ELEMENTS

OF

PHYSIOLOGY.

IN TWO VOLUMES.

Elements of Physiology;

BY

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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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M.DCC.XCV.

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 blanditious 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 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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ELEMENTS

OF

PHYSIOLOGY.

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. Kaau 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

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.

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 exſudes 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 exſudation, 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 frangibility 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.

§ 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 mafs, fimilar in its external appearance to gum arabic, which in a gradual manner, like the dried white of eggs, cracks and forms over its furface numerous *fulci* or fiffures running in a fomewhat fpiral direction, and exhibiting a very fingular appearance.

§ 12.

Befides thofe other properties of the ferum already mentioned, there is one highly worthy our confideration, to which my attention was firft called by the experiments of the illuftrious Prieftley *; but my belief of which has fince been fully confirmed by repeated obfervations of my own, viz. the facility with which the air, furrounding a veffel filled with blood, is able to act through the medium of the ferum or the craffamentum, though deeply covered by the former, in fuch a manner as to produce a very remarkable change in the colour of the latter, whereas, on the other hand, the fame action of the air would be very much impeded, if not entirely prevented, if inftead of the ferum, the craffamentum were covered with any foreign liquid, fuch as water, or oil, &c. or even with any other fluid of the human body itfelf, as the faliva or urine.

* Philof. Tranfact. vol. LXVI. P. I. pag. 244, feq.

§ 13.

§ 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 Leeuwenhoek. 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 nucleous, 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. Tranſ. 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 $\frac{1}{1400}$th part of an inch. Senac eſtimates their diameter at about the $\frac{1}{1000}$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 con-

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 *dephlogiſticated* 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, quick-ſilver.

§ 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.

§ 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 Ruyſch 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 ſometime 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 exſudes 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 Lithopœdion, firmly attach to the contiguous viſcera ſuch parts as are irritated to inflamation 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 MEMBRANE.

§ 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.

§ 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 fœtus, 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 conſtipated 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 groundwork

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 tranſuding 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.

§ 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 veſtage 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 tranſudes, 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 ſuet, 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.

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-

ed

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 figularity 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 *nisus formativus*, or formative propensity, which should be considered as the efficient cause of the whole process of *generation* (taken in so

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 *nisus 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 the

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 to e, 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 diſcuſion. 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

rity 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 *deſideratum* 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 develope the cause of the constant flux and reflux of its waters. C. C.

† The unfortunate *Servetus*, and that truly illustrious character *Andr. Cæsalpinus*, 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 Cœſalpinus, "*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 *prerogaitve* 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 minute 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 hypothenuſe 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 Leeuwenhoek 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 potarum.

§ 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

cle 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 refluent 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 fœtal 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 ſemilunar 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 ſemilunar 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 cartalaginous 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 Ruyſch has declared in his writings, that the whole fabric of the heart appears to be compoſed ſolely of ſanguiferous tubes.

§ 104.

§ 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-

ſolute 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 ſtriæ 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.

municated

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.

§ 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 ſinous, 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

which the larger arteries are found after death. To the ſame cauſe alſo Weiſs, 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.)

SECT. 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 encreaſing 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-

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

That the parietes, or walls themſeves 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 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 contributary 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 ſubſultory 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 ventircles 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 immoveable; 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 functionsof 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 spungy 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 sacs 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.

§ 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 aleady 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 *vomicæ*, 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

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.

§ 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

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, $\frac{11}{15}$ths of phlogiſticated, and $\frac{1}{15}$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 phlogiſticated 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 ſoot.

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 fœtus 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 mephitis is exſpired, 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.

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 exſpired 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

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 aſunder, 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 co-arction 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 va-

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 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 new-born 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 *division* of the letters by Ammanus into I. Vowels, II. Semivowels, and III. Consonants, 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, Consonants he divides, 1st, into the *Sibilantes* or *hissing* (i. e. into those consonants the pronunciation of which can be continued for an indefinite length of time). These are h, g, ch, s, sch, f, v, ph.

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

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

§ 157.

§ 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*, exſpirations ſhort, interrupted, and in ſome meaſure broken, follow each other in quick ſucceſſion.

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

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

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

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

The *Hickup* 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 exſpiration, 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 ſenſatious 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.

§ 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 $\frac{1}{87}$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.

§ 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 exspire 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 thoſe 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 11½ 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 ſemipellucid 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 re-produced 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 sepa-

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 seat 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 duskish 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 ſubtle 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.

§ 180.

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 Nadigſda, 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, flexility, 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 ſatyr), 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 exſpire 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 Caribeans, 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 *paristes* 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 encreaſed 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 alledges, 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 *ſulci* 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 conta'n 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 Sommering, 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 exſpiration, 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 medul'ary 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 ſimilares* (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

vour 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.

SECT.

SECT. 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.

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 ſitis, ſ. 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

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 ſubtility 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 perioſtium 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.

§ 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 exſudes 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 crouded 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 dioſyncraſies; 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 ſenſations 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 tremulous 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 percuſſated 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 *ſemicircular 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 Cotunnius, and which that celebrated phyſiologiſt diſcovered to be abſorbed by two very minute canals: theſe ſmall canals, called by Cotunnius, 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 and choroidea, is expanded on the concave surface of this last involucrum, 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 fœtus, 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 uvea, 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 *chryſtaline 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 crouded 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 palbebræ, 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 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 neceſ-

ſarily

ſarily, 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 fo al 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 two-fold 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

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.

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 *preſbytæ* 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 flexility, 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 inferior 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.

§ 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 exercıſe 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.

SECT.

SECT. 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

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 retrogade 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 ſimilares*.

§ 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

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 thr oughout, 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 nervea*.

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 nervea* 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

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 oppoſiton 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 sesimoidea, 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 obſerviug 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

in tender infants. and ſubjects far advanced in years), or a very exuberant ſource of fatuity 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 b[illegible] truly great in the production of dreams: thus [illegible] stimulus of the male semen gives rise to lus[illegible] ide[illegible];

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.