they are at other times so very remarkable, and assume courses much more rectilinear or direct; while at the same time they are subjected to a considerable extension of their diameters, and a consequent increase of their real capacities. Thus, even the uterine veins have become so extremely capacious and prominent, as to have been mistaken by numerous anatomists for true sinuses.

With regard to the parenchymatous portion of the impregnated uterus, it becomes gradually more and more lax and spongy, especially where it is in contact with the ovum contained; so that towards its fundus or bottom it becomes considerably thick, and in a living and healthy female, is greatly distended with blood, and possesses the powers of life in a very high degree. This organ is, notwithstanding, soft at the same time, and very widely different in its general habit and appearance from the firm and compact flesh of the
uterus

uterus in an unimpregnated state: this difference is still more striking if the subject containing the gravid *uterus* be dead, in which case, provided pregnancy be considerably advanced, this organ falsely assumes in its texture (as was formerly well observed by Arantius), a lamellated appearance.

It may not be amiss, on the present occasion, briefly to enumerate a few more of the most important changes to which the gravid uterus is subjected, together with the most remarkable ones that occur in the ovum and foetus. These changes we will consider in the successive order in which they appear throughout the series of *ten lunar* months, which period of time is now, with sufficient propriety, supposed to constitute the most natural term of pregnancy.

§ 583.

As we uniformly observe the uterus beginning to swell shortly after the time of impregnation, (§ 567.) so being from that period increased both in bulk and weight, it descends a little deeper into the superior part of the vagina; notwithstanding this descent it still retains its former figure in all, except the following, respects, viz. its fundus becomes a little more convex, its *anterior paries* or wall, recedes a little farther from the *posterior*, and its cavity, which was before very narrow and almost

almost triangular, now accommodates itself to the globose figure of the ovulum it encloses.

About the end of the first month, the ovulum itself amounts to the size of a pigeon's egg, and has the two deciduæ separated from each other, and also the small amnion situated at a distance from the larger chorion: about the termination of the third month it attains the size of a goose's egg, the *caduca reflexa* becomes approximated to the *crassa*, and the amnion approaches nearer to the chorion. The amnion abounds, at this time, with a profuse volume of fluid denominated *liquor amnii*. In this liquor the embryo, as yet very tender, and extremely small in proportion to the quantity of the surrounding fluid (being at this time scarcely equal in magnitude to a small mouse) appears to fluctuate in a loose and unsteady manner, and is even now in a precipitate position.

§ 584.

About the fourth month after conception, the uterus begins to assume more of an oval or somewhat globe-like appearance; its neck being more and more softened, gradually shortened, and as it were, destroyed, or rather latterly distended, it again protrudes upwards, and begins to ascend from the smaller into the larger pelvis. At the same time the fallopian tubes themselves, with the
convex

convex bottom of the uterus being elevated or borne upwards, are thus extended and elongated; these tubes are, however, attached and connected so closely to the sides of the uterus, that they cannot recede from them, more than one half of their own length; hence, when only viewed superficially, they appear to originate and proceed from the middle of the uterus, which has given birth to a very erroneous opinion respecting the astonishing increase of the *fundus uteri*.

From this time also the foetus acquires by degrees such an increased magnitude, as renders it more proportionate to the capacity of the ovum, and begins about the same period to fix itself in a more steady and firm position, which it preserves till the very close of parturition: in this position its head is placed in a downward direction, and its face turned towards the lumbar region of the mother, inclining, for the most part, somewhat obliquely towards the left side.

§ 585.

In the middle stage of pregnancy, which occurs about the end of the fifth month, the uterus has attained such a magnitude, that its fundus is elevated to a point half-way between the *pubes* and *umbilicus*, and the pregnant state becomes now
observable

observable from the external appearance of the abdomen.

About the same time, the fœtus becomes more perceptible to the mother from the agitative motion of its body, though we are not able to determine, with accuracy and definitude the precise period of time at which this motion takes place. It appears now, however, to be more vigorous and active, so that, according to the common use and acceptation of speech, it may be said to be the unequivocal action of life.

§ 586.

Throughout the five remaining lunar months the uterus, with the fœtus which it contains, make gradually still farther advancements in point of magnitude. Thus, at the end of the sixth month they reach nearly to the umbilicus or navel; and about the termination of the eighth approach even the scrobiculus cordis, in consequence of farther protrusion upwards. The *cervix uteri* is in the mean time more and more obliterated, reduced nearer to a level with the adjacent parts of that organ, and its parietes or walls considerably diminish in thickness.

§ 587.

§ 587.

Finally, about the end of the tenth month after conception, the uterus being oppressed and overpowered as it were, by its own bulk and weight, (its longitudinal axis, amounting in general to 11, and its transverse to 9 inches in length) begins again to subside, and as the period of parturition approaches, its *ostium* or mouth is gradually expanded, and thus exhibits an orbicular or ring-like opening.

Each *membrana caduca*, more especially the reflected one, which adheres to the chorion, having been gradually attenuated for several months immediately preceding, exhibits now a kind of net-like appearance distinctly marked by short fibres of a whitish colour.

Such is the size of the placenta at this advanced period, that its greatest diameter or breadth amounts to about 9 inches, its least diameter or thickness to about one inch; and its weight to about one pound, and sometimes more.

The length of the umbilical cord for the most part equals, and sometimes even exceeds, eighteen inches.

The weight of a mature and well grown fœtus is nearly seven pounds, its length about twenty inches.

The quantity of the liquor amnii is so extremely variable, that it cannot possibly be ascertained with any degree of definitude; in general, however, it scarcely amounts to a pound, provided the fœtus be healthy and robust.

SECT. XLV.

OF THE NISUS FORMATIVUS.

§ 588.

HAVING thus enumerated and described, in a plain and simple manner, the most obvious and unequivocal phenomena of conceptions, together with such changes as are discovered by attentive observation to succeed each other, during the progressive course of pregnancy, not only in the human ovum itself, but also in the fœtus which it embraces, and contains, we now proceed to an investigation of those physical powers, by the influence and efficacy of which the
sublime

sublime and truly astonishing process of generation appears to be most probably accomplished.

§ 589.

There are not wanting certain characters of high celebrity and distinction who attempt, even in our own times, to explain the divine process, in the following brief and summary manner; they contend that the genuine work of *actual generation* has not, at the present time, any real existence at all; on the contrary, they allege, that the whole human race possessed, under the form of original germs, a joint pre-existence in the genital system of one or other of our first parents, and that these germs have ever been, and are yet, subjected to gradual *evolutions*, according as the progressive lapse of time, aided by the co-operation of specific causes, has contributed to awaken them to the enjoyment of open and actual life.

Unfortunately, however, for the advocates of the foregoing hypothesis, an essential difference of opinion prevails among them on a point of considerable magnitude and importance; thus, while some of them are anxiously in quest of those *original germs* among the animalculæ that people the semen of the male; others are searching for those microscopic animals with no less industry and zeal in the ovaria of the female.

§ 590.

To the latter of these *sects* in physiology, I must acknowledge that I myself was formerly an adherent. I was lead to adopt the *opinion* of this learned body not only by the respectable authority of its numerous advocates, but also by the want of *another* more rational and satisfactory. At present, however, I am obliged to repudiate this doctrine entirely, to confess my errors, and endeavour if possible to correct them; having been fully convinced, from a more close and minute attention to the phenomena of generation, that nature performs this process in a manner quite different from that contemplated and embraced in the theory now under consideration.

§ 591.

For I am indeed daily more and more convinced, that all living organized bodies possess, from their earliest effort at organization to the closing glass of their existence, a peculiar power perpetually active, perpetually efficacious, the immediate destination of which is, first, to mould the bodies in which it resides into their native and *specific* forms by the mysterious process of *generation*, to preserve them afterwards from destruction by the ceaseless function of *nutrition*, and, in case of accidental mutilation, to restore their parts again, as far as consistent with the regular establishments

blishments of nature, by the process of *reproduction*. That this energy may not be confounded with the other kinds of vital energy, let it be distinguished by the name of *nifus formativus*. By this name, however, we mean to designate not so much a cause as a perpetual and uniform effect, the existence and reality of which are deduced from actual observations made on the constant and universal occurrence of certain physical phenomena. It is thus, with views, and on principles entirely similar, that we make use of the terms *attraction* and *gravitation*, to denote certain energies or sources of action, the *causes* of which are notwithstanding still involved in more than cimmerian darkness.

§ 592.

To me it appears, indeed, highly probable, that a stated period of time is requisite for accomplishing the intimate mixture, the union and complete concoction or maturity of those various inquisite humours, belonging to each sex, (§ 518. 524. 542. 543.) which are doubtless discharged into the cavity of the uterus, during every act of fruitful coition. This term of preparation having at length elapsed, and the liquors being fully matured and brought into the most perfect state of union and reciprocal influence, the *nifus formativus* is forthwith excited into action, by means of which the

spermatic mass, hitherto formless and chaotic, is partly arranged and organized into the elegant and beautiful envelopes of the nascent *ovulum*, and partly moulded into the figure of the living embryo which this minute bodies encloses. From this theory we can assign a satisfactory reason, why the uterus, for the two first weeks after conception, appears to contain a mass of crude and shapeless humours alone, and does not exhibit, even to our best glasses (now brought to very high perfection), the smallest vestige of an organized embryo, which, notwithstanding bursts into view almost instantaneously about the end of the third week, and is, even on its first appearance, of considerable magnitude.

§ 593.

Of the *nisus formativus* we are presented with more remote vestiges throughout every department of natural bodies, not excluding even the most simple elements of matter, where original germs cannot possibly be supposed to have the shadow of an existence. Thus, the clouds themselves assume their own determinate forms, and even the streaming torrents or veins of the electric fluid preserve specific figures. There are, again, in the mineral kingdom, specimens of metallic chrySTALLIZATION, which, if indeed the form alone be considered, and
the

the prerogative of life kept entirely out of view, bear the most striking resemblance to truly organized bodies.

In testimony of the truth of this, we need only mention the curious hypniform crystals into which refined or depurated copper shoots when first reduced to a state of fusion, or that exquisitely beautiful specimen of native peruvian silver which they call *filicinum* or *fern-like*, from the resemblance of its figure to that of the plant denominated fern.

§ 594.

In like manner both the animal and vegetable kingdoms afford numerous examples of organized bodies, in which, from their magnitude being sufficient to render them visible, from their beautiful and unclouded transparency and from the extreme rapidity of their progressive growth, the whole process of generation is completely unmasked as it were, and may be subjected to the examination of the naked eye. The result of attentive and minute observations made on this process in such subjects as these, will be sufficient to evince, on the authority of the most indubitable testimony that, at least in these bodies, no germs pre-exist. In illustration of the above position it will be sufficient to mention

from among the different individuals of the vegetable kingdom, the *conferra fontinalis*. And from those of the animal, the *hydra viridis*.

§ 595.

I should far exceed the limits prescribed to these institutions were I to attempt a minute and circumstantial detail of the various arguments which, in my view, nature herself furnishes to prove the potent influence of the nisus formativus in the process of generation. It may be proper, however, briefly to state a few of them, the force and efficacy of which will appear sufficiently evident on the slightest examination.

§ 596.

The first argument I shall further propose on this subject is taken from the history of those curious and interesting subjects of organized nature denominated *hybrids*. From a very beautiful and celebrated experiment it appears, that, if prolific female hybrids be successively through several generations impregnated by males of any given species different from the species of the females, the new offspring will gradually deviate so widely from the original form of the mother, and make such evident and effectual strides towards that of the father, as to lose at length every vestige of similitude to the former, and become finally, (by a
species

species of arbitrary metamorphosis) completely assimilated to the external figure and appearance of the latter.

§ 597.

There exists a phenomenon or fact relative to the history and production of *monsters*, (the truth of which is too well ascertained and established to admit of a doubt), that merits our attention while on the consideration of the present interesting and intricate subject. It is a circumstance well known to naturalists, that those animal productions denominated *monsters* (most of which are supposed, by the advocates for the celebrated doctrine of *evolution*, to have pre-existed in a monstrous *germiform* state from their original creation)—it is, I say, well known, that such preternatural productions, though very frequent among certain species of animals in a subjugated or domestic state (more especially among swine), are notwithstanding very rarely found among the original and free-born animals of the very same species, that have never been reduced to an humble state of domestication, but still range the commons and wilds of nature, wholly exempt from the tyrannic controul of man.

§ 598.

It is necessary further to observe, that not only monstrosities co-eval with the birth of animals, but also subsequent adventitious *mutilations* and other *species* of *deformity*, whether produced on the animal system by accident or design, become now and then completely *hereditary*; and thus, what was at first the effect of art alone, may be said to become at length the actual work of nature herself.

§ 599.

The phenomena of *re-production* in general are much more easily and rationally accounted for, by considering them as the result of a nifus formativus, than by referring them to the pre-existence of partial or local germs. This observation is more fully and clearly illustrated, and its truth more forcibly exhibited by an application of it to some particular instances of re-production, as that of the nails, for example, which after the entire loss of the *first*, are well known to be frequently regenerated on the *second* phalanx of the fingers.

§ 600.

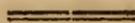
Again, in certain parts of the body where no pre-existence of germs can possibly be suspected, we not unfrequently see organic parts of a pre-ternatural

ternatural order produced by the *vis medicatrix naturæ*, when roused into action in consequence of *accidental diseases*: As an example, and in illustration of this, we may mention those small ossifications known by the name of *ossicula Wormiana*, which, in cases of *hydrocephalus internus*, are formed by the provident powers of the animal system, for the purpose of arching over and thus completely closing the enlarged *fontanel*.

§ 601.

Finally, on comparing with candour, and weighing with impartiality, the various arguments on each side of the question, it very evidently appears, that besides a *power of exciting* to motion and action, which the advocates for the pre-existence of germs attribute to the *male semen*, in order to render their favourite theory more specious and plausible, they must also bestow on that fluid *plastic* or *formative* powers of the utmost extent and influence: Whence it is obvious, that the doctrine for which they so zealously contend, is of itself wholly inadequate to the explanation of the numerous and intricate phenomena of generation, unless it be aided by the powerful concurrence of a *nisus formativus*: Whereas, on the other hand, the system which we have just proposed on the subject is, without the bold presumption of *pre-existent germs*, fully sufficient to explain all the multiplicity of phenomena attend-

ant on this divine process. Let us then on the present, as we should on every other point of controversy, adhere to that doctrine which is most simple in its nature, and most conclusive in its end, from a thorough conviction, that an unnecessary multiplication of entities or causes is no less repugnant to real and practical utility, than to the tenor and spirit of sound philosophy.



SECT. XLVI.

OF PARTURITION, AND ITS CONSEQUENCES.

§ 602.

THE fœtus being regularly formed and fashioned by the energies of which we have hitherto treated, and advanced through the progressive stages of its subsequent growth, till it be brought to a state of fœtal perfection, must, after arriving at this particular period of maturity, be finally ushered into the enjoyment of light and entire life, by the painful business of *parturition*.

§ 603.

This critical and important *period* arrives, agreeably to the usual order of spontaneous nature, (which is the only object contemplated in physiology),

logy), about the termination of the tenth lunar month, i. e. about the 39th or 40th week after conception.

§ 604.

When a pregnant female finally arrives at this eventful crisis, she is forcibly impelled to the labour of parturition by an insuperable *necessity*, already said (§ 295.) to be less subject to the controul of the will than that which urges to the performance of any other function belonging to the human body.

§ 605.

With respect to the *causes* of a revolution so determinate and sudden, different and even opposite opinions have been entertained by different physiologists. When we view, and take into attentive consideration, all the attendant circumstances, it appears necessary to refer the cause, which immediately impels to parturition, to an eternal law of nature, which has hitherto received no better explanation than has been given to a great many other physical phenomena, which take place in like manner at regular and *stated periods*; such, for example, as the metamorphosis of insects, the progressive stages of eruptive fevers, their crises, &c. &c. Without subjecting themselves to the just charge of fancifully entering on an absurd speculation,

speculation, certain physiologists have compared a mature ovum, in the uterus of the human subject, to the healthy fruit of vegetables, which when completely ripened, fall spontaneously from their parent plants, in consequence of a *self-constriction* of the vessels through which their nourishment was conveyed. It has been in like manner observed, that as the period of parturition approaches, the human placenta suffers a slight degree of constriction, and becomes thus prepared, as it were, for its impending separation from the surrounding uterus.

With regard to the *opinion* entertained on this subject by physiologists in general, namely, that the amazing expansion to which the impregnated uterus is subjected, with a multitude of other impressions or impulsive powers of a like nature, act as the genuine exciting causes of parturition, it appears to be very clearly and effectually invalidated by a great variety of *arguments*, which may be fairly deduced from the unequivocal phenomena of the animal economy itself: of these arguments we think proper to mention the following, namely, in numberless genuine cases of extra-uterine conception, where the fœtuses have been contained, for example, in the Fallopian tubes, or in the ovaria, the uterus has notwithstanding been attacked by painful and convulsive throws, about the

the termination of the tenth lunar month after the occurrence of such preternatural conception.

§ 606.

Besides the *exciting*, it is evident that there must be also the joint co-operation of very powerful *efficient* causes, arising from the nature and properties of the uterus itself, and of the contents which it encloses.

The *proximate* or immediate and primary cause must be doubtless referred solely to the *vita propria*, or specific life of the uterus itself (§ 47.)

Of the remote causes the leading and most considerable appear to be, the powerful efforts which are made by the assistance of the process of respiration, and the extensive consent or co-operation of the intercostal nerve with the other portions of the nervous system.

§ 607.

When finally the labour of genuine parturition is excited, its *phenomena* observe a determinate and regular order with regard to their commencement and subsequent progressive course. In consequence of this, they have been divided by accoucheurs into different *stages*, of which four have been enumerated by the latest writers on the obstetric art.

§ 608.

§ 608.

In the *first* stage, the parturient patient experiences a slight attack of those peculiar and well-known pains, called in that state *precursors* or *warnings*, which shoot in a direction from the loins to the lower parts of the uterus, and which are indeed felt at intervals, (though with diminished frequency and force), throughout the whole period of parturition: the orifice of the uterus begins, at the same time, to be considerably dilated, the abdominal tumor subsides, an inclination to pass urine becomes urgent and troublesome, and a copious discharge of mucus takes place from the genital organs, now in a state of distension and laxity.

§ 609.

In the second stage, the pains increase, and are now distinguished by the name of *preparantes*, or preparatory efforts: the inferior segment of the coverings or membranes of the ovum are, at the same time, protruded through the uterine orifice into the vagina.

§ 610.

In the third stage the pains still continue greatly augmented in their violence, and are now denominated *dolores ad partum* *. They act against the

* i. e. The genuine pains of parturition.

uterus with a more violent impetus, and thus potently protrude it downwards, while, at the same time the uterus presses with such astonishing force on the encarcerated foetus, as to occasion a rupture in the membranes by which it is inclosed.

§ 611.

During the *fourth* and last stage of parturition, while the patient is agitated with convulsive throws, and tortured with the most excruciating pain, she makes, at length, a violent exertion, (not unfrequently accompanied with horripilation, grinding of the teeth, trembling of the knees, &c.), by the impulsive force of which, the head of the emerging infant is urged forward, and finally protruded quite through the external orifice with its face foremost: in this unlooked for position it is forced to advance, in consequence of the vertex or crown of the head becoming lodged against the arch of the pubes, while its other parts are urged onward, and obliged to revolve on the stationary vertex, as on an *axis*, or centre of motion. Thus, amidst a profuse discharge of blood, the infant is finally excluded from its place of confinement, and introduced to the enjoyment of light and life.

§ 612.

The foetus being thus happily excluded, the *birth of the secundines* succeeds, after a short interval,

terval, accompanied, in like manner, with painful, though much less violent, throes: this latter birth is, as well as the former, followed by a discharge of blood, from that part of the uterine cavity to which the placenta adheres by means of the *crassa* or *grossa membrana decidua*.

§ 613.

The uterus, being thus, at once delivered of its two-fold birth, by which it had been encumbered and oppressed, is now contracted by little and little, till it is finally restored to its former figure, and reduced almost to its former size.

§ 614.

During the first week after the birth of the child, there exists, from the genital *organs* of the mother, an uninterrupted effusion of the *lochia*, a discharge very much resembling the catamenia, except that it is more profuse in quantity, especially when not in any measure checked or diminished, by the commencement of lactation. The bloody or florid colour of the liquid discharged by this evacuation is, notwithstanding, changed about the fourth day to a pale red, and from thence passes on to assume a white appearance.

As soon as the uterus is thoroughly cleansed of all remaining fragments of its deciduous membrane,

brane, and has thus finally completed the painful and tedious task of propagation, it may again resume the natural process of *menstruation*, or even return to the performance of fresh immolations on the altar of conception itself.

SECT. XLVIII.

OF THE DIFFERENCES BY WHICH THE HUMAN SUBJECT IS CHARACTERISED BEFORE AND AFTER BIRTH.

§ 615.

FROM what has been already said respecting the mode of life enjoyed by the fœtus, while yet incarcerated within the parietes, and immersed in the warm-bath of the maternal uterus, it is extremely obvious that an immense difference must exist, between the functions of the animal economy in this state, and that which shortly succeeds, when the infant is finally introduced, by birth, into entire life, and is possessed of a power of spontaneous motion. An enumeration and statement of the leading points or circumstances of this difference, constitutes the design of the present section.

§ 616.

To begin then with the circulation of the blood, it must be observed, that the *route* of this crimson fluid is different in the *fœtal* state, from what it is in *that* which immediately succeeds parturition or birth. During the continuance of the former state, the *fœtus* is connected, and preserves a circular intercourse with the uterine placenta, by means of the umbilical cord; it has never, as yet, inspired air for the purpose of supplying the blood with that vital pabulum, a process which immediately commences and is uniformly continued after birth, when this reciprocal connection between the mother and child, is finally destroyed.

§ 617.

The umbilical vein originating from the placenta of the mother, and passing through what is called the umbilical ring of the *fœtus*, directs its course towards the liver, where it discharges its blood into the sinus of the vena portarum; from thence the blood is distributed in part, by the ramifications of this memorable vein, throughout the liver, and in part, conveyed by a direct route through the *ductus venosus Arantii*, to the *inferior* or ascending vena cava.

The two foregoing canals, namely, both that portion of the umbilical cord which is contained

in the abdomen of the fœtus, and also the ductus venosus mentioned above, suffer after birth an entire obliteration of their cavities, and assume the nature and appearance of solid cords, insomuch that the former constitutes what is denominated the *round ligament* of the liver.

§ 618.

When, in the fœtus, the blood is conveyed from the inferior vena cava to the right side of the heart, the greater part of it is denied a passage from thence through the lungs, and is therefore directed towards the left or posterior auricle of the heart, by the valve of Eustachius, and admitted into that cavity through the *foramen ovale*.

§ 619.

For over the mouth of the inferior vena cava, after its ascent from the cavity of the abdomen in the foetal state, a valve of a lunated figure is extended, which, in honour of its immortal discoverer, has been called the valve of Eustachius. This luniform body is, for the most part, gradually obliterated as life advances, although in the foetal state it appears to perform the important office of directing the blood, emerging from the abdominal cavity, towards an *orifice* to be spoken of presently, which penetrates the septum situated between the two auricles of the heart.

§ 620.

The orifice referred to in the preceding paragraph is called the *foramen ovale*, through which by far the greater part of the ascending column of blood, derived immediately from the inferior vena cava, is conducted into the left *auris* of the heart during each diastole of the auricles: of this blood the regurgitation is effectually prevented, by the elegant falciform valve formerly mentioned, which is closely spread over the foramen, and appears to close that orifice completely, during each systolic motion of the auricles. During the first years of infancy the *foramen ovale* is in part closed by means of this small valve, and partly obliterated by the gradual but slow adhesion of its sides: in correspondence to such adhesion, the valve of Eustachius itself undergoes also a slow and gradual diminution in point of size, till scarcely a wreck of it is left behind.

§ 621.

Of that blood which, at the same time, enters the right auricle of the heart from the superior vena cava, a very small portion only can be received by the lungs of the foetus, as yet in a weak and inactive condition: it is therefore taken up by the *ductus arteriosus*, from the trunk of the pulmonary artery (of which this duct is indeed the leading branch) and conveyed by a direct and speedy route

to the arch of the aorta, without passing through the lungs at all. Within the course of a few weeks after the birth of the infant, the cavity of the ductus arteriosus is, for the most part obliterated, and its parietes or walls converted into the nature and appearance of a dense and firm ligament.

§ 622.

The blood being propelled through the trunk of the aorta, that portion of it, destined to be re-conveyed to the system of the mother, enters the *umbilical arteries* (§ 578.) which pass through the *annulus umbilicalis*, on each side of the *urachus*, and are, in like manner, after the birth of the infant, converted into solid imperforated cords.

§ 623.

As the lungs perform in the fœtus scarcely any function at all, their general *habit* and *appearance* differ very materially from those which they assume after the infant has commenced the process of respiration. Thus, their bulk is proportionably much less, their colour more dark, their substance more compact, and hence their specific gravity so much greater, that when immersed, recent and free from putrefaction, into a vessel of water, they sink instantly to the bottom; whereas, on the other hand, if the infant has been born in a living state, and taken in air by inspiration, these viscera,

for the most part, float on the surface of water, or of any other fluid equally ponderous. The right lobe of the lungs appears to possess the peculiar prerogative of being dilated a little sooner than the, left by the incipient influx of air in the first act of inspiration. With regard to the other phenomena of this new function of life, they were enumerated formerly, when we were treating particularly of the process of respiration.

§ 624.

From the observations which were formerly proposed on the nutrition of the foetus (§ 574, 581.), it may be very easily perceived that the state and condition of the *alimentary tube* and *chylipoietic system*, are extremely different before, from what they are after, the birth of the infant, these viscera being in the first case inert and wholly incapable of action. Thus, for instance, in the tender embryo of only a very few months existence, the *larger*, are perfectly similar in habit and appearance to the *smaller, intestines*; but during the closing months of pregnancy the *former* portion of the intestinal canal (being considerably distended with *meconium*) appears to merit unequivocally that name by which it is afterwards distinguished from the *latter*.

§ 625.

The *meconium* is a peculiar species of saburra, of a green colour, shaded with more or less of a brownish cast. It is doubtless derived from the inquiline humours of the fœtus itself, more especially from the bile: that it is indeed of a bilious origin we are induced to believe from the following considerations:—*First*, because the earliest appearance of this excrementitious substance corresponds exactly, in point of time, with the commencement of the biliary secretion; and, *Secondly*, because we learn from accurate observation, that such monsters as are destitute of a liver, have their intestines supplied with nothing else but a small quantity of colourless mucus instead of the more common and natural meconium.

§ 626.

In the new-born infant the form of the cœcum is also very widely different from what it is in the future periods of life; and this intestine is then continued in a direct line with the *appendicula vermiformis*.

§ 627.

Several other differences and peculiarities, of a similar nature, we have already spoken of on particular occasions, and shall here, therefore, only

glance on them in the most brief and transient manner:

They are the *Urachus* (§ 579.) the *membrana pupillaris* (§ 259.) and, in the male fœtus, the *descent of the testes* (§ 501.)

A few additional peculiarities will be spoken of with more propriety in the following section. Others, as being of less importance, we voluntarily pretermit in perfect silence.

§ 628.

The present appears to be indeed a very fit and favourable opportunity for calling the attention of the reader to three parts of the human body, altogether peculiar in their nature and obscure in their destination, which are of a greater proportional size in the fœtus than in the adult, and appear to be in a special manner subservient to the economy of the former. The true and unequivocal uses of the parts now in contemplation have not as yet, however, been clearly and satisfactorily ascertained, although, anxiously sought after by the combined labours of numerous and very respectable anatomists. These parts are designated by the name of glands, although their *parenchyma* is far, very far, different from the *glandular*, and they have never been discovered

to possess the faintest vestige of an excretory duct. They are denominated the *thyroid gland*, the *thymus*, and the *renes succenturiati*.

§ 629.

The *thyroid gland* is situated on the anterior side of a cartilage of the same name, which enters into the conformation of the larynx. It consists of two lobes, and is of a lunated or falciform figure; in the foetus it is distended with a lymphatic fluid, but, as life advances, becomes gradually more and more spoliated of its distending liquid.

§ 630.

The *thymus* consists of a mass of shining and very tender flesh, is, in like manner with the preceding substance, *bilobular*, now and then divided into two distinct portions, and contains also occasionally a cavity of considerable dimensions. This body is situated beneath the middle and upper part of the sternum, and ascends on each side even to the throat itself; in the foetus it is large, irregular in its figure, and abounds with a juice of a milk-like nature; but as youth advances it gradually diminishes in size, until, finally, on the accession of old age, it is so completely obliterated as to exhibit scarcely a shadow of its former existence.

§ 631.

Lastly, The *Renes succenturiatali*, (called likewise *glandulæ suprarenales*, *capsulæ atrabiliaris*, &c.) are situated beneath the diaphragm, resting on the upper extremities of the kidneys. In adults they are not only diminished in size, but are also removed to a small distance from the contact of the kidneys, and contain a dark coloured fluid, which in the fœtus is more inclined to a pale red.

 SECT. XLVIII.

 OF THE INCREASE, MATURITY, AND DECLINE
 OF MAN.

§ 632.

HAVING hitherto minutely considered the human economy, in detail, agreeably to the several classes into which its physical functions are divided, nothing further remains at present than to take a general, brief, and comprehensive survey of man in his transit over the diversified stage of life, and thus accompany him, from his earliest vital pulse in an embriotic state, throughout the
 leading,

leading *revolutions* and *æras* in his economy, down to the final termination of his existence.

§ 633.

First, then, about the third week after conception, the rudimental organization of the embryo appears to take place (§ 575.): about the fourth week afterwards, while the embryo still enjoys an extremely low and languid degree of life, bordering even on that of a vegetable, it is supplied with the first portion of genuine red blood (§ 13.) The motion of the *corculum* or minute heart, has been but very seldom observed by physiologists in the incipient human embryo, but was long since discovered by Aristotle in the incubated chick, and has been, from that period, designated by the name of the *punctum saliens*.

§ 634.

About the seventh or eighth week after conception, the momentous process of *osteogeny*, or the generation of bone, commences in the human subject. Those parts where osseous, or bony matter makes the first depositions for the formation of its *nuclei*, are the clavicles, the ribs, the vertebræ, the long cylindrical bones of the extremities, the mandible or lower jaw, and certain other bones of the face, &c. Those parts again where the osseous depositions are secondary in point of
time,

time, are some of the plain bones of the skull, such, for example, as the frontal and occipital:— while the bones of the neck, &c. are formed at a still later period.

The younger the embryo is, in particular, or to proceed on a more extensive and general scale, the younger the human subject is, whether before or after birth, with the greater rapidity does its growth advance, and *vice versa*.

§ 635.

About the middle period of pregnancy, the *foetus* becomes what may be called a genuine subject of *vitality* or life, agreeably to the rule of discrimination laid down on that particular point in a former part of this work (§ 585.) About the same time, the secretion of certain humours make their first appearance, such, for example, as the fat (§ 38) and the bile.

§ 636.

As the *foetus* advances towards maturity the tender *hair* begins to pullulate, the *nails* emerge into view, the *membrana pupillaris* gives way (§ 260), and in the male sex the *testes* begin to descend (§ 505).

§ 637.

About the close of the tenth lunar month, the *infant* is finally released from its imprisonment by means of parturition (§ 603); after which, besides the astonishing revolutions in almost the whole economy of its system, detailed more amply and minutely above, it is also subjected to various changes in its external habit and appearance; thus, for instance, that delicate lanuginous hair, with which the face of the new-born infant is overspread, disappears by degrees, its wrinkles are gradually obliterated, its anus retires within the *nates*, which now begin to be slowly protruded, &c. &c. &c.

§ 638.

The infant also learns, (though indeed by very slow degrees), the exercise of the various *faculties* of the *mind*, such, for example, as those of *perception*, of *attention*, of *reminiscence*, of *desiring*, &c. &c. from whence, in a very few months after birth, it is subjected to dreams, &c.

§ 639.

The organs of the *external senses* undergo also gradual or progressive improvements, and are advanced to still higher and higher degrees of perfection, such as the external ears, the internal nares,

nares, also the coverings of the eyes, such as their *supra-orbital* arches, their *supercilia*, &c.

§ 640.

The bones of the cranium acquire, in the mean time, an augmented degree of firmness. The *fonticuli* or chasms between the different bones are gradually arched over, and about the eighth month the process of *dentition* commences.

§ 641.

The infant is now ready to undergo *ablaetation* or *weaning*, being furnished with teeth for the express purpose of subduing more solid food, and not to injure the *papilla*, or nipple of the mother.

§ 642.

About the close of the first year, the infant learns to stand alone, and support itself *in an erect position*, the greatest and most enviable prerogative with which the human body is dignified.

§ 643.

The infant being thus removed from its mother's breast, and possessing the use and command of its feet, makes daily advances in growth, and improves in the power of spontaneous motion, while it acquires, at the same time, another very important privilege conferred on the human race, namely, the use of *speech*. Ideas which have become familiar

familiar to its mind it now begins to make attempts to express by the aid of that important organ the *tongue*.

§ 644.

About the seventh year of life, the *milk-teeth*, or first set, being twenty in number, drop out by degrees, and are replaced in a series of years by a second dentition, consisting of thirty-two perennial or permanent teeth.

§ 645.

During this period of infancy the *memory* far surpasses in strength and *perfection* the other powers of the mind, and appears to be indeed in a very peculiar manner adapted for receiving and retaining the *signs* of things; whereas after the fifteenth year of life, the glowing powers of the *imagination* usually gain the ascendancy.

§ 646.

This superior strength and activity of the imagination very happily manifests itself throughout those years of life in which the human subject is, by a variety of striking and very important changes in the body, gradually prepared for the future performance of such functions as constitute the characteristic distinctions between the two sexes.

§ 647.

§ 647.

Shortly after this period the mammæ or breasts of the female subject begin to swell, the chin of the male becomes clothed in a mantle of coarser down, and a variety of other phenomenon occur in each sex, which serve in like manner to announce the gradual approach of puberty: thus, in the female the *catamenia* begin to flow; while in the male the secretion of a true *femen* commences, which is uniformly accompanied by a more luxuriant crop of *beard*, and a very striking change in the voice from a shriller to a graver tone.

About the same time the *sexual instinct* (§ 289.) that spontaneous and potent call of nature, is first awakened into action, and man, now in the blossom of life, is fitted and inclined to venereal enjoyments.

§ 648.

The *crisis* or precise *period* of puberty cannot by any means be accurately ascertained. It is much varied by diversities of climate and of temperament. In general, however, it occurs earlier in the *female* than in the *male* sex; thus, in our climate females may be said to have arrived at this interesting period against the fifteenth, but males not before the twentieth year of life.

§ 649.

Shortly after the above period the human body finally ceases to increase in *stature*; this particular is also influenced and greatly diversified by difference of climate, not to mention the countless varieties that are exhibited relative to this point, not only by different individuals, but even by whole families.

§ 650.

About this period also the *epiphyses*, which had been hitherto distinguished from the bones to which they were attached by very visible lines of separation, become so intimately united to, and so completely coalesce with these bones, that not a vestige is left to serve as a memento of their former distinction.

§ 651.

With respect to the term of perfect *manhood*, which constitutes indeed the most lengthy, as well as most useful and important period of human life, we find it characterised by the highest degrees of *vigour* and *uniformity*, when we examine the functions of the body, and by that most invaluable prerogative, *maturity of judgment*, when we take into consideration the faculties of the mind. Throughout this interesting period the
lamp

lamp of human life blazes with the highest degree of intensity and splendor.

§ 652.

The *heralds* which unerringly announce the intrusive approach of *old age* are, in *females*, the cessation of the catamenia, (§ 547.), in *males*, a languid propensity to venereal gratifications, and in both an invasion of what is called the *rigidity* or *dryness* of old age, with a slow but sensible declination of the *vis vitæ*, or aggregate power of performing the various functions of life.

§ 653.

Finally, the frigid reign of the ultimate degree of old age is strongly characterized by the following concomitant phenomena, namely, a sluggishness and increasing dulness of the *senses*, both external and internal, an irresistible call for longer indulgence in sleep, and a torpidity and languor in all the functions of the animal economy. The hairs assume a silvery gray, and fall in part from their exalted situation. The teeth themselves drop spontaneously from their declining sockets. The neck is no longer able to support the head, nor the tottering legs to sustain the weight of the incumbent body. Even the bones themselves, those indispensable *fulcra* of the whole machine,

are obliged to bear a part in this irremediable and univerfal decay.

§ 654.

We have thus arrived at length to the remote *ultimatum* of phyfiology, namely, *death without difeafe*, or the *euthanafia of old age*. To conduct and protract human life to this only natural termination (the *caufes* of which are fufficiently obvious from what has been already laid down) conftitutes indeed the *alpha* and *omega*, i. e. the fole and exclusive end and object of the healing art.

§ 655.

The *phenomena* of this *natural death* (as obferved in man when about to refign himfelf to its potent grafp), are, a coldnefs of the extremities, a lofs of the brilliancy of the eyes, a very fmall and flow pulse, accompanied with intermiffions progressively increafing in frequency, and laftly a flow refpiration, which by a more forcible act of expiration, is at length clofed for ever.

In the live-diffections of animals belonging to the clafs mammalia, there is a convenient opportunity for obferving the laft exertions of the heart, from which it appears, that the right ventricle and auricle of that vifcus refift the encroachments

of death longer, and continue the motions of life to a later period, than the left.

§ 656.

Coldness accompanied by rigidity, a cadaverous stench, but more especially a flaccidity of the cornea, and a hiatus or gaping of the anus ascertain in the most unequivocal manner the complete death of the body. When in the corpse an *aggregate collection* of all these signs occur at once, not even the sceptical Pliny himself could find room to interpose the shadow of a doubt respecting the complete extinction of animal life,

§ 657.

To ascertain with definitude the natural *term* of the life of man, (or to point out that period which may be considered as the more frequent and regular *goal* or *ne plus ultra* of human existence), is, indeed, a matter attended with the utmost difficulty. I have notwithstanding learnt, from examining with care and comparing with accuracy, a great number of bills of mortality, that a considerable proportion of such Europeans as are advanced in years reach, but that very few of them pass, *the eightieth and fourth year* of life.

§ 658.

We may observe upon the whole, that in consequence of the weakness and tender susceptibility of infancy and childhood, the intemperance and irregularity of an infinitude of adults, the uncontrollable violence of diseases, and a countless multitude of fatal casualties, not more of mankind than seventy eight in a thousand resign their lives to that species of *death* now under consideration, namely, *death* without *disease*. Notwithstanding the truth and authenticity of the preceding observation, yet on making a genuine estimate of *human longevity* and comparing it, under similar circumstances, with *that* of the other subjects belonging to the class *mammalia*, whose *natural term* of existence is known to us, it will evidently appear, that, except the baseless declamations of *sophists* regarding the *miseries* of *human life*, nothing can be more unfounded and irrational than *their* splendid and verbose effusions respecting *its brevity*.



A P P E N D I X,

IN WHICH IS EXHIBITED A

Condensed and Summary View

OF THE

EXISTING DISCOVERIES AND SPECULATIONS

Relative to the Subject of, what is usually denominated,

ANIMAL ELECTRICITY.



STEADY and uniform as the lapse of time itself, are the exertions made by the enterprise and industry of man, to shed light on the *arcana* or *secret processes* of nature. In proportion as such laudable attempts are prosecuted with boldness and crowned with success, *revolutions* and *improvements* take place in the various branches of physical science. Revolutions derive birth from the detection of error, while improvements result from the discovery of truth. On the repudiation of false principles in science, as well as on the developement of new ones deduced from the reci-

procal concurrence of numerous and unequivocal facts, it is not without the sanction of reason and propriety that new systems are forthwith compiled, digested and ushered into the world.

For, to be complete and satisfactory, a system in any branch of science, should embrace and arrange in order all the well authenticated principles spontaneously resulting from facts already ascertained and observations already made, relative to that particular branch. A system less general and comprehensive in its scope than this, should be deemed, at best, but defective and partial, and received as the abortive production of a mind deficient in point of information.

Of the former description was the famous physiological system of Baron Haller, at the time its illustrious author first submitted it to the eye of the world. That excellent physician and philosopher grasped in his acute and comprehensive mind, and detailed at large, in the work to which I here allude, all the authentic and well defined principles resulting from the infinitude of facts with which the science of physiology was at that time enriched.

But all systems are stationary and have been as yet imperfect, while, happily for the interest of
man,

man, improvements in science are progressive and advancing towards perfection. In the course of a few years, such a blaze of physical light was diffused abroad by the industry and ingenuity of philosophers in general, but of physicians and chemists in particular, that the deficiencies and errors of the Baron's elaborate system were rendered obvious to the most weak and inattentive observer. In the important *doctrines* respecting the *causes* of animal heat and the *nature* and *purposes* of respiration, in particular, entire revolutions were effected by the numerous and ingenious discoveries of chemists in that branch of science denominated aerology.

To supply, as far as possible, the deficiencies of this system of Haller, and to circumvent the errors which the authority of so celebrated a character might tend to diffuse throughout the minds of his numerous readers, became *desiderata* of no small moment in the science of physiology.

The most effectual method of accomplishing these desirable ends was too obvious to escape discovery. For as violence is most effectually repelled by counter violence, and one disease not unfrequently removed from the animal system by the impetuous invasion of another, so in like manner, in science, the defects of one system are most advantageously

supplied, and its errors most effectually contraverted and exposed, by the plenitude and unequivocal certainty of the principles of a rival system.

This truth did not escape the observation of that learned and acute professor, of Goettingen, who now fills the chair which was formerly rendered vocal by the eloquence of the immortal Haller. Need I add, that professor Blumenbach is the man to whom I allude—a man, for the completion of whose greatness and utility in physical science, nature and art appear to have all but exhausted their abundant resources! For industry and perseverance in the collection of materials, for powers to combine and arrange materials when thus collected, and for ingenuity and acumen to deduce and speculate from such combination and arrangement, the present age certainly boasts few—too few physiologists who may be set in competition with the illustrious Blumenbach.

For this physician and philosopher was reserved the honourable and important task of collecting, digesting and consigning to publicity, a system of physiology destined to supply the deficiencies and correct the errors of that which had already resulted from the labours of his celebrated friend and predecessor. The system of professor Blumenbach was, like that of Baron Haller, perfect and
complete

complete at the time in which it was handed to the world. There existed not, at that period, an established principle, nor scarcely even a probable conjecture in physiology, with which he was not minutely acquainted, and which he did not draw into the extensive and powerful *vortex* of his system.

Had the science of physiology been finally complete at the time in which professor Blumenbach wrote, the industry, the immense resources and the comprehensive talents of that philosopher would, no doubt, have quite precluded the necessity of future systems in this branch of science. But in the unfathomed depths of the animal economy more *arcana* yet existed—more *terra incognita* lay yet unexplored, and further researches of enterprise were therefore essential.

By the combined labours of experimental physiologists in different parts of the world, this branch of science was at length matured for giving birth to another *discovery*, which will probably be found of equal importance, in explaining the phenomena, and in removing the defects of the animal system, with that which consigned to immortality the name of the illustrious Harvey. The discovery to which I wish at present to direct the attention of the reader is that of, what is usually called *animal electricity*,

electricity, or, of the existence and operation of a fluid extremely similar to electricity in the living animal system. For the fortunate Galvani professor of anatomy at Bologna, was reserved the honour of lighting *by accident* on this beautiful and divine discovery—a discovery which entitles its author to be ranked with the great promoters of science and the essential benefactors of man.

That such a fluid did actually exist in the bodies of animals, had been long suspected by physiologists and other speculative philosophers. The matter rested however on pure conjecture alone, and was yet unfructified by the tests of experiment and observation. The apparent intricacy of the subject depressed the hopes of the boldest experimenters, and the subtlety of the investigation seemed to throw an insurmountable bar in the road to success. But *accident* not unfrequently does more for the real advancement of science, than boasted genius and industry are able to accomplish. It was accident that first suggested to the celebrated Gallileo the construction and use of that optical instrument denominated the *telescope*—It was accident which first led the immortal Newton to the original conception of that principle of *gravitation*, by which he afterwards explained, with such facility, the movements and exquisite balance of the material universe. And it was,

was, in like manner, accident—fortunate accident, that first suggested to the industrious and acute Galvani the mode of experimenting, with effect, on the intricate subject of *animal electricity*—a subject which may possibly be destined as the only proper clue to conduct future physiologists to the genuine springs and principles of life itself.

“Whilst the professor (alluding to Galvani) was engaged in dissecting a frog in a room where some of his friends were amusing themselves with an electrical machine, one of them drew a spark from the conductor, at the same time that the professor touched one of the nerves of the animal. In an instant the whole body of the frog was shook by a violent convulsion. The professor was astonished at the phenomenon, and believed it owing to his having wounded the nerve; to assure himself whether this was really the case, he pricked it with the point of his knife, without any motion of the body being produced; he now touched the nerve with the instrument as at first, and ordered a spark to be taken from the machine, on which the contractions were renewed. The experiment was repeated a third time, but the animal remained motionless; however, upon perceiving he held his scalpel by the handle, which was of ivory (a bad conductor), he changed it
for

for a metallic one, and re-excited the movements, which he constantly failed of doing whilst using an electric substance.

“ After having made a number of experiments with the electrical machine, he resolved to prosecute the subject with atmospheric electricity. To this end he raised a conductor upon the roof of his house, from which he brought an iron wire into his room, and to this attached metal conductors, connected with the nerves of the animals destined to be the subjects of his experiments, and to their legs he tied wires, which reached the floor. Considerable movements were observed in the animals, whether of cold or warm blood, whenever it lightened. These preceded thunder, and corresponded with its intensity and repetition, and even when it did not lighten the movements took place when any stormy cloud passed over the apparatus.”

“ Professor Galvani one day suspended some frogs, perhaps with similar views, on metal hooks, fixed in the spine of the back, upon the iron railing of his garden; several times he remarked that these animals contracted, and appeared to receive shocks; at first he conceived the movements were owing to changes in the atmosphere, but a more scrupulous

scrupulous examination undeceived him. Having placed a prepared frog * upon an iron plate in his room, and happening with his dissecting forceps to press it against the plate, he observed the movements to take place. This experiment succeeded with all metallic bodies, but more particularly well with silver; non-conducting substances were not proper for it. From this period our author began to suspect the animal possessed an electricity of its own; and in this suspicion he was further confirmed by the following circumstance:—He held

* That the reader may not be entirely ignorant of what is meant by a prepared frog, I take the liberty of presenting him with the following brief extract from the first experiment detailed in Dr. Valli's publication: "My first experiment was made on a frog, in the following manner: I opened the abdomen in order to lay bare the spine of the back, and discover the crural nerves which issue from it; a few lines above this point I cut the animal in two, and by passing my scissors immediately under the origin of these nerves, removed the remaining portion of the vertebral column, so as only to leave the vertebræ which united the bundle of nerves. Having enveloped this portion of the vertebræ with a piece of sheet lead, with one end of a metal conductor, I touched the coated part, and with the other the surface of the thighs, which had been previously stripped of the skin. The movements were violent, and continued for a long time," &c. In general, throughout the whole of this physician's experimental treatise, when one or more of the nerves of an animal are coated with sheet-lead or any other metal, that animal is said to be *prepared*.

a prepared frog by a hook with one hand, so as to let its feet rest upon the bottom of a small silver cup, which he happened unintentionally to strike with the other; at the instant the body of the animal fell into violent convulsions. If one person held the prepared frog, and another touched the cup, no movements were excited. The professor being now aware of the necessity of a communication, undertook a series of experiments for the farther investigation of this subject. He first placed a prepared frog upon a non-conducting surface, and brought one end of a conductor in contact with the hook which secured the animal, and with the other touched its feet, on which the contractions took place. When the conducting arch was interrupted by a non-conducting substance, the frog remained motionless, &c."

No sooner had professor Galvani published to the world his experiments on animal electricity, than their fame dispread, swift as the intangible fluid which they regarded, throughout the different parts of Europe. Animal electricity became, in a short time, a subject of very interesting speculation to medical philosophers. Among the several physiologists who entered the lists in this investigation, the most distinguished whose writings have fallen into my hands, are Dr. Valli, an Italian physician, from whose publication the preceding
account

account respecting the first discoveries of Galvani is extracted, and Mr. Fowler, a native of the island of Great Britain.

Doctor Valli appears to have led the van of those philosophical characters who first co-operated with the celebrated Galvani in investigating that animal fluid, the existence of which had been so long suspected, but so lately realised by actual experiment. After repeating most of the experiments of his predecessor in this branch of physics, the Doctor proceeded to a series of new experiments, mostly conceived and instituted by himself.

The objects which he appears to have kept steadily in view throughout the whole course of his experiments and observations were, to ascertain the *nature* of the animal fluid discovered by the professor of Bologna, and to determine its *influence* and *medium* of operation in the animal economy. In the prosecution of these ends the Doctor has doubtless displayed all that industry and patient perseverance, so essentially requisite in the character who would successfully inquire of nature, through the medium of experiment. I am sorry, however, to observe, that all his experiments were not conceived and instituted with equal ingenuity, and perhaps I may add, not executed with equal accuracy and definitude. Many of
many

them appear to have been instituted without a direct reference to any specific or particular end— Equally unhappy with regard to conception, indefinite with respect to their nature, and inconclusive in point of result, they leave no *impressions* on the mind of the reader, save those of *disappointment* and *regret*—regret that a character of such learning and industry should, notwithstanding, interrogate nature with so little meaning, and (I am sorry to add) with so little success.

The preceding observations must be considered only in the light of *general rules*, and as such, are liable to numerous exceptions. Many of the experiments of Dr. Valli are, doubtless, both ingenious and valuable; and I even entertain the utmost confidence, that the period will yet arrive, when the whole of them, that are ascertained and related with justness and definitude, will be made subservient to the establishment of general and useful results. At present, however, they stand in an *insulated* state, completely detached from practical conclusions, and disconnected from all known principles in physical science.

After a series of experiments sufficiently lengthy and tedious, the Doctor conceived himself unequivocally authorized to conclude, that the animal fluid of Galvani, was entirely the same with the

subtle matter of electricity. This conclusion he alleges to be the spontaneous and necessary result of the following positions, which he delivers as substantiated and confirmed by actual experiment.

“ First, substances which conduct electricity, are conductors likewise of the nervous fluid.”

“ 2dly, Substances which are not conductors of electricity, do not conduct the nervous fluid.”

“ 3dly, Non-conducting bodies, which acquire by heat the property of conducting electricity, preserve it likewise for the nervous fluid.”

“ 4thly, Cold at a certain degree, renders water a non-conductor of electricity, as well as of the nervous fluid.”

“ 5thly, The velocity of the nervous fluid is, as far as we can calculate, the same with that of electricity.”

“ 6thly, The obstacles which the nerves, under certain circumstances, oppose to electricity, they present likewise to the nervous fluid.”

“ 7thly, Attraction is a property of the electric fluid, and this property has been discovered in the nervous fluid.”

Having enumerated and detailed the foregoing arguments, the Doctor, in an effusion of triumph, subjoins, “ We here see the greatest analogy between these fluids ; nay, I may even add, the characters of their identity.”

As an additional support to the same opinion, Dr Valli adduces the peculiar and striking phenomena exhibited by the *torpedo*, the *gymnotus electricus*, the *silurus*, &c. which proceed, as he alleges, from a fluid in every respect the same with that which was discovered in frogs, by the professor of anatomy at Bologna. As the Doctor, however, has advanced nothing in confirmation of such entire sameness, save a certain remote analogy which he says he has discovered between the muscles of animals, and the *electrical apparatus* of the torpedo, the gymnotus, &c. it is obvious that this latter argument will but very slightly impress the philosophical physiologist, who founds his belief of principles on *facts*, rather than on vague and visionary *conjectures*.

Having thus, as he supposed, satisfactorily ascertained the identity of the *nervous* with the electric fluid, he next proceeds to speculations on its influence in the diversified movements and functions of the animal economy. To me, however, I must confess, the greater part of this speculative investigation, appears to be rather the effervescent
effusions

effusions of an *imagination*, heated to excess in a favourite pursuit, than the solemn *decisions* of a tranquil and unbiaſſed *underſtanding*. I acknowledge myſelf unable, in many inſtances, to diſcern the neceſſary nexus or affinity between his concluſions, and the facts from which they are deduced:—or perhaps I may ſpeak my ſentiments more fully when I ſay, that the learned author appears not unfrequently to have ſubſtituted mere *hypothetical allegations*, for fair and logical *concluſions*—the vacant reſults of his own conjectures, for genuine principles developed by experiment, and aſcertained by obſervation. It very often happens, that by attempting to embrace too much under a ſingle cauſe, we extend the tortured principle beyond its natural limits, and thus, to appearance, weaken or render doubtful its influence, even on thoſe phenomena which it immediately regards. This obſervation applies with too much propriety and force, to the ſpeculations of the indefatigable Valli. By attempting to explain *all*, he has in fact explained *none*, of the phenomena of the animal economy, by that ſubtle fluid on which he ſo patiently experimented. Many of his phyſiological facts and ſpeculations are indeed ingenious and intereſting, but, in my view, they are equally deducible from any other ſeries of experiments, as from that by which they are preceded in the Doctour's publication. Many of the learned author's facts may be, no doubt, true and well

defined, and some of his principles and results to a certain degree interesting to the physician and philosopher, but, taken in the aggregate, they are too disjointed to constitute any thing like a system, too disconnected to form a regular chain of investigation. On my mind, his *speculations* on the causes of *muscular motion*, *sensation secretion* and *nutrition*, impress no more solid conviction than do *those* of Stahl on the subject of his *anima medica*, of Van Helmont respecting his subtle *Archeus*, or of the airy Paracelsus with regard to his *planetary influence*. Notwithstanding the apparent severity of the foregoing observations, I am still obliged to declare it as my opinion, that the novelty and importance of the subject on which Dr Valli has experimented and written, entitle his work to the particular attention of the learned and ingenious of every nation.

For the want of system and requisite decision in the writings of the preceding author, compensation is, in a great measure, made by a subsequent publication of the accurate and ingenious Fowler. The experiments and speculations of this young philosopher, on what he terms, the "*influence discovered by Galvani*," made their first public appearance at Edinburgh, in the course of the year 1793: they are not, indeed, so numerous as those of the Italian physician, but they appear to have been
conceived

conceived with more design, and executed with more judgment. Mr. Fowler seems to have been among the first who controverted the opinion of Galvani and Valli, respecting the identity of the nervous and electric fluids: and he has, doubtless, controverted it with ability and effect.

Mr. Fowler preliminates his observations, with a lucid and forcible statement of a certain previous combination of circumstances, which he alleges, must have strongly prepossessed the mind of professor Galvani, with a belief of the sameness of the preceding fluids.

That such a prepossession must have had, indeed, a powerful effect on the subsequent deductions and conclusions of the Professor, will be readily acknowledged, by every one who has experienced the influence of preconceived opinions—an influence pregnant with error, and leading countless evils in its train.

Mr. Fowler proceeds then to mention the first object which engaged his attention, in the commencement of his interesting inquiry, and which appears well calculated to pave the way, for the more easy and effectual accomplishment of his experimental course. This, to make use of his own words, was, “to ascertain, as well the various

rious circumstances, essentially requisite to the production of these new phenomena, as those in which they can be rendered most obvious." The issue of his enquiry on this subject, I will also lay before the reader in his own words. "After" says he, "a great variety of experiments, of which it would be unnecessary here, to relate more than the result, I found, that I could not excite in an animal the appearances described by Galvani, with any substances whatever, whether solid or fluid, except the metals: and that the mutual contact of two different metals with each other, so far as I was able to determine, was in every case necessary to the effect."

After a satisfactory attainment of this object, the ingenious author next proceeds to a judicious series of experiments, with a view to discover the genuine nature of the animal fluid, first realised by the fortunate professor of Bologna. Of those experiments he does not give us a minute specification, but only furnishes statements of their most obvious and striking results. These statements he also occasionally intersperses with interesting and important remarks, and some very ingenious speculations.

Having finished his series of experiments, (a series sufficiently numerous and diversified for the
establishment

establishment of general principles) relative to the nature of the nervous fluid, and its affinity to the matter of electricity, Mr. Fowler at length favours us on this subject with the following conclusions, which I shall take the liberty of presenting to the reader in the words of their ingenious author.

After having stated a few analogies between the animal fluid of Galvani, and that possessed by the *torpedo*, he then reverses the comparison, and lays down several points of essential difference, not only between the two preceding fluids, but also between the former of them, namely the fluid of Galvani, and the matter of electricity.

“ This influence, (says he, referring to the nervous fluid of animals) differs, both from that of the *torpedo*, &c. and from electricity, in producing no sensation (in man at least) at all similar to that of an electrical shock.”

“ — That some kind of disagreeable sensation is occasioned by it, even in frogs, independent of that which must necessarily arise from irritation and the contractions of their muscles, is evident from their restlessness and expressions of uneasiness. In other animals, as I shall afterwards have occasion to shew, these expressions are still less equivocal: and in man we can ascertain both their

degree and their kind. That they differ considerably from such as are produced by electricity will be proved when I come to speak of the effects of this influence upon our senses."

"But the most important, and characteristic difference which I have yet been able to discover, between this new influence and electricity, consists in their effects upon the contractile power of animals and of plants. The contractions of animals excited by electricity have a tendency to destroy that power upon which contractions depend. But the contractions excited, by the application of the metals, have, in all my experiments, had the directly opposite effect. The more frequently contractions have been in this way excited, the longer do they continue excitable: and the longer are the parts upon which such experiments are made, preserved from putridity. An influence, capable of exciting contractions without occasioning exhaustion, was a thing I so little expected to find, and so contrary to the character which had been given of this both by Galvani and by Doctor Valli, that I at first distrusted my own observation of the fact: but the number of comparative experiments which I had afterwards occasion to make, though with views different from that of ascertaining the point in question, convinced me that this influence, so far from
destroying

destroying the contractility of muscles, has a tendency to preserve it. Oxygene is, so far as I know, the only stimulus in nature, whose effects are at all analogous."

"When a frog has been long dead, I have been sometimes more than a quarter of an hour without being able to excite a single contraction by the application of the metals: but after this, without at all varying the means employed, contractions have appeared, and have become gradually more and more vigorous."

"It is said (for I have never had an opportunity of making the experiment), that a stream of electricity, passed through a sensitive plant, produces an almost immediate collapse of its leaves. But the influence discovered by Galvani produced no such effect in the following experiment. Having separated the leg of a frog from its body, I freed its crural nerves from surrounding parts, and with one hand held it supported upon the end of a probe. An assistant placed a piece of silver under its foot, and held the zinc with which it was to be touched. A sensitive plant formed the medium of communication between us. He held the bottom of its stem between his fingers, while I held the top; so that when the silver was touched by the zinc, the influence passed up the plant, and
through

through the whole of its stem. The frog's leg instantly contracted, and repeated its contractions every time the silver and zinc were brought in contact: but the leaves of the plant did not collapse; neither did they when any of its branches formed part of the circuit."

I must however, confess that the plant, upon which this experiment was made, had been kept through the winter. With a young one the result might possibly be different; but such an one I have not yet had in my power to procure.

"The torpedo does not appear at all affected by the influence which itself produces. Animals in which Galvani's phenomena are produced, are strongly affected."

The very ingenious author passes on next to report the result of certain experiments which he instituted, in order to refute the opinion of those, who allege, that the fluid of Galvani proceeds entirely from the metallic substances used, and does not reside at all in any part of the animal system. In his enquiry respecting this point he displays the same fertility in devising, the same sagacity in judging, and the same ingenuity in deducing, which so forcibly impress the reader throughout every part of his experimental investigation.

gation. He also farther shows, that the nervous influence of Galvani, and the subtle fluid of electricity differ very materially from each other in the following particular, namely, that against the effects of the former, animals are able to guard themselves by means of a certain voluntary exertion, whereas the operation of the latter is not in the smallest degree subject to the controul or influence of the will.

Having finished the consideration of the *nature*, Mr. Fowler proceeds to make some useful *applications*, of the influence discovered by the professor of anatomy at Bologna. In his attempts to shed light on certain controverted points, and to solve certain abstruse questions, in physiology, by means of this fluid, he appears no less ingenious and satisfactory than in the former parts of his enquiry.

He appears peculiarly happy and conclusive in his researches after the *source* from whence the nerves and muscles derive their respective powers. I beg leave to lay before the reader two of the author's experiments, instituted for the purpose of ascertaining this interesting particular—a particular which has so long furnished a subject of controversy among speculative physiologists. The latter of the two experiments, (to which the former serves

ferves only as a necessary introduction) is of itself more than equal to all that has ever been advanced on the opposite side of the question.

EXPERIMENT I.

“ I divided (says Mr. Fowler) the sciatic nerve of one leg, and tied the crural artery of the other in a large frog. Scarcely any blood was lost in doing either. Two days after this I strangled it. During the first 24 hours, the leg in which the nerve had been divided, appeared to contract with the most vigour; after this period the difference between them became more doubtful; but the contractions were at no time stronger in the leg whose artery was tied, than in that whose nerve was divided.

EXPERIMENT II.

“ The same operations were performed upon a large female frog full of spawn. Four hours afterwards she was covered by a male, who had been treated in a similar manner. I mention this circumstance, as it tends to prove, that the pain occasioned by the operation was probably not so great as to produce much fallacy.

“ On the day following, she had spawned, and on the sixth day from the operations, she was strangled. When laid upon a plate of zinc, and
excited

excited by means of a rod of silver, the contractions were found extremely feeble in the leg whose artery had been tied, and ceased altogether in about twenty-two hours after her death.

In the leg, whose nerve had been divided, they appeared as vigorous as they usually are in legs to which no injury has been previously done, and continued excitable upwards of two days after they had ceased to be so in the other."

It may be proper on the present occasion briefly to observe, that the influence discovered by Galvani was the test used by Mr. Fowler to determine the existence or cessation of irritability in the muscles of the animals subjected to the preceding experiment. For this influence, as our author judiciously observes, appears to be indeed by far the best and most delicate test that has ever yet been discovered for ascertaining the lowest possible degrees of muscular irritability. After having become wholly insensible to the impressions of all other stimuli, muscles still continue to vibrate to the kindred touches of this subtle fluid, to which nature appears to have given them such a nice, and, perhaps I may say, specific correspondence.

Mr. Fowler, after having transiently glanced on the subject of inflammation, passes on to the
attack

attack of a physiological doctrine, propagated with zeal, and supported with ability by that celebrated experimentalist, the Abbe Fontana. The doctrine alluded to, embraces the existence or residence of a certain vital principle in the volume of the blood. On this principle, as the industrious Abbe alleges, poisons produce their instantaneous effect, when introduced into the vascular systems of living animals. To all the different parts of this physical *doctrine* I could never yet be induced to subscribe, notwithstanding the respectability of its learned and numerous advocates.

By attacking and vanquishing one of its most powerful champions, Mr. Fowler has doubtless contributed much to its final demolition. For, in the contest now under our immediate consideration, I must confess, that to me the laurels of victory appear to be fairly wrested from the silvered temples of the *Italian*, and planted over the youthful brow of the *British* Philosopher.

I have thus exhibited a view, somewhat general indeed, though confessedly very succinct, of the results laid down, and of the opinions entertained, by the ingenious Fowler, on the subject of the animal influence discovered by Professor Galvani. To lay before the reader a full account of all that is useful and important in the observations of this interesting

interesting author, would be to transcribe and reprint his whole publication.

The only productions in the English language, which this country now furnishes, professedly on the subject of the animal fluid discovered by Galvani, are (as formerly observed) those of Fowler and Valli. On the comparative merit of those two authors I will here take the liberty of advancing a few general, and, I flatter myself, impartial, observations :

The experiments of Doctor Valli are more numerous and pompous—those of Mr. Fowler more definite and intelligible. The former author appears *ostén*, the latter, *never*, to have experimented without some determinate end in view. The experiments of the Italian may be compared to the promiscuous plants of the forest, strewn at random by the sportive and irregular hand of nature—those of the young Briton, to choice and valuable collections, arranged with order and elegance, in a well regulated and beautiful garden. The experiments of Valli appear to throw into *shade*, those of Fowler into *light*, the objects which they immediately regard. From the former, the reader collects information with difficulty, from the latter, without labour or painful attention.

In

In their deductions and speculations, the two preceding authors are no less dissimilar, than with regard to their experiments themselves. Valli is more diffuse and often hypothetical—Fowler more pointed and generally conclusive. Valli appears to give loosened reins to a glowing imagination—Fowler to be constantly under the steady guidance of a powerful and well-cultivated understanding. The former makes a greater display of learning, and, therefore, too frequently views objects through the more obscure *media* of previous publications—the latter exhibits a higher degree of ingenuity, and derives the principal part of his information, not from pages, sanctioned only by the names of celebrated, yet fallible, authors, but from the great *folio*-volume of *nature*, impressed with her own signature. On the whole, Valli has experimented and written in the most lengthy and profuse—Fowler in the most definite and conclusive manner. In many parts of the writings of the former, nothing else than the *fiat* of an almighty genius would be able to bring *order* out of *confusion*—in those of the latter, lucidity, connection, and regularity, shine pre-eminent through almost every page.

Having thus, without reserve, delivered my sentiments on the *publications of others*, I hope I may be allowed to trespass on the reader's attention

while I make a few observations relating to *my own*.

Nothing could have induced me thus hastily to forsake the humble, but secure, retreats of obscurity, and risk myself before the eye of the world in the hazardous character of an author, save a solicitous wish to contribute to the advancement of medical science, and thus aid in acquiring for man a more effectual exemption from misery and pain. I saw with regret the literary treasures of a Blumenbach concealed from the view of my fellow-citizens beneath the drapery of an ancient and an obsolete language. I was anxiously desirous to see the physiological system of that illustrious character completely clothed in the language of my country. I engaged in the translation of this work, not because I conceived myself better qualified for its execution than others, but because others appeared to me unpardonably remiss with regard to the undertaking. The execution proved laborious and difficult beyond my expectations. The difficulty of detecting an author's precise meaning through the dusky medium of a Latin expression, can be fully understood and realised only by him who has made the arduous experiment.

Even after the ideas and opinions in the original are fully embraced and completely comprehended, another difficulty of no small magnitude still remains, namely, to convey them to the reader with unequivocal definitude, through the indefinite medium of a different language. It is well known how extremely liable we are to misapprehend the precise meaning of an author who even writes in our own vernacular tongue, much more so of one who publishes in a language but little used in conversation, and, at best, but imperfectly understood by any man living.

Should the foregoing translation ever fall into the hands of the celebrated professor of Geottingen, I hope he will receive, with candour and indulgence, a well meant attempt to extend the empire of his utility and his fame, by increasing the number of his admiring readers. If the translation be in any part erroneous, in any part deficient, strictures and corrections will be thankfully received, and punctually attended to in a second edition of the work, should a second be demanded by a patronising public.

To preserve as far as possible the firm and energetic spirit which characterizes the writings of the illustrious professor of Goettingen, and to convey

convey to my readers the facts, the principles, the speculations, and the opinions contained in his original work, without even the shadow of alteration, diminution, or addition, has been my steady and uniform aim throughout the whole of the foregoing translation. Owing, however, to the different *constitutions* or *idioms*, as they are more generally termed, of the Latin and English languages, my translation is in many places far—very far from being strictly literal. *Phrasology* I consider, at best, as the mere trappings or drapery of *composition*, while *facts* and *principles* constitute its more substantial and important part. To preserve the latter, therefore, inviolate, and to communicate them with the utmost definitude, is the indispensable duty of a translator, from a principle of justice to the original author, to the public, and to himself; but in my opinion, he is not bound, by any principle whatever, to make an entire sacrifice of all *elegance* and *beauty*, to mere punctilious *literality* of expression. Impressed with the propriety and truth of these sentiments, I have, throughout the whole of the foregoing work, been sometimes *literal* and sometimes *free*, accordingly as the one or the other mode of translation gave birth to a phraseology or style most agreeable to my ear, and most accordant to the spirit of the original composition.

With respect to the appendix itself, it may not be amiss to make it the subject of a few transient observations. The *principle* which these additional pages regard, and are intended to communicate, is justly becoming, among medical philosophers, an object of primary importance. This principle opens to the view of the speculative mind a rich and spacious field, never yet printed, save by the adventurous steps of a few pre-eminently active and enterprising physiologists—A field, the salutary fruits of which will, no doubt, at a future day, serve to elucidate the nature, to develop the composition, and to alleviate the complicated misery of man.

My whole design in this appendix is to give a condensed, but somewhat general view, of this principle or influence discovered by professor Galvani.

By far the greater number of medical characters in the immense tract of country embraced within the limits of the *United States*, are, in consequence of their distances from literary institutions, excluded from access to public libraries, and situated quite beyond the free circulation of physical science. To such my appendix will serve the humble purpose of a *literary chronicle*; it will convey to them a brief account of the discoveries
2 which

which are now going forward in the delightful and important science of physiology.

On the subject of the influence discovered by Galvani I have myself instituted and performed a considerable number of experiments * ; some of

* That the reader may be acquainted with an easy, cheap and familiar method of experimenting on this subject, without having his feelings hurt by the agonizing pangs of tortured and dying animals, I will here take the liberty of inserting, in form of notes, a few extracts taken from a communication transmitted to Mr. Fowler, by his learned friend Mr. Robison, professor of natural philosophy in the university of Edinburgh.

I. " I find (says the professor) that if a piece of zinc be applied to the tongue, and be in contact with a piece of silver, which touches any part of the lining of the mouth, nostrils, ears, urethra, or anus, the sensation resembling taste is felt on the tongue. If the experiment be inverted, by applying the silver to the tongue, the irritation produced by the zinc is not sensible, except in the mouth and the urethra, and is very flight.

II. " If the zinc (finely polished) be applied to the ball of the eye, the brightness of the flash seems to correspond with the surface of contact of the silver with the tongue, palate, fauces, or cheek. The same thing happens when the silver is applied to the eye."

III. " When a rod of zinc and one of silver are applied to the roof of the mouth, as far back as possible, the irritations

my results have appeared striking and new, but my experiments have been neither sufficiently numerous nor varied to warrant the deduction and establishment of general principles. My present intention is (should heaven indulge me in life and health), to prosecute to some extent this highly

tions produced by bringing their outer ends into contact, are very strong, and that by the zinc resembles taste, in the same manner as when applied to the tongue."

IV. "I had been paring my toe-nails with scissars, and had cut off a considerable portion of the thick skin, so that the blood began to ooze through in the middle of the wound. I applied the zinc there, and an extensive surface of silver to the tongue. Every time I brought the metals into contact, I felt a smart irritation by the zinc at the wound," &c.

A variety of other experiments of a similar nature are contained in the same communication from Mr. Robison to Mr. Fowler; but a further detail of them I conceive unnecessary, as the ingenious reader, being acquainted with the foregoing, can with facility devise other experiments for himself. Thus I have frequently conveyed to my eye the luminous flash mentioned by Mr. Robison, not only from the internal vestments of the mouth, the nose, the urethra, &c. but also from between my fingers, from the cubital flexure of my arm, and from various other parts of my body, where the texture of the cuticle and skin is more fine and soft than ordinary; always taking care, however, to moisten the part previously to the application of the metals.

interesting

interesting subject. Should my investigation be favoured with the discovery of any thing curious in science, or useful in practice, a detail of it may be expected in a future communication.

To my solemn audit before the bar of the public, I now hasten in tremulous anxiety, "with all my imperfections on my head,"—imperfections which will no doubt awaken the censure of the critic, but receive, I flatter myself, the indulgence of the liberal and candid. The approbation of the former I neither court nor regard; that of the latter it shall be my constant ambition to deserve. The professed business of most modern critics appears to be, to condemn—promiscuously condemn, too frequently without the faintest shadow of either inclination or talents to discriminate merit from its reverse.

In my view the *approbation* of a professed critic is perfectly synonymous with the *censure* of the liberal and the ingenious, to whose candid examination the preceding pages are submitted with all that respect and deference due from an inexperienced writer.



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