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William Duncan
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19 December 1839

FIRST LINES

OF

PHYSIOLOGY.

FIRST LINES

OF

PHYSIOLOGY,

Thomas BY THE CELEBRATED Stuart 1780

BARON ALBERTUS HALLER, M. D. &c.

Strathavin TRANSLATED FROM THE Banff Shire

CORRECT LATIN EDITION

Printed under the INSPECTION of

WILLIAM CULLEN, M. D.

To which is added, A TRANSLATION of

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ADVERTISEMENT.

THE first edition of this work was published in 1747. It was designed as a correction and improvement of Boerhaave's Institutions, by adding the new discoveries of Morgagni, Winslow, Albinus, Douglas, &c.

IN 1751, another edition was published; in which some things were treated more fully, and others more briefly, than before. Descriptions, particularly, were here abridged; some new physiological discoveries added; and a great number of typographical errors corrected.

A THIRD edition was published in 1764. Here the author conformed the order of his subjects treated of in his First Lines to that of his larger work, and made the number of books contained in both equal; but did not think proper to abridge his First Lines any farther, lest they should thus have become less fit for the purposes of a text-book.

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Index, which may be conſidered as an elegant compend of the whole. It was thought proper, however, to retain the erroneous numbers of the paragraphs which had eſcaped in the original editions, for the more eaſily referring from one place to another, and that no confuſion might ariſe from uſing the different editions.

Of the laſt mentioned valuable edition the preſent is an exact tranſlation, in which all poſſible care has been taken to give the true meaning of the author, in a plain and eaſy manner: An undertaking to which the publiſher was incited by the conſideration, that the tranſlation with which ſtudents have been hitherto furniſhed, not only was done from an old edition, exceedingly imperfect in compariſon with the laſt one; but is alſo unneceſſarily extended in the printing to double the ſize of the original, and of courſe proportionably enhanced in the price.

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FIRST LINES

OF

PHYSIOLOGY.

CHAP. I.

Of the Animal FIBRES.

1. THE moſt ſimple parts of the human body are either fluid or ſolid. The fluid parts, being of divers kinds, we ſhall hereafter conſider in their moſt convenient places. But here the ſolids, which make the moſt ſimple and true baſis of the body, come firſt to be conſidered before the hiſtory of the other parts.

2. The *ſolid* parts of animals and vegetables have this fabric in common, that their elements, or the ſmalleſt parts we can ſee by the fineſt microſcrope, are either fibres, or an unorganized concrete.

3. A *fibre* in general may be conſidered as reſembling a line made of points, having a moderate breadth; or rather as a ſlender cylinder. And that the more conſtant or permanent parts thereof are earth, is demonſtrated from a calcination, or a long continued putrefaction.

4. Theſe earthy particles have their connection and power of coheſion, not from themſelves or a mere con-

tact, but from the intermediate glue placed betwixt them. This we know from the experiments mentioned above (3.); and from the eafy experiment by which a burnt hair, whofe parts yet hang together, recovers a degree of firmnefs by dipping in water or oil. Alfo the remains of ivory or bone fhavings, whofe jelly has been extracted, become friable, like bones which, by long expofure to the weather, are converted into a true earth very ready to imbibe water. But even bones rendered friable by having their gluten extracted, will recover their hardnefs when the gluten is reftored. It is this gluten alone which holds together the more fimple parts of animals.

5. That this glue is compofed of oil combined with water by the vital attrition in animals, appears again from the chemical analyfis of bones and hair; from the jelly of bones, ivory, and horns; and from the nature of our aliments themfelves. Nor is there any kind of glue that could more powerfully join the parts of animals together; as we experience in fifh-glue, and that of joiners or cabinet-makers, &c.

6. Earthy particles then (3.) cohering longitudinally, and tied together by an intervening cohefive glue (5.), compofe firft one of the leaft or moft fimple fibres, fuch as we have a knowledge of rather from reafon than fenfe.

7. But the fibres which appear firft to the fight are of two kinds. The firft kind of thefe fibres is lineal; namely, fuch as have their length confiderably large in proportion to their breadth; and which, by difpofing of the elementary particles in a right line, muft of courfe lay them generally parallel with the contiguous fibres. Examples of fuch fibres we fee in the bones, and moft eafily in thofe of a fœtus; and likewife in the tendons, ligaments, and mufcles: only we muft always remember, that the eye never reaches to the fmalleft fibres, but to larger ones made up of the fmalleft, and like to them in flendernefs, placed together in a rectilineal courfe. That thefe are not different from the fmalleft fibres, we are perfuaded by the moft accurate micro-

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ſcopes of Muyſc and Lewenhoeck ; by which the muſcular fibres, divided even to the laſt, appear ſimilar to the larger, till at length they ſeem mere lines.

8. The ſecond kind of fibres (7.) are thoſe in which the breadth is frequently larger than their length. Theſe, when looſely interwoven with each other, are called the *cellular* tunic ; though the name *tunic* or *membrane* is on many accounts very improper.

9. This cellular ſubſtance is made up of an infinite number of little plates or ſcales, which, by their various directions, intercept ſmall cells and web-like ſpaces ; and join together all parts of the human body in ſuch a manner, as not only ſuſtains, but allows them a free and ample motion at the ſame time. But in this web-like ſubſtance there is the greateſt diverſity, in reſpect of the proportion betwixt the ſolid parts and intercepted cells, as well as the breadth and ſtrength of the little plates, and the nature of the contained liquor, which is ſometimes more watery, and ſometimes more oily : and likewiſe in the mixture of fibres and threads ; of which in ſome parts, as in the coats of the arteries, there is a great number ; in others, as under the ſkin, ſcarce any.

10. Out of this net-like cellular ſubſtance, compacted by the little plates concreting and preſſed together by the force of the incumbent muſcles and diſtending fluids, or from other cauſes, ariſe broad and flat plates or ſkins in various parts of the body, which, being generally diſpoſed in a rectilineal direction, are more properly called *membranes* ; or, being convoluted into cones and cylinders, pervaded by a flux of ſome juice or liquors through their cavities, put on the name of *veſſels* ; or elſe, being extended round ſome ſpace that is in a plane parallel to itſelf, we call it a *tunic* or coat. But that tunics or coats are formed out of the cellular ſubſtance is proved by ocular inſpection, eſpecially in the aorta, ſkin, pericardium, or dura mater, by maceration ; and the coats of the muſcles are thus evidently of a cellular fabric, ſimilar to that of other tunics.

The ſame thing is alſo proved from the eaſy change of the dartos, and the nervous membrane of the inteſtines, by inflation, into a cellular ſubſtance; from the hard and thick membranes about encyſted tumors, and which have their origin only in the cellular texture; and, laſtly, from that membrane which, being gradually compacted moſt firmly together, forms the true ſkin lying under the epidermis, and being thence continued is partly reſolved into the ſubcutaneous cellular texture which is filled with fat.

11. All the veſſels with which we ſee tunics commonly painted, are an addition to the cellular net-work, and in nowiſe conſtitute the nature of a membrane, but are ſuperadded to the membrane itſelf, which is firſt formed of the cellular net-like ſubſtance. Betwixt the maſhes or ſpaces of the inteſtinal net-work of veſſels, perfectly well filled by the Ruyſchian art of injection, we ſtill ſee that the white cellular ſubſtance which remains greatly exceeds the bulk of the veſſels, although, by their preternatural diſtenſion, they take up more room by filling more of the ſpace. But for membranes compounded of fibres interwoven with or decuſſating each other, I know of none ſuch; unleſs you will take ligamentary or tendinous fibres for them, which yet are ſpread only over the face of ſome true membrane.

12. This cellular web-like ſubſtance in the human body is found throughout the whole, namely, where-ever any veſſel or moving muſcular fibre can be traced; and this without the leaſt exception that I know of.

13. The other elementary ſubſtance of the human body (2.) which cannot be truly called either a fibrous or cellular plate, is a mere glue evaſated and concreted, not within the fibres, but in ſpaces betwixt them. In the bones this extravaſated ſubſtance is manifeſt enough: for you ſee the fibres very diſtinct in the bones of a fœtus, in the intervals betwixt which you perceive the veſſels running; ſo that every bone in the ſkull, on all ſides, reſembles the teeth of a comb. But this

this fabric is ſo altered in an adult perſon, that the juice being extravaſated in the ſpaces betwixt the fibres, and the intervals thereby filled up, as happens with the juice of madder, plates are then formed of the teeth above mentioned cemented together. The cartilages ſeem to be ſcarce any thing beſides this glue concreted.

14. But here the courſe of nature ſeems to be ſuch, that even the filamentary fibres (3.) are all firſt formed of ſuch a transfuſed glue. And that the membranous or ſcaly fibres of the cellular ſubſtance (7.) are thus formed, appears from thoſe cellular fibres produced in the thorax from a concreted vapour, which joins the ſurface of the lungs to the pleura; for theſe perfectly reſemble the true and natural cellular ſubſtance. The ſame appears alſo from a compariſon of the fœtus with an adult; for the large ſubcutaneous cellular ſubſtance has in a fœtus a mere jelly in its ſtead interpoſed betwixt the ſkin and muſcles, which laſt we obſerve very firm in a fœtus: from the morbid diſſolution of the membranes of the muſcles into a mere glue: and from a ſimilar change into glue or ſize, made on the ſkin, tendons, and ligaments of animals, by means of boiling water. This theory is alſo illuſtrated from clots of coagulated blood, the ſanguineous membranes of Ruyſch, Albinus's membranes formed of mucus, polypus, ſilk, and glue. Laſtly, that the bones themſelves are formed of compacted gluten, is ſhown from diſeaſes in which the hardeſt bones, by a liquefaction of their gluten, return into cartilage, fleſh, and jelly: ſimilar changes are made on the bones of fiſhes and other animals by Papin's digeſter.

15. It ſeems, then, that a gelatinous water, like the white of an egg, with a ſmall portion of fine cretaceous earth, firſt runs together into threads, from ſome preſſure, the cauſes of which are not our preſent concern. Such a filament, by the mutual attraction of coheſion, intercepting ſpaces betwixt itſelf and others, helps to form a part of the cellular net-like ſubſtance, after having acquired ſome toughneſs from the neighbouring earthy particles,

particles, which remain after an expulſion of the redundant aqueous glue. And in this net-like ſubſtance, wherever a greater preſſure is impoſed on its ſcales or ſides, they turn into fibres and membranes or tunics; and in the bones, laſtly, they concrete with an unorganiſed glue (4.) Hence, in general, all parts of the body, from the ſofteſt to the hardeſt, ſeem to differ no otherwiſe than as the latter have more of the earthy particles more cloſely compacted together, with leſs of the aqueous glue; while in the ſofteſt parts there is leſs earth and more glue.

CHAP. II.

Of the CELLULAR SUBSTANCE *and its* FAT.

16. THE cellular fabric is made up of fibres and plates (9.), which are neither hollow nor vaſcular, but ſolid; although they are afterwards painted by an acceſſion of veſſels. But the principal differences of this fabric are the following. In ſome parts of the body it is open and looſe, being formed of long and diſtant plates; in others, it is thin and compact, being made up of ſhort fibres concreted together. I find it ſhorteſt betwixt the ſclerotica and choroides of the eye, and betwixt the arachnoides and pia mater of the brain. I alſo find it tender, but more conſpicuous, betwixt every two coats of the inteſtines, ſtomach, bladder, and ureters; in the lungs, where it obtains the name of veſicles; under the pulp of the glans penis; and between the ſmall kernels of the viſcera and glands. It is compoſed of longer fibres, where it is extended over the larger veſſels, under the name of *capſule* or *vagina*; as through the viſcera, and particularly the liver and lungs; and is vaſtly firmer in the veſſels which go to the head and joints. Its principal uſe is to bind together the contiguous membranes, veſſels, and fibres, in ſuch a manner as to allow them a due or limited motion. But the cellular

lar ſubſtance, ſo far as we have hitherto deſcribed it, hardly ever receives any fat; it is moiſtened by a watery vapour, gelatinous and ſomewhat oily, exhaled out of the arteries and received again into the veins. The truth of this is eaſily demonſtrable from injections of oil and water, either alone or with fiſh-glue, made in all parts of the body. When this vapour is wanting, the ſmall fibres grow one to another, and the contiguous membranes or plates are cemented into one, with a loſs of their motion.

17. The cellular texture is more lax, and formed of plates rather than fibres, where it divides the muſcles and all their fibres, even to the ultimate fibre; where it ſurrounds and ſuſtains the leaſt veſſels with their free motion; and within the cavities of the bones, where it is alſo made up of bony plates, with membranous ones intermixed. That is likewiſe very lax, which, under the ſurface of the body, is every where interpoſed betwixt the muſcles and the ſkin; but the laxeſt of all is that which ſurrounds the genital parts of the male with very wide cells.

18. Into the empty ſpaces of this cellular texture (17.) is poured almoſt every where in the fœtus, firſt a gelly, then a grumous, and laſtly a clotted fat, all under the ſkin, and in its ſmall hollows. It is compoſed of an inſipid inflammable liquid, lighter than water, which in a cold air concretes into a ſolid, eſpecially about the kidneys; and in graminivorous animals, in fiſhes, probably alſo in man, while they are alive, it is very nearly fluid, although apt to be indurated. In it, along with the oil, is united an acid ſalt in quantity almoſt equal to the ſixth part of the oil.

19. Through this cellular texture the blood-veſſels run and are divided; from the arterial extremities of which the fat is depoſited and abſorbed by the veins. This paſſage, from the arteries into the adipoſe cells, is ſo free and ſhort, that there muſt needs be very large mouths by which they open, and by which they give admittance to injected mercury, air, water, diſſolved fiſh-

fiſh-glue or jelly, and oil not excepted, which is always very ſluggiſh in paſſing through the veſſels even of living animals. Theſe are ſecreted not by any long ducts, but by tranſuding on all ſides through the whole extent of the veſſel; inſomuch that, when an artery is filled or injected with water, there is no part of the ſurrounding cellular ſubſtance but what ſwells with the moiſture. The warm fat, during the pulſation of the arteries, eaſily finds out the ſame paſſages. How quickly it is collected, appears from the ſpeedy renovation of it, by a returning fatneſs after acute diſeaſes.

20. But that this fat is abſorbed by the veins, we are taught from the ſudden effects which exerciſe of the muſcles more eſpecially has in conſuming the oil of very fat animals; alſo from the conſumption of our fat in fevers; from the cure of dropſies, where the water transfuſed into the cellular ſubſtance is in a manner abſorbed and thrown out by the inteſtinal tube; and, laſtly, from the tranſuding of water and oil from the venous orifices, when injected by the ſyringe. Whether the nerves are ſpread upon the adipoſe cells, is a queſtion. But it is certain they in moſt parts run through this ſubſtance, and hereby divide, in their courſe, into the minuteſt filaments, ſo ſmall that you can no longer trace them by the knife. But then the fat is both inſenſible and unirritable.

21. The intervals or ſpaces betwixt the plates or ſcales of the cellular membrane, are every where open, and agree in forming one continuous cavity throughout the whole body. This appears from the inflation which butchers, and likewiſe the ſurgeons of Ethiopia, make by a wound of the ſkin, and which raiſes the ſkin all over the body; alſo from an ephyſema, in which the air received by a wound of the ſkin, being retained, cauſes a ſwelling throughout the whole ſurface of the body; the paſſage of bodies, put under the ſkin, to a place remote from that at which they entered; the paſſage of pus, from an inflamed place to remote ulcers; and, finally, from diſeaſes, in which a watery or ſerous humour

is

is depofited into all the cells of this net-like fubftance throughout the body, and is emptied from them all by a fingle incifion. That none of the cellular fabric is excepted from this communication, appears from cafes wherein the vitreous body of the eye has received the flatus of an emphyfema; and again from difeafe, in which the gelatinous ferum of a dropfy has been found transfufed even into the cavernous bodies of the penis.

22. The great importance and ufe of this cellular fubftance, in the animal fabric, muft be evident to all who confider, that from this part alone proceeds the due firmnefs and ftability of all the arteries, nerves, and mufcular fibres of the body, and confequently of all the flefhy parts and vifcera formed from thence; and even the figures of the parts, their juft length, cavities, curvatures, flexures, and motions, depend entirely on the cellular membrane, in fome places of a lax and in others of a more denfe and hard fabric: That out of this fubftance, joined with veffels, nerves, mufcular and tendinous fibres (a great part of all which are before formed of this fubftance only), all the vifcera, all the mufcles and glands, with their ligaments and capfules, are entirely compofed; and that only from the different length, tenfion, quantity or proportion of this the diverfity of our glands and vifcera arifes; and laftly, that this alone makes up by far the greateft part of the whole body, as we are certain, although the whole be not formed out of cellular filaments of this kind.

23. This fubftance hath a contractile power, different from that of irritability, which, though not demonftrable by experiments, for the moft part difpofes the cellular fibre to fhorten itfelf after having been ftretched. This power, excited by cold, renders the fkin rigid; raifes the hairs; draws up the fcrotum; and, after geftation, reftores the fkin of the abdomen, and the uterus, to their former fize. The fame force, by a gentle but continual contraction, promotes the fecretion of the fat, the liquors of the fubcutaneous and other glands, and pus: in the veins and receptacles, it refifts

dilatation; and, when that is taken off, it reſtores the part to its former ſize. In the fœtus, this gentle force is among the principal cauſes of the change that happens to the body.

24. The *uſes* of the fat are various; as to facilitate the motions of the muſcles in all parts, leſſen their attrition againſt each other, and prevent a ſtiffneſs or rigidity: it fills up the intermediate ſpaces betwixt the muſcles, with the cavities about many of the viſcera, in ſuch a manner, that it readily yields to their motions, and yet ſupports them when at reſt: it principally conſtitutes the weight of the body; conducts and defends the veſſels: it gives an uniform extenſion to the ſkin; and, ſerving as a cuſhion to eaſe the weight of the body, renders the whole of a comely, agreeable ſhape: it probably, by mixing with many of the humours, abates their acrimony: it has a principal ſhare in forming the matter of the bile; and, by tranſuding through the cartilaginous incruſtations of the bones, it mixes with the articular liquid, and by abſorption ſerves to ſmear their fibres: by exhaling through the pores of the ſkin, it keeps off the inclement drying quality of the air: alſo, by exhaling in a living perſon from the meſentery, meſocolon, omentum, and round the kidneys, it lubricates the ſurfaces of the viſcera with an oily emollient vapour; and, by interpoſing betwixt their integuments, prevents their growing one to another.

25. The fat is depoſited into the cells of this ſubſtance by ſleep, reſt of body and mind, and a diminiſhed force of circulation; whence, being collected in too great a quantity, it proves injurious by compreſſing the veins; and, by cauſing too great a reſiſtance to the heart, it makes a perſon ſhort-breathed, and liable to an apoplexy or dropſy. The ſame humour is taken up by the veins; and, being rapidly moved along the arteries, is conſumed by violent exerciſe, venery, watchings, cares of the mind, a ſalivation, diarrhœa, fever, faſting, or ſuppuration. When reſtored to the blood, it increaſes acute diſeaſes, tinges the urine, and forms a part of its ſediment.

ſediment. After a ſudden conſumption of it, it is ſoon renewed again from good juices, or healthy humours: but, in a languid habit, a gelly, inſtead of fat, is depoſited into the cells; and this cauſes the dropſy we call anaſarca, together with an external hydrocele or watery ſwelling.

CHAP. III.

Of the ARTERIES *and* VEINS.

26. THE membranes we ſhall hereafter better deſcribe, each in its reſpective place. Of theſe membranes there are ſeveral common to the *arteries;* which are long extended cones, whoſe diameters decreaſe as they divide into more numerous branches. But where the arteries run for ſome length, without ſending off large branches, their convergency is not very evident; and at length, where they are called capillaries, and wherever they give paſſage to only a ſingle red globule, they are either cylindrical, or very nearly ſo, from the imperceptible diminution; but their tranſverſe ſections are every where and without exception circular, when the artery is full. Where they ſend off large branches, the light or cavity is there ſuddenly diminiſhed, inſomuch that they might be taken for a chain of cylinders, of which every one is narrower than the preceding. If you reckon them cones, then the common baſis of the cone in all arteries is either in one or the other ventricle of the heart; and the apex of the cone terminates either in the beginning of the veins, or in the beginning of the cylindrical part of the artery, or in the exhaling veſſel, unleſs it is cylindrical. In ſome places they ſeem to diverge or dilate; at leaſt they become there of a larger diameter, after they have been filled or diſtended with wax; which poſſibly may ariſe from ſome ſtoppage of the wax, by whoſe impulſe that part of the length of the artery becomes more di-

ſtended than the reſt. Examples of this kind we have in the vertebral artery, at the baſis of the ſkull, in the ſplenic artery, in the flexure of the carotid artery, according to Mr Cowper's injections; and, laſtly, unleſs all my experiments deceive me, in the ſpermatic arteries. In all places, likewiſe, where the ramifications begin, the diameter of the artery is a little increaſed.

27. There is indeed *no external coat* perpetual and proper to all the arteries; but the office of ſuch a coat is ſupplied to ſome of them by one ſingle external and incumbent integument, which in the thorax is the pleura, and in the abdomen the peritonæum. In the neck, arm, and thigh, a ſort of thicker cellular ſubſtance ſurrounds the arteries. The membrane of the pericardium, which on all ſides cloſes round the aorta, returns back with the veſſels to the heart. The dura mater imparts a capſule that ſurrounds the carotid artery as it paſſes out through a hole in the ſkull. But the firſt true external membrane common to the arterial tube in all parts of the body, is the cellular ſubſtance, which in ſome parts (as in the thorax) we ſee repleniſhed with fat.

28. This *cellular coat* is, in its external ſurface, of a *more lax* texture, painted with a great many ſmall arteries and veins; and it has nerves running through its ſubſtance, which are none of the ſmalleſt. There is ſometimes ſo much of this cellular ſubſtance about the artery as might occaſion one to think it hardly belonged to it as an external coat or lamella, but rather as ſome foreign net-work added to this veſſel. Thus we find it in the arteries of the neck, groins, and ſubclavians; in the meſenteric, cœliac, and hepatic arteries; where it is chiefly interwoven with long fibres. And theſe are the vaginæ or capſules of the arteries, formerly obſerved by ſome eminent anatomiſts.

29. As this *cellular coat* advances more inward, and nearer to the light and capacity of the artery, it becomes *more denſe*, ſolid, and is tied more cloſely together by a kind of wool, and may be called the *proper*

coat

coat of the artery. That there is no tendinous coat of the arteries diſtinct from this laſt part of the cellular ſubſtance, is evident from maceration, whereby the inner ſtratum of this arterious tunic changes into a cellular fabric.

30. Within the former, and nearer the light or capacity of the artery, it has *a coat of muſcular fibres*, which are in general imperfect circles: that is to ſay, no fibre any where makes a complete circle round the veſſel; but a number of ſegments conjoined together, with their extremities turned off ſideways, ſeem to form one ring round the artery. Theſe fibres, in the larger arterial trunks, form many ſtrata, appear of a reddiſh colour, and are remarkably firm and ſolid; but in the ſmaller arteries they are by degrees more difficult to demonſtrate, and ſeem to be wanting in the arteries of ſmall animals. I have never obſerved them to run along the veſſel lengthwiſe. Under theſe membranes, but pretty difficult to demonſtrate, is an exceeding ſhort cellular texture, into which a chalky concreting matter is poured when an artery oſſifies.

31. The *innermoſt coat* of the artery is thin, and finely poliſhed by the influent blood; ſo as to form a ſingle incruſtation that every where lines the fleſhy fibres, which are not very continuous one to the other, and prevents the blood from inſinuating into the ſpaces betwixt them. It is every where ſmooth and without valves; although, from a ſort of mechanical neceſſity, ſometimes certain folds, raiſed into a ſemicircle at the origination of branches, form a projecting eminence; as we ſee at the branches produced by the arch of the aorta. Yet, in arteries of the viſcera, the innermoſt coat is ſofter, lax, wrinkled, and almoſt friable, eſpecially in the ductus arterioſus.

32. The arteries themſelves *have arteries* which are more particularly ſpread through their external cellular coat; and, ſpringing on all ſides from the next adjacent ſmall arterial trunks, form numerous branchy networks, which are all of them indeed very minute, but plainly

plainly appear, even in the fœtus without injection, to be very numerous. There are alſo *nerves* which deſcend for a long way together through the ſurface of the artery, and at laſt vaniſh in the cellular ſubſtance of the veſſel; of which we have a ſpecimen in the external and internal carotids, and arch of the aorta. And from theſe, do not the arteries ſeem to derive a muſcular and convulſive force, very different from that of their ſimple elaſticity? Does not this force ſhow itſelf plainly enough in fevers, faintings, palſy, and conſumption, and paſſions of the mind? But the artery is in a manner inſenſible and unirritable; and if it is conſtricted by the application of poiſons, it has this in common with the dead ſkin.

33. The *ſections*, or diviſions, of arteries ſhow themſelves with a round light, or hollow capacity, becauſe they are elaſtic; and this is the reaſon why, from the ſmall arteries of the teeth, hæmorrhages are ſometimes fatal. The aorta, indeed, of the thorax and abdomen, the carotids of the neck, and ſome other arteries of the dead body, from their leſſened extenſion, appear ſomewhat flat or depreſſed; but their round figure, or circular ſection, is every where reſtored by injection. *Their elaſticity* is alſo evident in that powerful compreſſure, which a ſegment of a large artery makes upon the finger that diſtends it, and which is much ſtronger in a dead than in a living body. In the living body, indeed, this force yields to that of the heart; but inſtantly recovers itſelf, when the heart is relaxed, and reſtores the artery to its former diameter; and this makes the *pulſe*, whoſe full explication ought to be preceded by an hiſtory of the heart: at preſent, it may ſuffice for us to ſay, that all the arteries have this pulſation, although the ſyſtole and diaſtole thereof can be perceived by the finger, only in the larger, not in the ſmaller ones naturally; and in the ultimate inflection of the arteries, the pulſe totally vaniſhes; but, by an increaſed motion of the blood, even the leſſer arteries make a violent pulſation, as we ſee in an inflammation.

Theſe

Thefe veffels ftrongly contract lengthwife, and are rendered fhorter on diffection.

34. The *ftrength* of the arteries is confiderable enough: but as the denfe, hard net-work of the outer cellular coat refufes to yield to a diftending force, it breaks without much difficulty, almoft eafier than the coats of the veins; and from thence arife aneurifms. But, in general, the trunks are, in all parts of the body, weaker, and the branches ftronger, in their coats; whence the impulfe of the blood may exert a confiderable effect upon the former, but leaft of all on thofe of the limbs. From hence it is, that aneurifms are moft frequently formed near the heart; for, in the lower extremities, the ftrength of the arteries, and of the veins too, is much increafed, as well as in the fecreting organs.

35. With regard to the *courfe and general diftribution* of the arteries, nature has every where concealed them, except in a few membranes. But fhe hath difpofed of the trunks every where in places of fafety, becaufe wounds cannot happen to the fmaller of them without danger, nor to the larger without lofs of life. The fkin is fpread with numerous fhort and fmall arterial trunks; but the larger ones, defended by the fkin and mufcles, creep along near the bones. In general, the arteries are in proportion to the parts of the body to which they are fent. The largeft go to the fecretory organs, the brain, and fpleen; the leffer ones to the mufcular parts.

36. The proportion of the light or cavity of the artery to its folid part is not every where the fame, nor is it conftant even in the fame artery. This proportion, in the firft place, is leaft of all at the heart, and increafes as the arteries remove farther from it. Secondly, in a full-fed plethoric animal, whofe blood paffes freely, and with great force, through its arteries, the proportion of the folid parts of thefe veffels is lefs than in a famifhed extenuated creature, whofe blood hath a feeble motion.

37. From the trunks of all the arteries branches are ſent forth, and from theſe again proceed leſſer twigs by a numerous diviſion, of which you can ſcarce find the end, though you may perhaps count twenty ſubdiviſions of this kind. Here the lights or ſections of any two branches, taken together, always exceed the light of the trunk from whence they come, in nearly a ſeſquialteral proportion, or as one and a half to one, or ſomewhat leſs. Alſo every trunk, juſt above its diviſion, is ſomewhat broader or more expanded. The angles, at which the branches go out from their trunks, are generally acute, either half right angles or nearly ſo; to the forming of which angles, as we ſee in mechanics, there is required the longeſt projection. Inſtances of their going off at right angles, or nearly ſo, we have in the lumbal or intercoſtal arteries; of their going off in a retrograde or reflected courſe, we have one inſtance in the coronaries of the heart, and another inſtance in the ſpinal arteries, which are produced by the vertebrals. But, generally ſpeaking, thoſe which are eſteemed retrograde or reflexed were ſent off, at their origin, in acute angles; ſuch as the aſcending artery of the pharynx, the deſcending one of the palate, the umbilical mammary arteries, and the nutritious ones of the large bones. Laſtly, we often obſerve large branches ariſing under leſſer angles, and ſmaller ones under greater angles: but it is rarely that we obſerve two arteries of a large diameter run together into one trunk. An example of this, however, we have in that artery which is formed out of the vertebrals: in the ſmaller ones it is frequent, as in both the ſpinal arteries, and that of the ſincipital foramen. In many parts, the arteries have repeated alternate undulations or flexures, as they run on in a ſpiral courſe, wherein we ſee their diameter often conſiderably enlarged, as in the large inteſtines, womb, face, ſpleen, lips, and iris. Even the ſtraight arteries in other places, if too much diſtended, fall into ſerpentine flexures. Sometimes they are ſuddenly twiſted into a kind

kind of circles, as the carotids under the mammillary procefs.

38. The arteries are frequently conjoined one to another by intermediate *branches*, in fuch a manner, that the twig of fome certain artery fhall run to meet one of the fame kind from another neighbouring artery, and, by joining together with that, form one trunk. Inftances of this kind we have among the large trunks in the inteftines, among the middling ones in the kidneys, womb, &c. and among the fmaller in all parts of the body; infomuch that there is no part of the human body wherein the neighbouring arterial trunks, whether of the fame or of different denominations, do not form anaftomofes or joinings one to the other by intermediate branches. Of rings diverging laterally from the arteries, and returning again into themfelves, we have inftances in the eye and brain. The extremities of the arteries, which are either cylindrical or nearly fo, fend off fmaller branches, which, for their extent, are more numerous, and generally difpofed like a net; fo that each branch, by its fmaller twigs, forms anaftomofes with thofe of its neighbouring branches: and thus we find it in all membranes. By this means it happens, that, though the paffage from the heart to any part of an artery is obftructed, the blood may neverthelefs flow through the neighbouring arteries into all the branches of the obftructed one. Thus a gangrene or languor of the part is very ftrongly prevented, and the obftruction is more eafily refolved by the repulfion of the obftacle into the larger part of the trunk.

39. Laftly, one of the leaft arteries is either changed by a continuation of its canal into a vein, in fuch a manner, that the ultimate little artery, which is generally reflected, having furpaffed the angle of its reflection, becomes now a fmall vein; or elfe a branch, fent out at right angles from the artery, is inferted under a like angle into the branch of a fmall vein. Both thefe kinds of mechanifm are demonftrated to us by

the microſcope, and the eaſy return of injections thro' the veins into the arteries. And theſe vaſcules we ſee ſometimes large enough to receive only one, and ſometimes ſeveral blood-globules at a time. A large artery is never obſerved to open into a vein.

40. *In the viſcera*, we find the ſmall arteries diſpoſed not ſo much in net-works as in a different fabricature, wherein the ſmall branches deſcend very thick, or in cluſters, parallel to the trunk, ſo as to reſemble bruſh-pencils, a variety of little trees or buſhes, ſmall ſerpents, or threads, according to the various diſpoſition of the parts.

41. Sometimes the arteries end in another manner, namely, by being converted into veſſels of the ſmaller kinds. Theſe are ſometimes continuous to the arteries and real arterial trunks, as will be obſerved in the ophthalmic artery, upon tracing the arteries of the tunica choroides, or the colourleſs ones of the circle of the uvea and iris. That a net-work of pellucid arteries is continuous with the red branches of the ophthalmic one, is evident from inflammations, and the redneſs of the parts when relaxed by vapour or by cupping; from repletion, and the microſcopical experiments of Lieberkuhnius upon frogs, in which colourleſs globules were ſeen to paſs from a red artery into a lateral veſſel. In a fabric of this kind the red blood is eaſily forced into the ſmaller veſſels.

42. In other places the ſmaller veſſels ſeem to proceed laterally as branches from the trunks of the leaſt ſanguineous arteries, and are drawn out into trunks ſtill ſmaller. Theſe are called *excretory ducts*. It is with difficulty that theſe veſſels are filled with red blood; of this, however, we have examples in the kidneys, the liver, and breaſts. Indeed the blood, when vitiated, penetrates the excretory ducts of the whole body, even without hurting the veſſels, nor is that aberration found to be productive of any evil conſequence after the diſorder of the blood is cured.

43. Another

43. Another termination of the arterial extremities is *into the exhaling veſſels*; and this is a manner of their ending very frequently to be obſerved in all parts of the body. The whole ſkin, all membranes of the human body which form any cloſe cavity, all the ventricles of the brain, the anterior and poſterior chambers of the eyes, all the adipoſe cells and pulmonary veſicles, the whole cavity of the ſtomach and inteſtinal tube, thro' which the air has a paſſage, are all of them repleniſhed with exhaling arteries of this kind. Theſe breathe out a thin, watery, gelatinous humour, which, being collected together by ſtanding, ſometimes makes no inconſiderable quantity; and, particularly by diſeaſe or death, is converted into a watery, but coagulable lymph. The truth of this is eaſily demonſtrable from the watery ſweat that enſues after injecting the arteries with that liquor warm. In ſome places, indeed, they exhale, not a thin vapour, but blood itſelf, as we ſee in the heart, the cellular fabric of the penis, urethra, clitoris, and nipple of the female breaſt; in all which the blood itſelf is naturally poured out. Does not every ſecretion that is made in true glands or hollow cryptæ bear ſome analogy to this exhaling fabric?

44. Whether or not in all parts of the human body, do the pellucid veſſels ariſing from the ſanguine ones, and carrying a humour thinner than blood, again ſend out other ſmaller veſſels to be ſubdivided into ſtill leſſer orders? We ſeem, indeed, not to want examples of this in the manner propoſed to us by the moſt celebrated profeſſors. That the aqueous humour is ſeparated by very fine veſſels, generated from the colourleſs arteries of the iris, is very probable. That the red-coloured veſſels in the cortical ſubſtance of the brain ſeparate a juice, pervading the medullary ſubſtance, by the intermediation of another order of veſſels, we are almoſt certain. And the like we are perſuaded from an eryſipelas or yellow inflammation, ariſing from the yellow or ſerous globules impacted into ſmaller veſſels.

45. It may be then aſked, If there are not yellow arterious veſſels of a ſecond order, which ſend off lymphatic ones of a third order, from whence by degrees ſtill leſſer kinds of veſſels branch out? Such a fabric does not ſeem agreeable to the very eaſy tranſition that is made by the blood, mercury, or wax, into the exhaling and perſpiratory veſſels, or into the uriniferous tubuli, with the adipoſe and pulmonary cells; nor is it very difficult for the blood to ſtray into the lactiferous, lymphatic, and lachrymal ducts, whither it ſhould ſeem not able to penetrate, if it went through any other intermediate vaſcular ſyſtem, ſmaller than the blood-globules, which make the ſame journey. Nor can this ſyſtem be allowed by the great impediment or retardation that muſt ariſe to the humours in a third, and much more in the leſſer orders of veſſels.

46. The VEINS, in many particulars, reſemble the arteries. There are ſix, of which two anſwer to the aorta, and the remaining four to the pulmonary artery. Their baſis is in the ventricles of the heart, and their apices in the extremity of each branch, through all parts of the body, excepting one inſtance in the liver. And, in a great number of parts, they run parallel with the arteries, one by the ſide of the other; but yet they differ from the arteries in various reſpects.

47. The fabric of the veins is ſlender, every where ſmooth, difficultly ſeparable into diſtinct coats or membranes, like the arteries; and the cellular texture ſurrounding this fabric is very eaſily diſtended. This fabric, both above and below the heart, is ſurrounded, except in one place, with muſcular fibres. Every where, however, it is lax, like the cellular texture of the arteries by which they are joined to the other parts of the body. Notwithſtanding this ſlender fabric, the veins are every where ſufficiently firm, and do not eaſily burſt with inflated air; being, in moſt inſtances, ſtronger than the arteries themſelves. But they burſt much more eaſily in living than in dead animals, as appears from morbid inſtances in the arm, face, leg, thigh,

thigh, &c. Nor do they ſupport themſelves like cylinders after being divided, but they collapſe together, ſo as to make their light or capacity appear like a ſlit; except they are ſuſtained and hindered from collapſing thus by ſome ſtronger cellular ſubſtance placed round them, as we ſee in the liver and womb. They are but ſlightly irritable, unleſs the ſtimulus be of the chemical or more acrid claſſes; for, in that caſe, they contract themſelves with a convulſive force greater than that of the arteries. They have no pulſation, if we may truſt all accounts, unleſs the venous channel is ſomewhere obſtructed; or when, in dying people, the blood is thrown back again from the right auricle into the deſcending and aſcending cava, or when falling back from the brain.

48. The veins are much larger than their correſponding arteries, having the ſquare of their diameter often double or triple that of the latter; and, in ſome places, almoſt quadruple; as near as the emulgents and veſſels of the kidneys. In general, however, the diameter of the veins is to that of the arteries as nine to four; yet the capacity of the capillary veins but little exceeds that of the arteries which accompany them. They differ likewiſe from the arteries in their diviſion, having more numerous trunks and branches; for to one artery in the limbs, we uſually meet with two veins. The larger veins are alſo branched in a more net-like diſpoſition, by forming more frequent anaſtomoſes one with another; for not only the ſmaller branches, but even the larger trunks, of the veins, are conjoined one to the other within its neighbourhood, upper with lower, and right with left, by apparent inlets or inoſculations. They affect to run near the ſurface of the body; and through the limbs, neck, and head: they run a long way covered with little more than the bare ſkin, which is a circumſtance we very rarely obſerve in arteries; and, for the ſame reaſon, they often go out, in their courſe, to a conſiderable diſtance from the arteries. For, in this caſe, the veins

follow

follow the ſurface of the parts next the ſkin, without their correſponding artery, which, in the mean time, deſcends to a conſiderable depth, attended in its courſe by ſome ſmaller venous branch. In the ſmaller branches of the veſſels, where they make net-like diſpoſitions in the membranes and the internal fabric of the viſcera, the veins and arteries commonly run contiguous one with the other; but here the veins have generally a leſs ſerpentine or inflected courſe.

49. In the larger ſanguineous veins, little valves are found in great plenty. The innermoſt membrane of the vein, being double, riſes into the cavity of the veſſel like a curtain, ſtretching itſelf farther along the vein every way, ſo as to form what may be called a a kind of little horns; but the baſis, which is the part that ſuſtains the weight of the blood, is ſtrongeſt, and grows out of the vein in the ſhape of a circular ſegment. Theſe, joined with the ſide of the proceeding vein, intercept a ſpace, of which the outer ſide is the vein itſelf, and the inner the valve, which, by its convexity, ſtands out within the bore of the vein; ſo that the parabolic ſpace or hollow mouth of the valves always looks towards the heart: they are found in all the ſubcutaneous veins of the limbs, in thoſe of the neck, face, tongue, and in the veins of the penis: at the origin of the larger branches there are two, three, four, and ſometimes five of them together, while in their ſmaller branches they are only ſingle. There are none of theſe valves in the deep running veins of the viſcera; and, therefore, none in thoſe of the brain, lungs, heart, or liver, or through the whole ſyſtem of the vena portarum, nor in the kidneys or womb (except one or two valves in the ſpermatic vein); nor, laſtly, are there any in thoſe ſmaller blood-veins, which are of a leſs diameter than the twelfth part of an inch. Sometimes, though rarely, they are found in the vena azygos, and at the mouths of the hepatic and renal veins: there I have ſeveral times obſerved a ſort of wrinkles in the place of valves. In the ſmaller venous branches there

there are a ſet of long, ſharp-pointed or parabolical valves, of a more extended figure as the vein is ſmaller: and theſe make a greater reſiſtance than the larger valves, to hinder the blood from returning back upon the parts.

50. The veins have their origin, as we ſaid before, from the terminations of the arteries. They ſometimes ariſe by a continuation from the inſerted branches, or from a reflection of recurved trunks of the ſmalleſt arteries. Others again are either continued from veins leſs than thoſe which carry blood, or elſe receive additions and roots from them; as we ſee, for inſtance, in the lymphatic veins of the thoracic duct. Others of a bibulous kind take their origin from the abſorbing veins that are diſperſed all over the ſurface of the body, as in the chambers of the eyes, the cavities of the inteſtines, bladder, womb, breaſt, peritonæum, pericardium, and ventricles of the brain. From theſe iſſue a watery ſweat, by injecting the venous trunks with that kind of liquor, which may be eaſily imitated throughout the whole human body: hence water, jelly, or oil, diſtil from the the vena portarum into the cavity of the inteſtines; hence alſo water, injected into the abdomen of a living animal, quickly vaniſhes: but of theſe things we ſhall ſpeak more largely in a proper place.

51. Not much differing from the former are thoſe veins which, ariſing in all parts of the cellular membrane, return thin vapours, dropſical waters, diſſolved fat, or extravaſated and corrupting blood, and the poiſon of opium introduced into the cellular texture, again into the maſs of the blood; or which take up again and return the blood itſelf from the cellular fabric of the penis, clitoris, or nipples of the breaſts, after the venereal act. And that inhaling veins of this kind open into all the glands, is highly probable; where, by abſorbing the thinner humour, they leave the remaining maſs of a thicker conſiſtence, of which we have inſtances in the bile, ſperm, mucus, &c.

52. That

52. That there are veins of a *ſmaller claſs*, but reſembling thoſe which convey blood, appears from the ſame experiments which demonſtrate the pellucid arteries: thus, in the iris of the eye there are ſmall veins, and not a few in the adnata tunica of that organ; nor is it to be doubted that, in a healthy body, ſmall pellucid veins may be found in the vitreous body of the eye itſelf.

53. But, in moſt parts of the human body, are found other veins, full of a reddiſh, yellowiſh, or almoſt pellucid liquor, coagulable by heat; which veins, being formed of very tender coats, have a degree of irritability from any chemical or very acrid ſtimulus. They have very frequent valves or partitions, which make them in thoſe places ſeem jointed or knotted like a reed when they are turgid; theſe, by degrees, meeting together, either all or moſt part of them empty their contents into the thoracic duct. They ariſe from the cellular texture throughout the whole body, as I long ago learned concerning the lactiferous veſſels of the breaſts, the vaſa efferentia of the teſticles, the lymphatics which originate from the meſenteric glands; and as is now ſhown to be the caſe with the lymphatic veſſels of the teſticles, ſpleen, and other parts. From analogy, eſpecially from hydropical appearances, it is very probable that they ariſe likewiſe from the large cavities of the body; nor is it improbable that this kind of veſſels receive a thin humour from veins of the ſmalleſt ſize. But all the lymphatics, in their courſe, meet together in a peculiar kind of conglobate glands, into which they enter; and, from the ſhape of veins, becoming arterial, or like converging cones, they divide into ſmall branches, and then proceed to meet together again in other little trunks.

54. Theſe glands themſelves are only as it were ſmall clues of lymphatic veſſels, connected together by a cellular texture, into which the arterial liquour exſudes, and is conveyed from the ſame by the veſſels which ſerve to bring back the lymph. They are co-

vered with a continuous membrane, almoſt of an oval ſhape, and this whether they are ſingle or heaped together: and they chiefly follow the courſe of the veins through the whole trunk of the body, even to the tops of the limbs; running along the jugular and ſubclavian veins, the vena cava ſuperior, the aſpera arteria, gullet, lumbal vena cava, vena porta, the iliac, hypogaſtric, and crural veins, the veins of the thigh, and likewiſe the veſſels of the ſtomach, ſpleen, meſentery, and meſocolon.

55. They are found ſeated on all the ſurfaces of the viſcera, in the thorax and abdomen; but are more eaſily diſcovered in brutes. They run through the lower part of the face, muſcles of the tongue, the adjacent parts of the neck, and thoſe parts of the upper limbs which are neareſt the trunk, as far as the bending of the elbow; throughout the whole length of the mediaſtinum, before and behind, and wherever we find conglobate glandules, either in the neck or thorax: the lymphatic veins are alſo ſpread through the whole lumbal region that is contiguous to the aorta, the meſocolon and pelvis, veſſels and ſurface of the teſticle; and in the lower limbs, wherever they are ſupplied with conglobate glandules, even to the knees. Whether they extend further into other parts throughout the whole body, or through the brain, eyes, hands, feet, back, fore part of the peritonæum, &c. remains as yet undetermined; at leaſt, there are not examples enough in the human body upon which one can depend to evince the truth of their exiſtence. But they are every where to be found upon the ſurfaces of the viſcera. They are almoſt every where collected into bundles, not far from the large blood-veſſels. Thoſe from the inferior limbs, pelvis, and loins, run into one duct, which is joined by another bundle coming from the liver, ſpleen, and ſtomach; and that trunk, at length, becomes the thoracic duct. The ſuperior veſſels, from the whole extent of the breaſt, the head, and ſuperior limbs, empty themſelves into the ſame duct towards its

upper extremity. They ſeem, however, likewiſe to terminate in the red veins.

56. Of what ſervice theſe glands are to the lymphatic veſſels is not well known. In the fœtus they are ſwelled with a milky liquor, as alſo the thymus and glandulæ renales; but it is not certain whether this juice is poured out into the cellular texture. It is rendered probable by late experiments, that ſome kind of juice is prepared in theſe glands, which is mixed with the lymph; and that a thin humour, injected into the arteries, likewiſe enters the lymphatic veſſels. By age, this juice vaniſhes; and the glands themſelves, being dried up, almoſt totally diſappear. A very ſudden ſcirrhus happening to theſe glands ſeems to be the cauſe of their decay.

57. The *valves* of theſe pellucid veſſels (53.) are compoſed of two ſemicircular membranes, which give way to the fluid that goes towards the larger trunks; ſo that, by applying themſelves cloſe to the ſides of the veſſel, they leave a free light or capacity through it. But the ſame valves, if the contained liquor is preſſed back towards the ſmaller branches of the veſſel, being filled out therewith, ſwell or expand, ſo as to ſhut up the light of the canal.

CHAP. IV.

Of the CIRCULATION *or* MOTION *of the* BLOOD *through the Arteries and Veins.*

58. THE arteries and veins, which we have hitherto deſcribed, contain either blood or lymph. The red blood, whoſe nature we ſhall explain when we come to treat of ſecretion, fills the arteries and veins commonly known, which we call *red*, or thoſe of the firſt order, and which have their origin in the heart. Theſe it ſo fills in a living perſon, that at ſome times they are very looſely and imperfectly diſtended by it, and

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at other times they are rendered very full and turgid. After death, the veins are found fuller of blood than the arteries; but ſometimes, when the perſon has been dead a conſiderable time, the ſmall veins have been found diſtended with air. But the arteries of a dead body commonly contain only a ſmall quantity of blood.

59. This diſtending blood, then, is rapidly moved through all the veſſels of a living body. The truth of which is demonſtrated to us from wounds, by which the patient ſoon expires, from the loſs of ſo much blood as was neceſſary for the maintenance of life; which loſs of blood happens almoſt inſtantly from the larger arteries, and ſometimes very ſuddenly from the ſmaller ones: but from the veins, unleſs they are ſome of the largeſt, this loſs of blood is more ſlow and difficult; yet are there not wanting inſtances of fatal hæmorrhages from wounds of the veins, in the inner corners of the eyes, and thoſe under the tongue. Experiments made upon living animals, ſufficiently evidence the impulſe and rapidity with which the blood is moved, particularly through the arteries. In the larger trunks, it runs moſt ſwiftly; but, in the leaſt of them, ſomewhat ſlower. And, in the larger veins, the blood's celerity is leſs than in the arterial trunks, in the ſame proportion as the lights or ſections of the arteries are leſs than thoſe of the veins, i. e. twice or almoſt thrice ſlower. Another argument of the circulation, is the compreſſure and relaxation of a vein, whereby the motion of the blood is promoted from one valve to another. This motion of the blood is, in the veins, uniform or equable enough; but, in the arteries, it is alternately greater when the veſſel is more dilated, and leſs when it is contracted. This is proved by ocular inſpection in living animals.

60. That the motion the blood deſcribes is a courſe through the ſanguineous arteries into the veins, is diſcovered from experience. For, firſt, it is certain, that all the arteries and veins communicate or open one into the other; becauſe often, from one, and that a ſmall artery, all the blood ſhall run even until death, and

make all the flesh exceedingly pale; and this not only out of the wounded limb, but from the whole body. Of such fatal examples we have a number, from an inner artery of the nose, from the gums, a finger, tooth, cutaneous pore enlarged, from the lachrymal point, from the wound of cupping on the skin, and even the bite of a leach. There are, therefore, of course, open ways by which the blood speedily flows from the venous into the arterial system.

61. That the blood, again, in the arteries, flows from the heart toward the extreme parts of the body, is proved by the microscope, and by a ligature on the artery of a living animal. For whatever artery shall be stopped by a ligature, a swelling ensues in that part betwixt the heart and the ligature, whilst the other part is emptied beyond the ligature, which is the part of the artery more remote from the heart: neither has it there any pulsation; nor, if it be there wounded, will it yield any blood. The same effects which we see follow from a ligature, are likewise often produced by disease; as when some tumour, by compressure, or an aneurism, intercepts the motion from the heart. Experiments of this kind have been made by us on most of the arteries; anastomoses, however, or the blood flowing through a neighbouring branch, or the retrocession of the blood in a dying animal, form exceptions to this rule.

62. But for the course or motion of the venous blood, it has been always more doubted of; almost all the ancients have been persuaded, that the blood in the veins flowed through them, either from the heart or from the liver, to all parts of the body. Very few of them have known, that this was an error. Several of them have, indeed, acknowledged it to be false in the pulmonary vein. But that the blood did not move from the heart in the vena cava was known to still fewer anatomists of the ancients; perhaps only to Andreas, Cæsalpinus, and (from an extraordinary accident) to Vesalius.

63. Dr

63. Dr William Harvey is the firſt who experimentally aſſerted the motion of the blood returning in the veins to the heart, in ſuch a manner as to render the whole intelligible, and leave no room to doubt of it. And, firſt, *the valves of the veins* lead us to this truth: for the common uſe or office of theſe valves is, to determine the preſſure that is given from any quarter upon the veins, towards the heart, by allowing no opportunity to the venous blood, that has once entered the trunk, which they intercept, to flow back to the branches. For, ſince the covering ſpaces of the valves open upwards towards the heart, the blood enters into and expands them. Thus thoſe parts of the valves which ſtand out with a free motion within the light of the vein, approach each other towards the axis, until the oppoſite ſides, by meeting together, ſhut up the tube. This we know from inflations, ligatures, and injections of the veins; for you never can force a liquor eaſily into the veins by urging it againſt, or contrary to, their valves. They do not, indeed, every where ſhut up the whole cavity of the veins; but where they ſhut not cloſe, they always intercept the greateſt part of the light.

64. Another office of the valves in the veins ſeems to be for ſuſtaining the weight of the blood, that its upper columns may not gravitate upon the lower; nor the blood, flowing through the trunks, make too great a reſiſtance againſt that which follows it through the branches. For if, from the ſlower return of the blood into the veins, its weight or preſſure ſhall, in any part, much exceed the impulſe that drives it on, ſo as to cauſe ſome part of the column to deſcend by its weight; it is, in that caſe, immediately catched, and ſuſtained in its relapſe by the next adjacent valve, which hinders it from urging againſt the next ſucceeding column, and affords time and opportunity for ſome contiguous muſcle, by its preſſure or concuſſion, to ſend forward the ſaid column. And this is the reaſon why valves are placed in veins of the limbs and neck; in which

parts

parts they are both more numerous and more robuſt than elſewhere. And this is the cauſe of varices, when the blood, entering the hollow valves, urges their ſolid convexity downwards, and makes the vein dilate in that part. Likewiſe, in muſcular motion, the valves occaſion the whole preſſure which the veins then ſuſtain, to forward the due courſe of the blood towards the heart.

65. Moreover, the valves, placed in the right ventricle *of the heart*, have ſuch a fabric, as we ſhall hereafter ſee, that they freely permit blood, flatus, or wax, to paſs from the venous trunks of the cava into the heart, but deny any paſſage from the heart again into the veins.

66. Again, *ligatures*, in a living perſon, may make the thing more evident. When the veins of the limbs are tied, either by deſign or accident, with the limb itſelf about the hams, arms, ancles, or wriſts, the limb below the ligature ſwells, the veins fill and diſtend themthemſelves, and when opened make a free diſcharge of blood: but, at the ſame time, nothing of this kind happens above the ligature, nor are any of the veins to be ſeen there. The ſame phenomenon happens when the veins are compreſſed by ſwelled and ſcirrhous glandules in the viſcera; and from polypuſes the veins are often largely ſwelled, or enlarged into tumours. Theſe ligatures will ſerve to keep the blood in any limb round which they are tied, that it may not return to the heart and be loſt through a wound in another part.

67. The experiments to prove this courſe of the blood, which have been made in living animals, are ſtill more accurate. From them, even from our own, it appears, that, by tying any vein, in a living animal, near the cava, or belonging to the pulmonary veins, that part always ſwells which is moſt remote from the heart, all below the ligature appearing diſtended with the retained blood, while above and next the heart they are pale and flaccid. Laſtly, if the arteries are tied at the ſame time with the veins, theſe laſt remain flaccid and empty; but,

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upon removing the ligature from the arteries, the veins are immediately filled. In like manner, the infusion of poisons or medicinal liquors shew, that, into whatever vein you inject chemical acid spirits, the blood is driven along with the force of the poison to the heart itself. But when, from this cause, the brain is affected with the narcotic virtue of opium, and the intestines and stomach with the virtue of purgatives and emetics, this is a demonstration that the blood, with which these substances were mixed, had passed through the ramifications of the veins to the heart, and from thence through the whole body.

69. Another proof we have in the *transfusions* of blood; in which all the vital gore from the arteries of one animal is urged into the veins of another exhausted of blood, whereby the heart, arteries, and empty veins of the latter become so turgid and well replenished, that they work the whole machine of the animal with a remarkable degree of vivacity, or even cause it to labour by a plethora.

70. But that the blood passes from the least arteries into the least veins, we are clearly taught by *anatomical injection*; where, by one arterial trunk, we easily fill all the arteries and veins, almost throughout the whole body; provided the liquor be watery or very fluxile, so as to pass easily in the vessels of the head, mesentery, heart, and lungs.

71. Lastly, *the microscope* has put the matter beyond all doubt in the pellucid tails, feet, and mesenteries, of animals; where we see, that the blood, brought to the extreme parts by the arteries, is poured either into small veins, continuous with the reflexed artery, or else goes through branches of the arterial trunk into the parallel communicating vein, by which it goes on to the parts nearest the heart. This is the way in which the blood passes, as well into the least veins, which are capable of receiving only one globule, as into those that are somewhat larger, being able to admit two or more globules to advance forward in a breast. But, that there is no

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ſpongy or parenchymous interpoſition betwixt the arteries and veins, in the general courſe of the circulation, is proved both from microſcopes and injections. For, if there were any ſuch parenchyma or ſpongy maſs betwixt the arteries and veins, the hardening injections would ſhow it, by appearing extravaſated in a like unſhapen maſs.

72. The circulation of the blood is, therefore, now received as a medical truth by every one; namely, that all the blood of the human body is carried through the aorta, from the left cavity of the heart, to the extreme parts or converging ends of the arterial branches; from whence the whole maſs is again tranſmitted into the leaſt veins, which convey it to the larger, and from them into the cava and heart itſelf; in which courſe it perpetually goes and returns during life.

73. Yet there are ſome inſtances where, by paſſions of the mind, a ſudden revulſion by copious blood-letting, or a vaſcular convulſion, the blood has been forced to recede back from the ſmaller into the larger arteries. And, on the other ſide, where an obſtruction being formed above the valves, the blood has been known to ſlide back from the venous trunks into their ſmaller branches. But then theſe accidents are very momentaneous or ſudden, nd the blood ſoon returns into its natural courſe. Theſe things happen moſt frequently in the abdomen and vena portarum.

74. The courſe of the humours *in the lymphatic veins* which have valves, appears both from the nature of thoſe veins, and from ligatures: for every lymphatic vein tied, ſwells betwixt the ſmaller extremities of it and the thoracic duct; but grows flaccid betwixt the ſaid duct and the ligature. All the valves in theſe, like thoſe of the blood-veins, give a free paſſage for flatus and mercury to flow to the thoracic duct: but they make a reſiſtance, and often an obſtinate one, to any return the other way; although ſometimes they have been known to yield.

75. *The vapours* that moiſten the whole cellular ſub-

ſtance,

ſtance, the ſteams of the abdomen and other venters, are all thus drank up by the leaſt pellucid veins, and ſo conveyed along to the blood-veins, that their contained juices may paſs on to the heart: and from thence it is, that an œdema enſues when a vein is compreſſed by a ligature; becauſe, by intercepting the courſe of the abſorbing veins by the ligature, the vapours ſtagnate unabſorbed. In the other ſmaller veſſels, we can make no experiments: but they appear conformable to what we have ſaid, both by reaſon and analogy; and are likewiſe ſupported by the experiments of water or other liquors, abſorbed out of the cavity of the inteſtines, thorax, and pulmonary veſicles.

76. All juices, therefore, in the human body, are drove out of the heart into the aorta; from whence they are all returned again to the heart by the leaſt veins; thoſe humours only excepted, which are exhaled or diſcharged without ſide the cavities of the body. To complete this circle, it only remains for us to find out a courſe for the blood, from the right to the left cavities of the heart: but then this ſuppoſes us to be firſt acquainted with the hiſtory of the heart, and the pulmonary veſſels.

CHAP. V.

Of the HEART.

77. THE fabric of the *thorax*, compoſed of bones and cartilages, in general reſembles a truncated cone, as we ſhall hereafter declare more at large. The lateral parts of this cone are two membranous bags, terminated above by an obtuſe end at the firſt rib, where they lie very near together, and are diſtinguiſhed only by the interpoſed cellular ſubſtance. The obliquity of the plane, dividing theſe two bags, is ſuch, that the right is much the broadeſt, and adheres in its deſcent all along to the whole middle of the ſternum;

 but,

but, in its deſcent, is inclined to the left ſide, and comes from the margin of the ſternum itſelf; while the left bag deſcends, not from the ſternum, but from the cartilaginous ends of the ribs. The inner central ſides of theſe bags, oppoſed one againſt the other, make up what anatomiſts call the *mediaſtinum*. Theſe bags have no where any communication one with the other; ſo that the right may be opened, and the lungs therein may be deſtroyed, without injuring the left. But the ſimple denſe membrane, which forms theſe bags, outwardly inveſted with the cellular ſubſtance, is called the *pleura*; being harder than the peritonæum, eſpecially where it adheres to the back; but is ſomewhat ſofter in its fore part, and is almoſt deſtitute of feeling. The capacity of the mediaſtinum, or that interval which lies betwixt the right and left bag, broadeſt above, and likewiſe below, contains the thymus, and ſome conglobate glandules, fat, and veſſels, and, in ſome diſeaſes, pus.

78. Below, the ſame bags, growing broader, depart one from the other, and leave a capacity through the whole middle part of their extent, by which the ſaid bags are divided one from the other. And this capacity is that of the pericardium. But the bags of the pleura on each ſide the pericardium, deſcending both before and behind it, terminate finally on the diaphragm, about the fifth or ſixth rib; and on this their baſe is cut off obliquely, ſo that each cavity is before ſhorter in the fore part, as behind they deſcend longer and lower, in ſuch a manner as to be hollow in the upper part. Within theſe bags, then, play the dilatable lungs. The back parts likewiſe of theſe bags are more tender; and tho' they ly near to each other, are yet ſeparated by the cellular ſubſtance, which terminates in the pericardium, and includes the aorta, together with the œſophagus; and this we call the *poſterior mediaſtinum*. The triangular productions of the ſides of the mediaſtinum form the ligaments of both lobes of the lungs.

79. The *pericardium*, or third bag, which firſt the cellular

cellular ſubſtance, and then the conjoined pleura, looſely cover on all ſides as an outer coat, touches the ſternum indeed but by a very ſmall part; ſince the lungs, when diſtended, cover the heart almoſt wholly before, and interpoſe betwixt the ſternum and pericardium in their lower part; and the mediaſtinum, gradually departing towards the left ſide, forms altogether a narrow interval under the lower end of the thymus, cloſe to which the lungs meet on each ſide: but this vital ſituation you will alter or corrupt, unleſs you are very careful in your manner of opening the thorax. The pericardium has a broad, but ſomewhat rounding, baſis, adhering to the tendinous part of the diaphragm, and by a ſmall part to the fleſhy ſubſtance of the ſeptum on the left ſide, about the fifth or ſixth rib. In young ſubjects it adheres more laxly; but, in adults, very firmly, by the cellular ſubſtance ſpreading broader to the right, and narrower towards the left. It is ſomewhat larger than the heart; which, therefore, may move freely therein. This membranous capſule, or fence of the heart, was never known to be abſent.

80. Upwards the pericardium grows gradually narrower, ending above the heart in an obtuſe conical appendix, extended over the coats of the large blood-veſſels almoſt to the upper edge of the ſternum. It adheres firſt to the inferior branch of the right ſuperior pulmonary vein; then to the vena cava; after that to the aorta, on its acceſſion to which it riſes higher up; then it adheres to the deſcending trunk of the ſame veſſel, and to the ductus arterioſus; from hence it is ſpread upon the left branch of the pulmonary artery, then on both branches of the left ſuperior pulmonary vein. On the back part it is again attached to the right pulmonary vein; then to the left ſinus, to both pulmonary veins on the left ſide, and to the auricle of the ſame ſide; from thence it proceeds a long way from the pulmonary vein even to the inferior cava, then to the ſeptum of the ſinuſes, then to the inferior cava. Beſides, it goes to the pulmonary arte-

ry, its right branch, and the aorta under the origin of the large branches, in ſuch a manner as to ſurround both arteries with a cylindrical production of its ſubſtance, whence it appears like a kind of partition between every two neighbouring veſſels. Thus alſo it contains the vena cava ſuperior as in a ring, the anterior and poſterior cavities of the pericardium being freely continued between that vein and the aorta. In like manner it ſurrounds the inferior cava. But this ſheath, by which the veſſels are ſurrounded, preſerves its nature only for a ſhort ſpace, and immediately returns to the heart with thoſe large veſſels to which it ſerved as an external coat. It alſo ſends a cellular fabric like a ſheath, along with the great arteries and veins, to the lungs.

81. The *arteries* of the pericardium are either from thoſe of the thymus, which accompany the upper and lower phrenic nerves, or from the larger phrenic arteries, from the branches of the mammaries and mediaſtinals, the bronchial, œſophageal and poſterior mediaſtinal arteries, or from the coronaries which inoſculate with the bronchials and others. The *venous trunks* of the pericardium have a like origination, but appear with moſt evident anaſtomoſes from thoſe of the right into the others of the left ſide. The *nerves* of the pericardium are from the ſuperficial branches of the cardiacs.

82. That which makes the proper ſubſtance of the pericardium, is a ſtrong, white, compact membrane, more robuſt than the aorta itſelf, through which the nerves of the heart and ſome ſmall veſſels deſcend. Its outer ſurface, being ſpread with the cellular ſubſtance, gives it there a ſomewhat rough appearance, while internally it appears highly poliſhed, and moiſtened on all ſides by a watery vapour. This vapour, which we have, times without number, obſerved in the living animal, compoſes ſome, though naturally a very ſmall quantity, of a water within the pericardium; which is either limpid, yellowiſh, or reddiſh,

and

and subviscid or gelatinous; by disease, it is sometimes increased to an immense quantity; yet the existence of such a water here is injudiciously denied by some. The *water* of the pericardium is of a lymphatic nature; because, by the heat of fire, it hardens into a jelly; and from hence small fibres and a cellular substance are often found, in some diseases, mixed with the natural viscous humour which every where exsudes from the heart and its pericardium. This liquor is separated, without any intermediate glandules, or any visible pores, from the small exhaling arteries of the heart, auricles, and pericardium; as may be proved by a similar transudation of water or fish-glue injected into the large arteries.

83. The *use* of the pericardium is to contain the heart, along with this vapour; and to support and strengthen it as a fulcrum or prop, that, in contraction, the fibres of the heart may be drawn together without distorting the large blood-vessels, and that it may less fluctuate like a pendulum every way by altering the position of the body. For these reasons, we find it in all animals that have a true heart. A watery vapour here bedews the heart, hotter and quicker moved than other parts, so as to hinder attrition and cohesion betwixt it and the pericardium; but, when this vapour is dried up or deficient, the pericardium adheres either to some one part only of the heart, or to its whole surface, so that it sometimes seems to be entirely wanting.

84. Nature hath given a heart to most animals, even to many insects and worms: to others she hath denied it; and these are the most simple of all animals, although large, seeing they are irritable throughout their whole body, as, for instance, the prickly hydra. To those animals who have no heart, vessels are also denied.

85. The veins which carry back the blood from the whole body to the heart, if we except those of the lungs, are reducible to two. The *cava* is improperly named in the singular by anatomists, since it is no where, or for a very short space, one single trunk. The

The lower of the two large veins, which is the biggeſt of them in man, aſcends immediately above the diaphragm from the right ſide, towards which it is a little convex or gibbous, to its union with the upper cava, and, together with that in its back part, forms a middle partition betwixt the right and left ſinus: but the left ſide of the venous tube degenerates into the right auricle, whoſe fibres are a continuation from thoſe of the cava. What we have here ſaid of the lower cava is alſo true of the upper.

86. Thus, by the meeting of the upper and lower cava, a ſinus or cavity is formed with a convexity to the right, and inwardly filled with ſtrong, fleſhy fibres, detached betwixt the two ſimple membranes, and variouſly interwove. But the ſame cavity, to the left and fore part, dilates forwards into an almoſt perpendicularly oblong or oval form, and terminates above with a blind-pointed end, which is free from adheſion with the heart, and lies incumbent on the great artery. This cavity alſo, like the former, has plenty of fleſhy fibres placed betwixt two very thin membranes, almoſt in a parallel poſition; and theſe form a kind of arch extended from the right to the left edge of the whole cavity, and round the anterior half cylinder of this cavity; and theſe muſcular arches are connected together by ſome of the leaſt fibres. This anterior and ſtringy part of the cavity is called the *auricle;* but that to the right and poſterior part is called the *ſinus:* it is thin at the partition of the auricles, and likewiſe between the oval ring and where the vena cava enters the heart. In this appendix there ſeem to be three large muſcles, the anterior, poſterior, and inferior.

87. In the partition which ſeparates the two auricles, the baſis lying in the middle between the two venæ cavæ is depreſſed to the left ſide, more on the upper, and leſs on the under part; and, at its baſis, the partition is exceedingly thin. I ſhall call it the *oval foſſa.* It is bounded on both ſides by a fleſhy column, by the union of which an arch is formed at top, while the thinner parts at bottom are turned backwards to meet

one

one another. This I call the *oval ring*; others, the *iſthmus*.

88. Where the lower cava opens into the right auricle, from the tumid column of the left ſide of the foramen ovale ariſes a moon-like membrane, naturally complete in its figure, and from its thinneſs in adults ſometimes net-like: and this being extended round the lower edge of the auricule, grows thinner all the way as it is incurvated to the right; but does not quite ſurround half of the auricular circumference, the cavity of which it ſerves like a partition to divide from the vena cava. This is called *Euſtachius's valve*. The oval foramen we ſhall deſcribe hereafter.

89. The blood of the two venæ cavæ is propelled by a muſcular force, in either vein, into this *atrium* or porch of the heart, compoſed of the ſinus and auricle. Theſe veins, as far as they lie within the breaſt, are endowed with ſtrong and irritable muſcular fibres, by whoſe contraction the blood is driven into the neighbouring auricle.

90. In like manner, the auricle, being irritated, is contracted on all ſides. And firſt, by a conſtriction of its muſcular fibres, the anterior ſemicylinder of the auricle is reduced to a plane; while the ſame fibres, by their contraction, bring back the middle arch towards the anterior extremity or beginning of the heart, and likewiſe towards its poſterior extremity or ſinus. Then the appendix to the auricle deſcends, and is contracted tranſverſely by itſelf, while the lower part aſcends; and thus the auricle becomes ſhorter. Again, the left edge turns evidently to the right, and the right edge a little to the left; and thus the auricle is rendered narrower. Thus the blood of both cavæ, being mixed together in the beginning of the heart now diſincumbered, is drove through the edges of the open valve, in ſuch a manner as to urge the valves of the right ventricle cloſe to the ſides of the heart. But the blood is now hindered from returning again into the lower cava, both by the contraction of the auricle, the reſiſtance of the ſucceeding blood from the abdomen,

and

and of the *Euſtachian valve;* and upwards it is hindered from aſcending, both by the motion and weight of the conſequent blood. It is driven back, however, on both ſides, if there happens to be any obſtacle in the lungs.

91. The *figure of the heart* itſelf, in ſome meaſure, reſembles half a cone, if the cone be ſplit into two longitudinally in the direction of its axis. It is almoſt triangular; only the end of it is obtuſe, and the lower ſide of it is flattened in proportion to the diaphragm on which it lies incumbent, and is thereby ſuſtained. But the convex ſurface of the cone is ſo inclined within the pericardium, under the great blood-veſſels, as ſuffices to place its thicker ſemicircular curvature, which modern anatomiſts call its *obtuſe margin*, directed to the upper and to the left ſide of the breaſt: in its lower and anterior part, the heart is alſo extenuated into a kind of edge, which is called its *acute margin*; but the point is turned a little forewards. This is the general ſituation of it in mankind; but, in brutes, the heart being almoſt parallel to the larger axis of the thorax, its apex or tips only extend to touch the diaphragm.

92. The whole heart is hollow, having its *anterior*, formerly called its *right ventricle*, communicating into the right auricle and ſinus, which is broad, and ſhaped like the fourth part of a cone; not ſo long as the poſterior left ventricle, but larger; and it terminates in the ſhorter tip of the bifurcated apex of the heart. The mouth of this ventricle, where it opens into the auricle, is elliptical; and terminated by a white glutinous margin, more callous than tendinous: over this, plates of muſcular fibres are ſpread, and ſome fat lies outwardly upon theſe.

93. From this callous margin is extended, within the heart, a membranous ring, formed by a reduplication of the internal membrane of the auricle, extended ſo as to float within the ventricle, to which it was before continuous. But this ſame ring, in that part which fluctuates in the ventricle, is ſo ſplit or divided into three

three unequal triangular portions, that you may, in ſome meaſure, give them the name of valves, and count three of them in number, although they are, in fact, only continued parts from one broader ring. Theſe were, by the ancients, named *triglochines*, or *tricuſpid* valves.

94. That part of theſe valves which lies next to the ſides of the heart is ſtrengthened by tendinous fibres, which, meeting together in their courſe, are inſerted by very ſtrong cords, partly into the ſides of the heart, and partly into papillary or cylindric muſcles, which ariſe upward from the left ſide of the right ventricle towards its right ſide. The largeſt of theſe muſcular columns is that which anſwers to the biggeſt of the valves, which is both the uppermoſt and that which anſwers to the adjacent mouth of the pulmonary artery. The leaſt of them is the loweſt, and is ſituated before the acute margin.

95. The uſefulneſs of this valve is evident enough; for the right auricle (90.) being contracted, the blood contained in the right porch of the heart, at the looſe extremity of the auricle, being impelled from the circumference towards the axis, like a wedge, ſeparates the pendulous portions of the ring, called *tricuſpid valves*, and preſſes them to the ſides of the heart. Thus is filled the right ventricle of the heart, while the uppermoſt valve (94.) ſhuts the pulmonary artery, leſt the blood, by the weak impulſe of the auricle, ſhould flow into that artery; the blood thus received, and confined within the right ventricle of the heart, is, by the ſtrong contraction thereof, more powerfully expelled into the artery.

96. The ſenſible fleſh of the heart, being irritated by the quantity and weight of this warm blood, is thereby ſolicited to a contraction: for that the heart, being irritated, will contract itſelf in a perſon dying, or even lately dead, is proved by injections of water, and inflations of air, whereby the heart, then quieſcent, is recalled to its motion.

97. The heart's motion is performed by *muſcular fibres;* the originations of which, in general, are from rings formed of the cellular ſubſtance, compacted into a callous ligament, agreeable to the deſcription given in 92. and with which all the larger blood-veſſels, at their opening into the heart, are ſurrounded. From thence the fibres which ariſe deſcend gradually in an oblique winding courſe towards the left ſide, and forward to the apex, in many diſtinct plates, and ſometimes a little traverſing each other, the middle ones being the moſt tranſverſe, while the outermoſt and innermoſt deſcend in a ſtraighter line. In the flat ſide of the heart (91.) there are few fibres; and ſo thin, that, when you have removed the fat, the cavity appears almoſt uncovered. That which is called the left ventricle is, however, very firmly inveſted by the fibres; which, after ſurrounding the ſame ventricle, form a ſlight decuſſation in the ſeptum cordis with the fibres of the right ventricle, and are interwoven with them. Some of theſe fibres deſcend into the cavities of the ventricles, and form there the fleſhy columns mentioned at 94. Others, at the tip of the heart, are wound in a vortical or whirling poſition, the two horns ending by a ſtrong faſciculus or bunch in each ventricle. A very thin and ſmooth membrane covers the external and internal ſurface of theſe fibres; but the external membrane, eſpecially where it is ſpread over the coronary veſſels, contains much fat beneath it. I have, for my own part, not been able to diſtinguiſh any thing more particular in the muſcular fabric of the heart, with any tolerable degree of evidence; becauſe it is the peculiar property of the fibres in the heart to join together in branchy appendices or heaps, in ſo ſtrict union, that they cannot be ſeparated without laceration.

98. But there are ſeveral eminent anatomiſts, whoſe ingenuity and communicative freedom I reſpect, who have repreſented and deſcribed thoſe fibres diſplayed and ſeparated: namely, the external fibres of the heart,

heart, common to both ventricles, defcending to the tip, and then, taking another courfe, to infert themfelves into the feptum; others again, at the tip, to perforate the left ventricle, and return, in a contrary courfe, to the bafis, along the inner furface of the faid ventricle. But the middle fibres, betwixt the aforefaid inner and outermoft ones, being varioufly inclined towards the bafis, they form the feptum. And others have given us figures and defcriptions of ftill different orders of fibres, of which the outermoft run counter to the innermoft, while the intermediate are tranfverfe. Which defcriptions, as they are not much different from my own obfervations, I fhall make no oppofition to, although I have never been able to fee this difpofition of them fufficiently manifeft, and am acquainted with great anatomifts who have not herein been more happy than myfelf.

99. Thefe fibres of the heart, like other mufcles, are furnifhed with *nerves* of their own, very numerous and of various origin. The firft and uppermoft are on the left fide from the ganglion of the intercoftal with the uppermoft cervical nerve. With thefe are joined others from the pharyngeal plexus of foft nerves; others, produced from the pharyngeal and gloffo-pharyngeal ganglions, are mixed with them; others alfo are added from the trunk of the intercoftal nerves; and others from the middle ganglion feated on the ftraight mufcle about the paffage of the thyroid artery, which has branches both from that uppermoft nerve, and from the trunk of the intercoftal and phrenic nerves. Others come from the recurrent nerve of the eighth pair. The nerves of the heart, originating from thefe fources, (wove together into a plexus, partly before the great artery, in which the following ones are mixed together; and partly forming feveral fmall plexufes between the afpera arteria and the large arteries going out of the heart,) form one or more plexufes out of the nerves of the right and left fide; which plexufes are

commonly joined together, though ſometimes they are diſtinct. From this ſame plexus, or plexuſes, other nervous twigs paſs betwixt the aorta and pulmonary artery to the right artery of the heart; others croſs the pulmonary artery, and go betwixt it and the left auricle to the coronary artery of the ſame ſide; others behind the pulmonary artery to the ſame coronary; and others, again, deſcend very deeply behind the pulmonary artery to the left ſinus and flat ſurface of the heart. To the cardiac plexus, above deſcribed, other large nerves accede from the fifth and lower cervicals, and ſometimes from the phrenic nerve, and from a ganglion of the loweſt cervical with the intercoſtal, to which join large roots from the loweſt cervical nerves. The laſt deſcribed nerves, which are larger, ſofter, and more tranſverſely diſpoſed, are partly mixed with the foregoing plexus, and partly go to the lungs. Laſtly, there are ſome ſmall branches, uncertain as to courſe and number, which join the cardiac plexus from the recurrent and eighth pair of nerves; and, making various inoſculations with the intercoſtals, are confounded with thoſe of the eighth pair. As for thoſe nerves, which ſome eminent anatomiſts have ſeen aſcending from the great abdominal plexus to the heart, through the foramen of the vena cava, I have never been able to find ſuch; although it is eaſy enough to diſcover the diaphragmatics in that place, having ganglions peculiar to themſelves, of which thoſe anatomiſts make no mention.

100. That theſe nerves conduce powerfully to move the heart, is the opinion of eminent anatomiſts, from a conſideration of the common nature of muſcles; and from the increaſe which follows in the heart's motion, by irritating the eighth pair of nerves, either at the brain, or the ſpinal medulla; and from the languors that enſue upon tying thoſe nerves, which proves fatal, either ſuddenly or within a few days, even though you happen to make the ligature on but a few of the nerves that come to the heart; for the intercoſtal, and eſpecially

cially thoſe from the ganglion of the upper thoracic, cannot be tied.

101. But that there are ſtill other cauſes, beſides that of the nerves, conducing to the motion of the heart, we are perſuaded from obſerving its motion undiſturbed by the irritation of all the nerves in the living animal; from its remaining after the greateſt wounds of the head, and even of the cerebellum and medulla ſpinalis; likewiſe from its motion when torn out of the breaſt; moſtly in thoſe animals in which the lungs, being impermeable, make no reſiſtance to the heart's motion; for the motion of the heart is obſerved to be very vigorous in the fœtus before the brain is well formed, and likewiſe in animals wanting the head. And all our experiments agree in this, that the quieſcent heart, in dead or dying animals, when irritated by heat, cold, vapours, poiſons, and eſpecially the force of impelled flatus, watery liquors, wax, or blood, or on receiving an electric ſpark, immediately contracts itſelf, by putting all its fibres into a rapid motion, by a force ſometimes common throughout the whole heart, and ſometimes affecting only a particular part of it.

102. Thus then we ſee, that there reſides in the heart a kind of impatience of ſtimulus; ſo that even in the viſcus, when almoſt dead, wrinkles, and motions of different kinds, appear to be propagated along its ſurface, from places as it were irradiating from points: again, the heart, when torn out and cold, on being pricked, inflated, or irritated, contracts itſelf; and its fibres, when diſſected, corrugate themſelves orbicularly, when there is neither nerve nor artery to bring it ſupplies of any kind. This irritability is greater, and remains longer, in the heart than in any other part of the body; ſeeing, by ſtimulating it, the motion of the heart may be renewed at a time when that of no other muſcle can. The heart of the fœtus is moſt irritable, as well as larger, in proportion, than in adults; and moſt tenacious of its motion, even in the cold. That motion is *peculiar to the heart itſelf;* coming neither from the brain, nor the ſoul;

ſoul; ſeeing it remains in a dead animal, even when the heart is torn out of the breaſt; neither can it, by any act of the will, be made either quicker or ſlower.

103. It is, therefore, evident, that the ſtimulus, occaſioned by the impulſe of the venous blood, cauſes the heart contract itſelf; and that this contraction is convulſive, made with great celerity, and a manifeſt corrugation of the fibres; whereby the whole heart becomes ſhorter, thicker, and harder, ſo that the left ventricle is drawn ſomewhat towards the ſeptum of the heart, and the right one much more. The baſe alſo advances towards the apex; but the apex more evidently towards the baſis. This I have often obſerved with the greateſt certainty in diſſecting brute animals; ſo that thoſe learned gentlemen muſt have ſome way or other been deceived, who have aſſerted, that the heart is elongated during its contraction. But the heart does not ſeem to turn pale in ſuch animals as have warm blood. Even the ſeptum of the heart is rendered ſhorter, and draws itſelf towards the baſis. By this action, the fleſhy parts of the heart ſwell inwardly, and compreſs the blood, as they do the finger, when introduced into its cavities. But that the heart is conſiderably enough emptied in this action, appears both from the event; the evident paleneſs of animals whoſe heart is white, as frogs and chickens; and from the internal ſurface being full of eminences, which exactly anſwer to oppoſite cavities, and to the thick reticular arms or columns interrupted by ſinuſes. Finally, the apex of the heart, being contracted a little like a hook, ſtrikes againſt that part of the pericardium next the thorax. Forwards, there is alſo a pulſation from the left venal ſinus; which is, at that time, particularly filled. In exſpiration, the heart ſtrikes violently more upwards and forwards. The truth of both theſe we know by experiment.

104. The blood, which is preſſed by the contracted heart (103), endeavours to eſcape in all directions; but being driven from the muſcular ſides, towards the axis of the ventricle, by the reaction of what is lodged betwixt

twixt the venal ring (93.) and ſides of the heart, the looſer ends of the ſaid ring are driven forwards and extended inward at the ſame time. By this action upon the whole circumference of the ring, it not only becomes extended itſelf, but, at the ſame time, throws back a part of that blood into the right auricle which had before deſcended into the cone of the open valve, whoſe ſides, now approaching, ſhut up the venous orifice more cloſely as the heart contracts more ſtrongly, by whoſe force the tricuſpid valves, as they are called, would be preſſed reduplicated into the auricle, if the muſcular nipples (94.) or columns did not keep down their edges, and hold them firmly by their contraction (which is the ſame with that of the heart) in ſuch a ſhape, as will extend the annexed chords of the valve, without injuring them.

105. But the niſus of the remaining blood, now reſiſted by the tricuſpids, ſeeks another courſe; and, whilſt it derives the larger of thoſe valves that is ſeated to the right (94.), from the ſide towards the axis of the heart, this leaves open the mouth of the pulmonary artery, which it before covered; whereupon the blood preſſing the valves in the mouth of the ſaid artery cloſe to its ſides, it thus ruſhes into it.

106. To deſcribe this more particularly; from the upper and poſterior part of the right ventricle, a way leads into the *artery*, taken in as it were between the fleſhy parts of the heart produced, and ſtrongly connected to it by a cellulous, callous ring, from whence the artery aſcends to the left backward, and diſplays itſelf behind the arch of the aorta. The ſtrength of this artery is not extraordinary, being much weaker than that of the aorta. But from the inner ſurface of the artery, where it is joined to the heart, *three ſemilunar valves* ariſe, by a reduplication of the arterial membranes extended upwards, and towards the axis, in an arch that is flat or obtuſe enough; and theſe valves always fluctuate with their edges at free liberty, in a parabolical ſhape. The middle of the edges, in each of theſe valves, is generally

rally divided, ſometimes in the fœtus itſelf, by a ſmall, denſe, callous body, of a conical ſhape, but made up of inclined planes; whereby each whole valve, in itſelf reſembling an half-moon, is thereby again ſubdivided into two leſs half-moons. Betwixt the two membranes of the valve, appear ſome muſcular or tendinous fibres, partly in a tranſverſe poſition; ſome of which hold faſt the valve to the next contiguous ſide of the heart, leaving ſometimes ſpaces betwixt them in a reticular manner. Other fibres aſcend from the baſis of the valve; and, by growing to the callous corpuſcle, draw back the ſaid valve, and open its concavity.

107. Each of theſe valves, in conjunction with the ſides of the artery here diverging, intercept a ſpace, which is blind or impervious downward; but open upward in a parabolical ſhape, as we obſerved of the valves in the veins (49.) When, therefore, the blood is impelled from the ſides towards the axis of the contracting heart, it endeavours to eſcape in the direction of the ſaid axis; and, by ruſhing forth like a wedge, betwixt the valves, preſſes their looſe ſail-like edges againſt the ſides of the pulmonary artery, ſo as to run freely out of the heart. The truth of this appears from the plain fabric, from injections, and from ligatures, which, by obſtructing the lungs, will not ſuffer the large cavities in the right ſide of the heart to be emptied.

108. The blood now received into the pulmonary artery, goes on then to make its circulation through the lungs. That artery is firſt divided into two branches; of which the left, being leſs and ſhorter, enters directly into the ſubſtance of the lungs: but the right branch, being larger and longer, paſſes tranſverſely through the arch of the aorta; and, after going a little way behind the ſaid aorta, enters the correſponding lungs of the ſame ſide. From each of theſe branches, by a multiplied ſubdiviſion, ariſe the very leaſt arteries, ſome of which tranſmit the blood directly into the continued ſmall veins, and others exhale part of its aqueous juices into the pulmonary cells. That the blood goes thus di-

rectly

rectly from the arteries into the pulmonary veins, appears evidently from their ſtructure; alſo from a ligature, which, intercepting the blood's courſe, while the heart and lungs ſtill urge it, cauſes an aneuriſmatic dilatation of the artery; and from polypuſes, by which, the mouth of the pulmonary artery being obſtructed, the right cavities of the heart become monſtrouſly enlarged, and at length burſt, while the left remain empty. Laſtly, from injections; for water, fiſh-glue, and milk, are very eaſily forced from the pulmonary artery into the vein, and from thence into the left cavity of the heart. But the direct anaſtomoſes or final openings of the arteries into the veins in the lungs, is proved even to the ſight by the microſcope, in frogs, &c.

109. Nor can the blood, which has once entered the pulmonary artery, return back again upon the heart; becauſe the valves therein (106.) are of ſuch dimenſions, that, when diſtended, they perfectly ſhut up the opening at the heart; and are ſo ſtrong, that they reſiſt a much greater force than the contraction of the pulmonary artery, without being conſtrained to yield. However, ſometimes, from a greater contractile force of the artery, they grow ſomewhat callous; or, from a laceration of their outer membrane, a bony matter is poured in betwixt the duplicature of the valves. For, when the blood, by the contraction of the artery, returns towards the heart, it meets and enters the open ſail-like concavities of the valves (107.), which are, by that means, expanded, and driven together towards an axis in the middle: whence the valves, once expanded, quite ſhut up the mouth of the artery, ſo as to leave not the leaſt ſlit open; for any opening that might be left, is precluded by the ſmall callous bodies remarked at 106.

110. The *pulmonary veins*, of which we ſhall ſay more hereafter, gather into larger branches, which, at laſt, terminate in four (ſeldom two, and ſtill more rarely into five) trunks; to which it has been cuſtomary to affix a name in the ſingular, by calling them the *pulmonary vein*. Theſe enter the cavity of the pericar-

dium, from whence they receive an external covering; and are then inserted at angles into the square left or *posterior sinus*, which is sometimes likewise called the pulmonary sinus. In this course the upper veins descend, as the lower ones ascend. But that these veins bring their blood towards the heart, in the same direction with the sinus into which they open, is proved by a ligature, which causes a turgescence or swelling, from the blood retained, betwixt the ligature and the lungs.

111. This pulmonary sinus, which is almost of a cubical figure, being firmly built of divers bundles of fibres running betwixt two membranes, has, forward and to the right, one single side or partition, in common to itself and the right sinus (86.); but, forward and to the left side, it goes into a conical appendix, which is divided into processes, or indentations, like a cock's comb; and, after two or three serpentine turnings, makes what is called *the left auricle*, incumbent on the left ventricle, and pointing forwards. Some of its fibres, as in the right auricle, by their bending, contract it into the form of an arch; others, coming from the origin of the appendix, and inserted into its apex, depress it. This sinus, with the left auricle, are somewhat less than the right sinus and auricle.

112. In this left sinus, the blood waits for the heart's relaxation; at which time the nisus of the blood impelled against the venous valves, and the contracting stronger force of the sinus, grow less. Then the left sinus stretches itself forward across the heart, is contracted transversely along with it, and the appendix becomes evidently shorter and narrower. Thus the blood is driven into the left ventricle, in like manner as the right auricle impelled its blood into the right ventricle, (95.) For here, as before, a like membranous oval ring forms productions called *mitral valves*, of which there are usually two only counted. These valves are longer and stronger than those of the right ventricle. They have each a muscular column, often single only, and joined to the tendinous threads of each valve: but they are much

much ſtronger than thoſe of the tricuſpids. And here, more frequently than in the valves on the right ſide, callous knots, or cartilaginous humours, are found in the tendinous ſtrings, at their originations from the membranous ring.

113. From what has been ſaid, then, it appears, that the ſame blood is now arrived into the left ventricle of the heart, which was a little before ſent from the venæ cavæ into the right auricle (89.), which drove it into the correſponding or right ventricle (95.); by which, again, it was urged into the pulmonary artery (105.); and, from thence, paſſing into the pulmonary veins, was conveyed into the left ſinus (110.); and, out of this, we here find it driven into the left ventricle (112.). This courſe of the blood, from one ſide of the heart to the other, through the lungs, is called the pulmonary or leſſer circulation, and was known to many of the ancients. It is proved by the increaſed bulk of the pulmonary veins on the left ſide; and likewiſe of the right cavities of the heart, on an obſtruction of the entrance into the left ventricle.

114. The *left*, or poſterior, and upper *ventricle* of the heart, which is always firſt formed, and in a great number of animals the only one, makes up that part of its half-cone-like body, which we before called obtuſe, (91.) It is ſomewhat narrower than the right ventricle, a little longer, rounder, and generally of a leſs capacity within. For the contents of this ventricle are about two ounces, while thoſe of the right advance up to three. Its fabric internally is reticular, but more nicely wrought than in the right ventricle; and within the mouth of the artery it is ſmooth: but its force is conſiderably greater, as the muſcular fleſh that ſurrounds it is much thicker, and almoſt three times ſtronger. The ſeptum of the heart belongs moſtly to the left, but ſome part of it alſo to the right ventricle: the whole of it is reticulated in like manner; but ſolid, and incapable of ſuffering any injected liquid to paſs from one ventricle to another.

115. Again, this left ventricle, being instigated to motion by the impelled blood, does, from the same irritable nature before mentioned (103.) contract, and drive its contained blood with a violent motion in the direction of its axis, and determine it towards the basis, at the time when the tip or cone of the heart is drawn nearer to its basis. And since the apparatus of the *mitral valves* is here the same as before in the tricuspids, the venous blood, now expanding the ring from whence they arise, removes that valve which lay against the mouth of the aorta, so as to open a way for itself to the artery; in dilating the mouth of which, the said blood presses the semilunar valves, there placed, against the sides of the aorta, into which it rushes with a violent impetus. This is proved by ocular demonstration in living animals, where the left ventricle swells upon shutting the passage into the aorta.

116. The *semilunar valves of the aorta* differ little from those in the pulmonary artery: only as the opening is here greater, so the valves are proportionably larger and stronger, and are not so often distinguished in the middle by those callous globules or little round bodies. The fibres too of the valves, both transverse and ascending, are here somewhat more conspicuous.

117. After the contraction of the heart, follows its relaxation or diastole, in which it becomes empty, lax, and soft, recovers its former length, the ventricles recede from the septum, and the basis from the apex. But, while it is in this state, the blood in the auricles, having been as it were in a state of expectation, rushes through the openings of the valves of the veins, dilates the opposite sides of the heart, and makes it at once longer and larger. After the auricles have freed themselves of the blood they contained, they are in like manner relaxed, and their opposite sides remove from each other. Then the blood, collected in the venæ cavæ and pulmonary veins, fills the auricles by the contraction of the veins; renders them long, broad, and thick, like the ventricles; and even distends and fills the tooth-like processes

ceſſes of the creſted margin. That the fibres of the heart are not dilated, is proved from the junction of thoſe fibres; which, being tied together by their middle branches, cannot be ſeparated: alſo, by the diſſections of live animals, in which the whole heart is ſhown to be contracted.

118. But we muſt now conſider, that theſe motions of the right and left auricle, with the right and left ventricle, are not performed in that ſucceſſion in which, for the ſake of method, we have here deſcribed them; for both the auricles are contracted, while the ventricles are relaxed: ſo that the contraction of the auricles precedes the contraction of the ventricles; as we are aſſured from manifeſt experiments on dying animals, and on thoſe whoſe living blood is cold. But both auricles are filled together in the firſt inſtant, as both of them are emptied together in the ſecond inſtant; and both the ventricles are contracted together in the third inſtant, which is the ſame with the firſt; and both ventricles, being evacuated, are relaxed in the fourth inſtant, which is the ſame with the ſecond. Thoſe who have miſtakenly taught otherwiſe, have not taken the advantage of making a ſufficient number of experiments on living animals. That the auricle, near death, makes frequent palpitations, before the ventricle of the heart performs one contraction, is true enough. The auricle with its ſinus forms one cavity, and both are filled and both emptied in the ſame inſtant.

119. But it may be aſked, why the heart never ceaſes from *its perpetual motion*, through ſuch a number of years as there are in one's life, through ſo many days as there are in a year, and through ſo many hours as there are in a day; when, in each hour, the heart of a healthy perſon contracts not much leſs than 5000 times: ſo often are there ſucceſſive repletions followed with new contractions, perpetually in the ſame conſtant order. Nor is there any other muſcle, beſides the heart and diaphragm, but what becomes tired and painful, by acting inceſſantly, even for a few hours. Different

anſwers

anſwers have been given to this queſtion by different profeſſors, founded either upon a compreſſure of the cardiac nerves betwixt the large arteries, or upon an alternate repletion of the coronary arteries and cavities of the heart, &c.

120. But to me the ſimplicity of nature ſeems very great in this matter. When the auricle is relaxed, it is directly filled by the muſcular force of the continuous great vein; and ſo the heart alſo contracts itſelf, when, in like manner, it is irritated by the blood driven into it from the auricle. Therefore, the heart, having once received the blood, is contracted by that ſtimulus or irritable force, whereby muſcular fibres are excited into contraction; whereupon it empties itſelf of the blood, and, being freed from the ſtimulus thereof, immediately reſts or relaxes itſelf. But the heart being now relaxed, the auricle is in like manner irritated by its contained blood, and by contracting fills it again; while the inceſſant actions of the heart and arteries continually urge new blood into the right ſinus and auricle. That this is the true ſtate of the heart's motions, is proved from actual experiment or obſervation; whereby we plainly diſcern the ſucceſſive repletions and conſtrictions made in the great vein, auricle, ventricle, and artery, eaſily ſeen in a weak or expiring animal; but more eſpecially, and more evidently, in thoſe animals which have but one ventricle in the heart; as the tortoiſe, frog, ſnake, fiſhes; and in the chick hatching in the egg, which, inſtead of a heart, has only one crooked canal. The ſame is alſo confirmed from the reſting of the heart, which follows upon tying the veins; and from the return of its motion, by removing the ligatures, or by the impulſe of wind or liquors injected; and, laſtly, from the perpetual contraction of a frog's heart, round or upon a veſicle of air inflating it; which air, urged into it by the veſicle, it will alternately receive, and for many hours tranſmit into the common air. The left ventricle firſt ceaſes its motion; then the auricle of that ſide; then the right ventricle; after that, the

the right auricle; and, laſt of all, the pulmonary veins, and venæ cavæ. Whatever motion is in the venæ cavæ, ought to be attributed to the auricle repelling the blood into both theſe veins, and which the heart, when dead, is not capable of receiving.

121. Nor do I believe there is any thing more required to the heart's motion, than a continual ſtimulus applied to a very irritable part. For, even in the article of death itſelf, the very coldneſs of the limbs, which the warmth of life has left, contracts the veins, and drives the blood to the heart; when the lungs, being impermeable for want of reſpiration, tranſmit no blood to the cavities of the left ſide. And, on the other hand, the heart, after it is thoroughly emptied, remains at reſt. It may thus happen, that, inſtead of the vena cava and right auricle, the laſt appearance of life may be transferred to the left auricle and ventricle; if we ſuppoſe the right cavities to be empty, the left may be irritated by the blood contained in them. But if you derive the reſting of the heart from the compreſſion of its nerves, the motion of the auricles will be an objection, becauſe their nerves are not compreſſed. An example alſo we have in fiſh, and little chicklings in the egg, where there can be no room for a compreſſure of the nerves. If, again, you deduce the heart's reſt from a compreſſure or occluſion of the coronary arteries, this is contrary to experience; ſince they are not covered by the valves of the aorta, and from a wound of the ſaid arteries, during the ſyſtole of the heart, the blood ſtarts out to a great height.

122. Nor, with the ſtrength of the heart, do I join the oſcillations of the very ſmall veſſels, which is refuted by experiments: nor the force of external heat; ſeeing animals are found to live and thrive in the coldeſt regions of the north: and though the contractile force of the artery, and the weight of the parts and of the atmoſphere, aſſiſt the motion of the blood during the diaſtole of the heart, the ſame powers reſiſt it during the ſyſtole; ſo that, indeed, by theſe means, the blood

is

is moved no farther through the contractile arteries, than even through the rigid arteries of the ſmaller animals.

123. But with what celerity, and with *what force*, *the heart* drives forward the blood, is controverted, and variouſly computed. The more modern writers have raiſed their calculations upon a ſuppoſition that, for the celerity to be determined, we are to admit two ounces of blood to iſſue out of the heart with ſuch a celerity, that the part of the pulſe, called its *ſyſtole*, makes one third of the whole pulſation, and is finiſhed within a $\frac{1}{225}$ part of a minute; but the area of the mouth of the aorta, they have eſtimated 0.4187 parts of an inch: ſo, by dividing the ſpace filled by two ounces of blood, (3.318 inches) by the area or ſection of the aorta at its mouth, [and length of its cylinder filled by two ounces, viz. $=7\frac{29208}{33180}$], the number thence produced divided by $\frac{1}{225}$, the time in which the heart contracts, they find 149 feet and two tenths of an inch for the ſpace thro' which the blood runs in a minute, if it goes on in a cylinder with the ſame velocity it firſt had from the heart. But the incumbent weight of blood moved by the heart, they have computed by the jet wherein the blood ſtarts forth from the larger arteries in a living animal, being ſeven feet five tenths; and from the ſurface of the ventricle, whoſe area make 15 inches; which produce 1350 cubical inches of blood, or 51 pounds five ounces, which preſs againſt the ventricle of the contracting heart. The heart, therefore, thus drives forward a weight of 51 pounds, with a velocity by which it may run through 149 feet in a minute; which force it exerts four thouſand eight hundred times in an hour.

124. Although there are many particulars here unthought of, which may render the eſtimate incomplete, and ſuch perhaps as we may never get over; and although the mouth of the diſtended aorta may be wider in a living animal, though the area of the ventricle is of uncertain dimenſions, and the jet of blood computed from an inſufficient height; yet, if we conſider the

the violence with which the blood ſtarts from ſome of the leaſt ſanguine arteries in the living animal, although we cannot eaſily determine how much of the heart's ſyſtole it aſſumes to itſelf, variations in which will greatly alter the computation; yet, in the mean time, it will plainly appear, that the machine we call the heart is a very powerful one. The truth of this is evident from experiments, in which it appears to be very difficult to fill all the red blood-veſſels by anatomical injections, and quite impoſſible to fill all the ſmaller of them: yet the heart, we ſee, not only gradually diſtends all the larger, the ſmaller, and even the leaſt veſſels, with blood, but alſo drives it forward through them with a conſiderable celerity. Even in the leaſt arteries, the blood is urged forward by the heart with ſuch a force as to make the alternate motions of that muſcle perceptible. Likewiſe, in the veins and ſmaller veſſels of cold animals, even while contained in the inſects egg, there is no other force beſides that of the heart, by which the blood is driven through their ſmall veſſels. And, from ſome of the leaſt arteries, I have ſeen the blood ſtart forth ſeveral feet, the jet deſcribing a parabola, whoſe height was four feet, and amplitude of the projection ſeven feet; and ſome aſſert, they have ſeen the blood aſcend from the aorta to the height of twelve feet.

125. Moreover, that we may make a juſt eſtimate of the heart's force in living animals, we muſt conſider what great reſiſtances that complex muſcle overcomes: we muſt compute the enormous weight there is of the whole blood; a maſs, perhaps, of fifty pounds and upwards: for all that quantity of fluids, once ſtagnant in a perſon lately drowned or fainted away, are eaſily put into their former motion by the heart only. We muſt again conſider the great decreaſe of the blood's velocity, ariſing from the greater light or capacity of the dividing branches, (from whence the ratio of its celerity, even in the inteſtines, may be computed to only a 24th or a 30th part of its original impulſe), abates

two-thirds from the heart's force. And yet we ſee there are humours ſwiftly moved through much ſmaller veſſels; as, for example, in thoſe of the Sanctorian perſpiration, which, in a ſubterraneous cavern, I have obſerved to aſcend ſwiftly in form of ſmoke or vapour; and the ſame celerity of the blood in the leaſt veſſels of little fiſhes, &c. is apparent to the eye by a microſcope. Now, ſince the frictions, in every machine, always conſume the greateſt part of the moving forces; much more do they in the human body, whoſe blood and juices are ſo much more viſcid or clammy than water, and driven through veſſels ſo ſmall, that they permit only a globule at a time to paſs through, and even hardly allow that without changing their figure: but from ſo ſtrong and extended a friction there muſt neceſſarily follow a very great hindrance to the motion; whence we may eaſily underſtand, that the force muſt be very great which drives ſo ſwiftly ſuch a prodigious maſs of fluids over ſo many reſiſtances and decrements of the moving forces. But aneuriſms, and likewiſe arteries, are burſt by the force of the heart; and great weights are elevated along with the human body by the force of its ſyſtole.

126. The blood, being driven into the aorta, immediately finds the two openings of the coronary arteries, which lie next the arterial valves, but above them, or within the aorta; and, in conſequence of this, it ruſhes firſt of all into the ſaid coronary arteries, by which the heart ſupplies itſelf with blood. Theſe arteries are almoſt conſtantly two; which going off from the aorta next the heart at an obtuſe angle, the right goes off between the aorta and pulmonary artery, and the upper and left one between the left auricle and the aorta. All the external arteries are ſurrounded with much fat; but their cavity is more intercepted with valves than that of other arteries. Theſe arteries communicate, by inoſculations of the ſmall branches, every where about the ſeptum and tip of the heart; but they

no where make a complete ring round the heart. They terminate in a two-fold manner.

127. The firſt termination of them is into the coronary veins, whoſe branches running in company with thoſe of the arteries, have their trunks of neceſſity diſpoſed in a different courſe. The *great coronary vein* is, therefore, a companion of the left coronary artery; and is inſerted with a large opening, ſecured with valves, or a number of little membranes, on the left ſide of the Euſtachian valve of the right auricle: the root of this ſurrounds the left auricle externally, and then accompanies the ſuperficial branches of the left artery.

128. The other coronary vein (which you may make a part of the former, ſince they have both one common inſertion) deſcends along upon the ſeptum of the heart to its flat ſide; and may be properly called the *median coronary*. The *third* bends tranſverſly round the ſurface of the right auricle; and then terminates within, or at leaſt very near, the large opening of the coronary vein (127.) anteriorly. This vein ſupplies that part of the right ventricle which lies in the flat ſide of the heart; and often receives thoſe nameleſs veins we ſhall hereafter deſcribe.

129. There are ſtill ſome other *anterior veins* of the heart; but one, more particularly large, goes along the adjacent edge of the right ventricle, and, running for ſome length obliquely betwixt the membranes, is inſerted into the moſt anterior part of the right auricle, and ſometimes into the trunk of the upper vena cava. This anterior vein ſends off another concealed one through the root of the right ſinus; and, being again inſerted into the great coronary vein, it makes a complete circle round the heart, like the arterial circle which ſome have deſcribed, but has not yet been ſeen by me.

130. But there are a great many more veins, uncertain in their number, which belong to the baſis and internal parts of the heart, to which the anatomiſt has

ſeldom any acceſs, becauſe they lie concealed betwixt the origins of the large veſſels: and theſe open by numberleſs ſmall mouths into the right ſinus and auricle; and ſome, but a few only, into the left ſinus. Thus I have ſeen a particular vein, which, from a latent ſinus in the fleſh of the right auricle, has aſcended towards the aorta and pulmonary artery, and inſerted itſelf on one ſide into the greater coronary vein. Another I have obſerved, concealed betwixt the mouth of the coronary vein and the aorta, inſerted into the right ſinus; and another through the remains of the oval foramen, and ſeptum of the two ſinuſes, inſerting itſelf into the right ſinus; and others again belonging to the venous valves; beſides which, there are ſtill others too numerous to deſcribe. I have obſerved alſo a vein ariſing from the left ſinus, and inſerted into the vena cava.

131. There are ſtill more, and much ſmaller, veins in the heart, whoſe little trunks, being very ſhort, cannot eaſily be traced by diſſection; and theſe open themſelves by an infinite number of oblique ſmall mouths, through all the numerous fovæ or little ſinuoſities and excavations obſervable throughout the ſurface of the right and left ventricle. Theſe are demonſtrated by injections of water, wind, or mercury, made by the coronary arteries, after you have firſt tied their correſponding or accompanying coronary veins; or even by injecting into the great coronary veins, after you have firſt intercepted the openings of their largeſt trunks. For, in either of theſe caſes, there are drops of the tinctured water, bubbles of air, ſpherules of mercury, ruſhing out through the whole extended ſurfaces of both the ventricles of the heart: and this, without any violence that can be ſuppoſed ſufficient to break the veſſels. But the paſſage from the arteries into the cavities of the left ſide is more difficult.

132. There are ſome who will have the coronary arteries filled with blood, not by the contracting of the heart, but of the aorta in its ſyſtole; which they think

muſt

muſt be a conſequence of the retrograde angle of the blood's courſe here, and the paleneſs of the contracted heart, with a ſuppoſition that the valves of the aorta cover or cloſe the mouths of the coronary arteries. But the two laſt of theſe are diſproved by experience; and the firſt, or retrograde courſe, can only impede or leſſen, and not intercept, the flux into the heart: for the injections of wind or mercury, into all the ſeminal and biliary veſſels, demonſtrate, that the large retrograde angles, which the veſſels often there make, do not hinder the fluids from taking their natural courſe, though they retard it. But a proof, ſtill more evident, is, that the coronary artery has a pulſe at the ſame time with all the other arteries in the body, and the blood ſtarting from it makes a higher ſaltus at the time when the heart is contracting (121.)

133. Concerning the reflux or return of blood from the muſcular ſubſtance of the heart, there is ſtill leſs room to doubt: for all the coronary veſſels diſcharge their blood into the auricles and ventricles, either right or left, (but leſs into the latter), by thoſe larger (127, 128, 129.), and by the ſmaller orifices (130.), as well as by the leaſt (131.), which ſo eaſily tranſmit the injections, after you have firſt tied the larger coronary veins. The circulation through theſe veſſels ſeems to be compleated in the ſhorteſt ſpace of time that can be in any part, from the great velocity the blood receives from the heart itſelf, urging the ſame through its own ſubſtance. But that the whole contents of the veſſels are cleared in each contraction, does not ſeem to me probable; for the blood-veſſels of the heart do not look pale enough in that action to produce ſuch an effect as an entire evacuation. There is a very free or open paſſage from the arteries of the heart into the cellular ſubſtance, or fat, which ſurrounds it. If you aſk, What are the uſes of thoſe leaſt or ſhorteſt veins which open obliquely through the ſurface of both the ventricles (131.)? they ſerve to return the blood of thoſe

deeply

deeply feated fmall arteries, which have no correfponding veins.

134. The humours of the heart, which are thinner than blood, return by the valvular *lymphatic veins*, which accompany the coronary blood-veffels, and afcend towards the thoracic duct and fubclavian vein; but are very rarely to be feen, although I have obferved them in brute animals.

CHAP. VI.

Of the Nature of the BLOOD *and* JUICES *of the Human Body.*

135. THE liquor which is contained in the beating arteries and their correfponding veins, is called, by one general name, the *blood;* which, to a loofe examination, appears homogeneous, or of fimilar parts, red and coagulating throughout; and is obferved to be redder in proportion to the ftrength of the animal: in a weak and famifhed one, the blood inclines to a yellow: it hath a whitenefs mixed with it, which comes almoft totally from the chyle. But experiments of diverfe kinds have fhown us, that diffimilar parts of various natures refide in the compofition of this animal liquor.

136. That fire is contained in the blood may be proved from its heat, which, in human blood and that of fome other animals, is from 92 to 100 degrees of Fahrenheit's thermometer, more than the mean degree of atmofpherical heat, but lefs than the greateft. Again, a kind of volatile vapour or exhalation continually flies off from the warm juice, with a fort of fetid odour coming betwixt that of the fweat and urine. This vapour, being catched and condenfed in proper veffels, appears of a watery nature, joined with a fmall tincture of an alkaline difpofition.

137. After this vapour is gone off, the blood of a healthy

healthy perſon ſpontaneouſly congeals into a ſciſſile trembling maſs; and, with a leſs degree of heat than that of boiling water, (viz. 150 deg.), it grows more tough, like to a boiled egg. This toughneſs is greater in feveriſh perſons than in ſuch as are in health. It ſometimes coagulates in the veins of a living perſon, and is found clotted in wounds of the arteries. But even within the veſſels of a living perſon, and in one dying of a fever, the blood has been ſeen, by the violence of that diſtemper, changed into a concreted tremulous jelly throughout all the veins. The principal part of this coagulated maſs is the *craſſamentum* or *cruor*, which has the red colour peculiar to itſelf, and gives it to the other parts of the blood. This, if it be not kept fluid by the attrition of a vital circulation, or ſome ſimilar concuſſion, runs confuſedly into a compact, but ſoft maſs, like liver, merely by reſt and a moderate degree of cold; as it alſo does by the addition of alcohol, by mineral acids, or by a heat of 150 degrees, of which 98 is the blood's heat in robuſt people. It is, either as a fluid or a ſolid, ſpecifically heavier than water by near an eleventh part; and, when freed from its water, it is wholly inflammable. In a maſs of healthy blood, one half or upwards is red cruor: and, in ſtrong laborious people, the ſerum makes only a third part; and is ſtill more diminiſhed in fevers, often to a fourth or fifth part of the maſs.

138. From this coagulum there ſeparates, at firſt as it were ſweating out of its pores, but which afterwards collects in ſufficient quantity to allow the concrete to ſink in it, another white, ſomewhat yellowiſh, part of the blood; which again ſeems to be a liquor, conſiſting of homogeneous or ſimilar parts, when it is not really ſo. This part of the blood is, in general, one thirty-eighth part heavier than water, and almoſt a twelfth part lighter than the red globular maſs of craſſamentum: this too, by an heat of 150 deg. or by mixture of mineral acids or alcohol, and by a concuſſive motion, is congealable into a much harder coagulum than

than the red cruor (137.); and forms an undiſſolvable glue, a fleſh-like membrane, which at length ſhrinks up to a horn-like ſubſtance, or friable gum. From thence are formed the pleuritic cruſts or ſkins, polypuſes, and artificial membranes. In this ſerum of the blood, beſides the albumen, which will harden like the white of an egg, there is concealed a great deal of ſimple *water*, which even makes the bigger part of the whole; and ſome quantity of a ropy *mucus*, capable of being drawn into threads better than the red cruor; which laſt, however, is not coagulable like the albumen, neither by fire nor by acids.

139. But, by putrefaction only, or the diſſolving power of the air hot to 96 deg. equal to the blood's natural heat, the whole maſs, but eſpecially the ſerum, diſſolves or melts into a fetid liquor; firſt the ſerum, and then the cruor more ſlowly; till, at length, the whole maſs, both of ſerum and cruor, is turned into a volatile and fetid exhalation; leaving very few feces behind. The blood being a little diſſolved by putrefaction, and even before that, becomes fetid; with the fetor, aſſumes an alkaline nature; and effervesces with acids. This property it afterwards loſes, the alkaline ſalt being deſtroyed by putrefaction. The putrid blood cannot by any art be inſpiſſated, as it is alſo very difficult to be reſolved after it has been coagulated by ſpirit of wine. By too ſevere exerciſe, heat, and malignant diſorders, the coheſion of the blood is diſſolved, and it aſſumes an alkaline nature almoſt as if from putrefaction.

140. Beſides theſe parts of which the blood appears to conſiſt, without ſubjecting it to any violence, it contains in its ſubſtance a quantity of *ſea ſalt*, which is diſcernable to the taſte, and ſometimes viſible by the microſcope. That there is *earth* lodged in the blood, is demonſtrated from nutrition; and from a chemical analyſis, whereby the earth appears to lodge in the moſt fluid, and eſpecially in the oily, parts of the blood. By ſome very late experiments, it appears, that a conſiderable

fiderable quantity of ferruginous earth, eafily reducible into metal by the addition of phlogifton, is contained in the blood when calcined. Laftly, another part in the blood is *air* in an unelaftic ftate, and that in a very confiderable quantity; the exiftence of which air in the blood and ferum is proved by their putrefaction and diftillation, or by removing the ambient air from them by the pump. But we are not to think, from hence, that the blood-globules are bubbles full of air, for they are fpecifically heavier than the ferum.

141. By the admixture of neutral falts, the colour of the blood becomes deeper and brighter, as by them it is neither diffolved nor thickened. It is fcarcely altered by a weak acid. By fermented liquors it is coagulated. Fixed alkaline falts have almoft the fame effects as the neutrals. The volatile alkalies rather turn it brown, and coagulate it. Alcohol and diftilled oils coagulate it, as alfo vinegar. It does not effervefce with any falt.

142. Chemiftry has, by various ways, fhowed us the nature of the blood. (1.) When frefh drawn, before it has time to putrefy, the blood, diftilled with a flow heat, yields a *water* to the quantity of five parts in fix of the whole mafs; which water has little or no tafte or fmell, till you come towards the end of the operation, when it is proportionably more charged with a fetid oil, as it draws nearer to a conclufion. (2.) The refiduum, expofed to a ftronger fire, yields various alkaline liquors; of which the firft, being acrid, fetid, and of a reddifh colour, is ufually called the *fpirit* of blood; confifting of a volatile falt, with fome little oil, diffolved in water, to the amount of one twentieth part of the original mafs of blood. There is an acid obfervable in the fat, and likewife in putrid flefh and blood. (3.) A little before, and together with the oil, that next afcends in the diftillation, a dry *volatile falt* arifes, and adheres in branchy fleeces to the neck and fides of the glafs; and this in but a fmall proportion, lefs than an eightieth part of the firft mafs. (4.) The next

liquor is that called *oil* of human blood, which afcends gradually thicker and heavier, is at firft yellow, and afterwards black, till at laft it refembles pitch, being very acrid and inflammable, but in a fmall quantity, about a fiftieth of the whole mafs. (5.) There now remains, in the bottom of the retort, a fpongy inflammable coal or cinder of the blood, which, being kindled, burns away, and leaves afhes behind. From thefe, by lixiviation with water, is obtained a *mixed falt*, partly fea-falt, and partly fixed alkali, together with a fmall quantity of fixed earth. This fixed falt is fcarce the five hundredth part of the firft mafs, and of this only one fourth part is alkaline: but, being urged with the moft intenfe degrees of fire, the whole falt affords fome portion of *an acid fpirit;* which we judge to arife partly from the fea-falt in the blood, fome of which is demonftrable even in the fpirit of blood; and partly from the vegetable kind of the aliments, not yet digefted into an animal nature. For which laft reafon, an acid is procurable from the blood of graminivorous animals, as well as from that of man. But the *earth*, feparated from the lixivium by filtration, will, perhaps, make about an hundred and fiftieth part of the original mafs; and contains fome particles which are attracted by the loadftone.

143. From the preceding analyfis of the blood, it evidently contains a variety of particles, differing in bulk, weight, figure, and tenacity; fome watery, others inflammable, and moft of them inclined greatly to putrefaction or to an alkaline nature. For the blood, in a found healthy ftate, not injured by putrefaction, or too violent a degree of heat, is neither alkaline nor acid; but mild or gelatinous, and a little faltifh to the tafte: yet, in fome difeafes, it is fharp enough, and comes near to a ftate of putrefaction; as, for inftance, in the fcurvy, where it corrodes through its containing veffels; and in dropfies, the waters of which are often next to alkaline. But the calx of the blood of infects is alkaline, and effervefces with acids.

By

144. By viewing fresh blood in a small glass tube by a microscope, or by applying the same instrument while it is yet moving in the veins of a warm living animal, as a hen-chicken, or a cold one, as a frog, we perceive in it red globules; which, doubtless, make that part called cruor or crassamentum, mentioned in 137. If it be questioned, whether these are not rather lenticular particles of the same kind with those observed by Lewenhock in fish, and lately discovered in our own species; we confess it is a point difficult to determine: nor have I ever made a sufficient number of microscopical experiments on those globules which seem most dense and convex.

145. The colour of these globules is red; and so much the deeper, and more inclined to scarlet, the stronger the animal is: and, in the same proportion, their number increases, when compared with the quantity of yellow serum. Their diameter is very small, being between $\frac{1}{3000}$ and $\frac{1}{4000}$ of an inch. They are said to change their figure into an oblong egg-like shape, which I could never observe with sufficient certainty. They are also said to dissolve into other lesser globules of a yellow colour, which I have neither observed myself, nor can easily admit.

146. From the red part of the blood, fibres are generated in abundance; from the serum, in smaller quantities. They are procured by pouring the blood into a linen cloth, and washing it gradually with a great deal of water, or by beating it with a rod. In quantity, they equal the 28th part of the whole mass. These are formed of the gluten, and are not generated in a living animal; seeing they are neither to be perceived by the microscope, which yet so easily renders visible the red globules, nor yet does their long thread-like figure seem adapted for receiving motion.

147. From the preceding experiments compared together, arises that knowledge which we, at present, have of the blood; namely, that the crassamentum or cruor is composed of globules. The inflammable or

combuſtible nature of theſe globules is proved from dried blood, which takes flame and burns; as alſo from the pyrophorus, which is generated from the human blood: and from theſe, moſt probably, ariſes the greater part of the pitchy oil that is obtained from blood by the violence of fire.

148. The ſerum of the blood, diſtilled with a ſtrong fire, gives over almoſt the ſame principles with the cruor, viz. ſalt, oil, and earth. It yields, however, much more water, but no iron at all. Similar principles, but with a leſs proportion of oil and ſalt, are obtained from the aqueous humours prepared from the blood; as the ſaliva, and mucus.

149. The exact maſs or quantity of blood, contained in the whole body, cannot be certainly computed. The weight of the maſs of humours, however, is much greater than that of the ſolids; but many of them do not flow currently in the circulation, as the glue or jelly that lodges in moſt parts, and the fat. But if we may be allowed to form a judgment from thoſe profuſe hæmorrhages that have been ſuſtained without deſtroying the life of the patient, with experiments made on living animals by drawing out all their blood, joined with the bulk of the arteries and veins themſelves: from theſe principles, the maſs of circulating humours will be at leaſt fifty pounds; whereof about 28 will be true red blood, current in the arteries and veins; of which the arteries contain only one fifth, and the veins the other four.

150. Nor does the blood always contain the ſame, or a like proportion, of thoſe elements or principles abovementioned: for an increaſed celerity, whether by laborious and ſtrong exerciſes, a full age, fever, or otherwiſe, augments the craſſamentum, with the redneſs, congealing force, and coheſion of the particles; and the hardneſs and weight of the concreted ſerum with the alkaline principles are, by the ſame means, increaſed. On the other hand, the ſerum, and the mucus it contains, are increaſed by the contrary cauſes, the more as the animal

is younger, lefs active, and fed more on a watery vegetable diet; by all which, the craffamentum of the blood is leffened, and its watery part increafed. Old age, again, leffens the craffamentum, and the gelatinous part likewife.

151. From thefe principles, but with a conjunct confideration of the folid fibres and veffels, the different temperaments of people are derived. For a *plethoric* or *fanguine* habit arifes from an abundance of the red globules; a *phlegmatic* temperature, from a redundancy of the watery parts of the blood: a *choleric* difpofition of the humours feems to arife from a more acrid, acid, and alkalefcent property of the blood; as appears from thofe who live on flefh, and on the human fpecies, being fo much fiercer and more paffionate than thofe who live on plants or on vegetable food. In the folid parts, a great firmnefs, joined with an exquifite fenfibility, or nervous irritability, difpofes to a choleric habit; a lefs irritability, with a moderate denfity, to a fanguine habit; and a leffer degree both of denfity and irritability are to be referred to a phlegmatic temperament. There is alfo a kind of dull heavy temperament, in which there is the greateft ftrength of body, joined with no great degree of irritability. In the melancholy, again, a weaknefs of the folids is joined with the higheft degree of nervous irritation or fenfibility. But you muft be careful not to take thefe temperaments as the fole and limited fyftems or claffes of conftitutions; which, in the courfe of nature, are found to be not only four, or eight, but are really diftinct in numberlefs degrees.

152. The red part of the blood feems chiefly of ufe to generate heat, fince its quantity is always in proportion to the heat of the blood. This being confined, by the largenefs of the globules, within the red and firft order of veffels, hinders them from collapfing; and, in receiving the common motion of the heart, by the greater denfity of its parts, it has a greater impetus, and fets in motion the leffer orders of humours. Nor is it improbable, that the heart is more ftrongly irritated by the

the ponderous cruor of the blood. The globular figure of its parts, together with their denfity, makes it eafily pervade the veffels; and the quantity of iron it contains, as well as of oil, perhaps increafes its power of generating heat. And hence it is, that the red part of the blood being too much diminifhed by profufe bleedings, there follows a ftagnation or leffened motion of the humours in the fmaller veffels; whence fatnefs, and dropfy. By the fame rule alfo, a due proportion of cruor is neceffary within the habit, to generate and repair new blood. For, by large hæmorrhages, we fee the blood lofes its red or denfe nature, and degenerates into a pale, ferous, or watery ftate.

153. The coagulable ferum is more efpecially defigned for the nutrition of the parts, as will be hereafter more apparent, Chap. XXXI. The thinner juices ferve various purpofes; as the diffolution of the aliments, the moiftening of the external furface of the body, and furfaces of the internal cavities, to preferve the flexibility of the folids, and conduce to the motion of the nerves, the fight, &c. The faline particles feem proper for diffolving the aliment, and ftimulating the veffels. The properties of the aërial part are not yet well known. The heat produces fluidity, and is not eafily raifed to fuch a degree as to coagulate the humours.

154. Therefore, health cannot fubfift without a denfe and red blood, whofe quantity too much diminifhed caufes a ftagnation of the juices within the fmaller veffels; whence all parts of the body become cold and weak. Nor can life or health fubfift without a fufficiency of thinner juices intermixed with the red blood; feeing the cruor, deprived of its watery part, congeals and obftructs the fmalleft paffages of the veffels, and kindles too great a heat.

155. If it is afked, whether there be any difference betwixt the arterial and venous blood? we anfwer, that fome difference there feems to be; the former having lately fuffered the action of the lungs. But, in experiments, I fcarce find any obfervable difference either in colour,

colour, denfity, or any other known diverfity. Otherwife, however, I have found a moft evident difference; for the bright red colour of the arterial blood feems to diftinguifh it from the dufky dark-coloured blood in the veins; but this, in the plain example of the hatching of a chicken, arifes only from the deeper feries of globules in the thicker vein. But we have not fufficient certainty of a difference in the blood of different arteries. However, the arterial blood is apparently of a more bright or fplendid red; and having a greater degree of fluidity and proportion of watery parts, may fo far differ from the venous darker-coloured blood. But, in this refpect, it remains that we make further experiments.

156. From one and the fame mafs of blood, driven into the aorta, are generated all the fluids of the human body; which, from their affinity one to another, are reducible to certain claffes. The manner by which they are feparated, ought to be accounted for by the fabric or mechanifm of the glands themfelves. But we muft firft confider what the blood fuffers from its containing veffels.

CHAP. VII.

Of the Common Offices *of the* Arteries.

157. THE blood is driven from the left ventricle of the heart into the aorta; which takes its courfe firft a little towards the right, and then to the left, in an arch that is very fharply bent: and here the mafs of this purple fluid ftrikes firft againft the right fide, and is then reflected to the left fide again of the aorta; whence, flowing in a vortical or whirling motion, as much as that full veffel will permit, it goes on through the arteries, with an alternate collifion againft, and repercuffion from, their fides. The aorta fwells a little in bulk at the place where it proceeds from the heart.

158. The

158. The arteries are, in a living perſon, *always full of blood;* ſince the jet or ſtream that ſtarts from an artery, is not interrupted by alternate ſtops, while the heart reſts or relaxes itſelf, but it flows on in a continued thread: add to this, that the microſcope ſhews the arteries, in living animals, to be full, both in their ſyſtole and diaſtole; nor can the circular fibres of the arteries ſo far contract themſelves, as entirely to evacuate theſe tubes. Since, therefore, a new wave or column of blood is ſent into the arteries, already full, although it bear a ſmall proportion to the whole maſs contained in the arterial ſyſtem throughout the body, hardly ever exceeding two ounces; yet, by its immediate contact with the precedent wave or column, which moves ſlower as it gets farther from the heart, it conſequently drives the ſame forwards, lengthens the artery, and makes it aſſume a cylindric form, augments its diameter, preſſes the membranes cloſer to one another, urges the convex parts of the arterial flexures outwards, and cauſes their ſpiral waves to be more ſerpentine, as injections demonſtrate to us. This dilatation of the artery, whereby its light or capacity is changed from a leſs to a greater circle, is called the *pulſe;* the *diaſtole* of which, is an expanſion of the artery beyond its natural diameter. This being the proper or characteriſtic action of life, reſults from the heart only, and is in nowiſe natural to the arteries left to themſelves. Hence, when the motion of the heart is intercepted, whether by aneuriſm, ligature, or otherwiſe, there is no pulſation of the arteries to be felt; and from hence, too, there is a ſudden ceſſation of the pulſe, by a wound through the heart, in a living animal. But the artery is proportionally more dilated, as the wave of blood flows on before more ſlowly, and the more the velocity of the new wave exceeds that of the former one.

159. The *ſyſtole* or contraction of the artery follows the dilatation of it. For the heart, having emptied itſelf, and removed the ſtimulus of the blood, comes into a ſtate of relaxation and reſt. But the artery, at this ſame time,

time, by its innate elaſticity, and contractile power reſiding in its circular fibres, irritated likewiſe by the ſtimulus of the blood, contracts itſelf, and expels as much blood as ſerved to dilate it beyond its mean or middle diameter: this quantity of blood is either forced into the ſmaller and ſcarce-beating arteriolæ, or elſe returned into the veins, from the reſiſting ſemilunar valves of the aorta, which oppoſe the reaction of the blood from the neighbouring parts of that veſſel. So ſoon as the artery has freed itſelf from this wave or column of blood, being no longer ſtimulated by diſtention, it directly collapſes by its own proper contractile force, and is now again ready to yield to a new wave or column of blood, ſent into it from the heart; whence follows a repeated diaſtole.

160. That the arteries thus contract, and, by that force, drive forward their contained blood, is proved evidently from their ſtrongly contractile nature; from the apparent diminution of the diameter or dilatation they receive from the heart; from the evacuation that follows, by the proper force of the artery itſelf, driving out all the blood that is contained in the lateral branches, betwixt two ligatures; from the return of the blood to the heart through veins whoſe artery is tied, and ſo cannot propel the blood to the heart; from the jet of blood being greateſt when the heart is in its diaſtole, as obſerved by ſome eminent anatomiſts; from the ſtrength with which the blood is thrown out of the tied aorta, below the ligature; from the evacuation which the arteries make of their contained blood, even after death, into the veins, whereby theſe latter appear much fuller than the arteries; and, laſtly, from the conſiderable jet or ſaltus of blood, that iſſues from a large artery in an animal, even after death, mounting to the height of two feet: to which add, the convulſive contractions of the animal in which the artery is thus wounded, and the remarkable cloſings of the mouths of divided arteries in wounds, and a ſphacelation of the limbs from

an oſſification of the artery; whence the veins become diſtended.

161. The mean ſwiftneſs of the blood's motion being diminiſhed in the time of the heart's ſyſtole, but increaſed during its diaſtole, is ſuch as carries it through a ſpace ſomewhat leſs than one foot in the ſpace of a ſecond of time; and the conſtant plenitude of the arteries renders it impoſſible for us to perceive any ſucceſſion in the pulſes of different arteries; whence all the arteries of the body ſeem to beat at one and the ſame inſtant, whilſt the heart ſtrikes againſt the breaſt: and yet there is certainly a ſucceſſion in the ſyſtole of the arteries, by which the aorta ſeems to contract in the ſame order ſucceſſively, as it is filled by the blood expelled from the heart; ſo that the part of the artery next the heart is firſt conſtringed, and thence, gradually, the arterial contracting force proceeds to the extremities. An inſtance of this we have in the inteſtines; and the ſame is evident to the eye in inſects, who have a long fiſtulous and knotted heart, manifeſtly contracting in a ſucceſſion from the beginning to the end. But the mind cannot diſtinguiſh the leaſt points of time, which are the meaſures of this ſucceſſion, and amount only to a few thirds of a ſecond.

162. If it be aſked, Where this pulſation ends? we anſwer, In the leaſt arteries, and cylindrical originations of the veins. We have already mentioned the velocity with which the blood comes from the heart. But that velocity continually decreaſes. Certain we are, (1.) That the lights or ſections of the arteries, compoſed by the aggregation or ſum of their tranſverſe ſections, as they divide farther, in their courſe, from the heart, greatly exceed that of the aorta; ſo that ſince the ratio, or leſs proportion of the trunks to their branches, continually diminiſhes as they make leſs ramifications, and this in a variable or uncertain proportion; the difference of that ratio or proportion will be the greateſt betwixt the light of the aorta at the heart, and the ſum of the ſections of all the ſmall arteries,

teries, where they are leaſt, in the extreme parts of the body. Again, (2.) The proportion of the arterial membranes or coats in thickneſs, with reſpect to their bores or capacities, is greater as the arteries grow leſs; and is largeſt in the leaſt of them, which tranſmit only one globule at a time. The truth of this is proved from anatomy, and the forcing of air into the arteries, by which they burſt always more difficultly as they are leſs; and from the calculation itſelf, by which the magnitude of the leaſt arteries is determined from the globules diſtending their two ſemicylindric membranes. Add to this, (3.) The friction of the juices through the leaſt veſſels, inflected and meeting together in angles; which friction, even in the moſt fluid water, running through long pipes that are ſingle, and in a direct courſe, greatly diminiſhes the velocity, and more in proportion as the tube is of a leſs bore; while again, as the artery is leſs, there are a great number of globules rubbing and grating againſt its membranous converging ſides. And by the conical figure of the artery, it happens, that the broader wave of blood coming from the trunk is reſiſted in its paſſage through the narrower branch, and ſo muſt diſtend it by force. But moreover, (4.) The *inflections and folds*, or plates, of the veſſels, greatly ſlacken the blood's motion; ſince always ſome part of the impelling force is ſpent and loſt in removing the convex parts of the folds, and changing the figure of the inflected veſſel. The angles likewiſe take off more from this force in proportion to their acuteneſs, or the more they recede from a ſtraight line. Laſtly, (5.) The great viſcidity or tenacity of the blood itſelf muſt be conſiderably allowed for; ſince, by reſt only, it directly hardens into clots; and ſince it is from the circulatory motion only of the blood, that this mutual attraction of coheſion in its parts is overcome, ſo as to hinder it from adhering together, or to the ſides of the arteries; for ſo we find it adhere in aneuriſms and wounds of the arteries, or elſe the globules clot together, as we ſee uſually after death.

From all which confiderations, you will obferve, that the blood meets with the greateft retardation, in its courfe, in the leaft veffels. And the oppofition it meets with in the branches leffens the velocity of the blood alfo in the trunk: the oppofition of torrents of blood to one another in the anaftomofes of veffels alfo deftroys fome part of its motion. We may eafily perceive the amounts of this retardation will be very confiderable, although it be difficult to make a juft eftimate of it. In the larger trunks, the blood of a living animal flows with the rapidity of a torrent: but, in the leaft branches, it creeps along very flowly; fo that, in thefe, it begins to put on a ftate of coagulation. It is alfo well known to furgeons, that a fmall branch of an artery near the heart or aorta bleeds more dangeroufly than a much larger one that lies at a greater diftance. The weight of the incumbent atmofphere, of the mufcles and flefhy parts lying above the artery, and the contractile power of the veffel itfelf, make a refiftance indeed to the heart, but do not leffen the velocity of the blood, feeing they give as much in the diaftole as they take away in the fyftole.

163. It is certain, however, from incifions made in living animals, that the fingle globules of blood, which move feparately in the fmall veffels, do not lofe fo much of their velocity as, by calculation, they ought to do. We muft therefore give fome other caufes by which this deftructive power of the blood's motion is leffened. And, in the firft place, it is certain, that the lights of the branches do not bear fuch a proportion to the trunk in the fmalleft veffels; their great fmoothnefs diminifhes the friction. The facility, likewife, with which the blood flows through the veins, expedites its paffage through the little arteries which immediately communicate with thefe veins. No great effect, indeed, can be expected from the weight of the blood, or the force of the nerves, which are both capable of diminifhing and accelerating the motion we fpeak of; but, in live animals, thefe have very little ftrength.

ſtrength. The power of derivation, whatever that is, and the motion of the muſcles, are capable of producing a new velocity.

164. The pulſe therefore enſues, becauſe the anterior wave or column of blood moves on ſlower, while the ſubſequent or poſterior wave comes faſter; ſo that the precedent is an obſtacle to the conſequent blood (158.) But ſince the force of the heart weakens as the blood goes on, and the contractile power of the arteries increaſes, therefore the diſproportion of celerity, betwixt the antecedent and conſequent waves or columns of blood coming from the heart, will be continually leſſening, with reſpect to the blood that is urged on by the contraction of the ſmaller veſſels, till, arriving at a part where there is no exceſs or difference, it will there ceaſe to make any pulſation of the artery; becauſe here the anterior and conſequent blood flow evenly, or with the ſame celerity. But this place of equality, in motion, cannot be in the larger and more conſpicuous arterial branches: for in them, the wave, laſt coming from the heart, moves quicker than what went before; as is evident from the inflammatory pulſation of them, eſpecially in the ſmall arteries of the eye. But, in the leaſt red arteries, the pulſe at length begins to vaniſh. This is evident from the equable motion of the blood, often ſeen by a microſcope, thro' the arteries of a frog. In the larger veſſels, however, ſuch as may be about the ſixth part of a line in diameter, the pulſe is perceptible. But in the leaſt veins viſible to the eye there is no ſenſible pulſation or accelerated motion of the blood, whilſt the heart contracts, demonſtrable either by the microſcope or any other experiment.

165. Even in the veins, the blood preſſes againſt their ſides, as appears from the furrows hollowed out of the bones, and the ſwelling of the veins on being tied. If it is aſked, why the veins do not beat? (for we do not allow that to be a pulſe which happens from reſpiration, from the rejection of the blood from the right

auricle,

auricle, or from the muſcular part of the vena cava); the reaſon of this ſeems to be, that the blood, when it immediately leaves the heart, is more retarded in its motion, than when it paſſes into the ſmalleſt veſſels. Hence, the ſhort ſpace of time by which the velocity of the laſt wave exceeds the foregoing, is greateſt at the heart, and grows gradually leſs, till at laſt it totally vaniſhes. This is illuſtrated by the experiment, in which a pipe, fixed in a leathern tube, and driving forth water in a continual, but ſtarting ſtream, does, by a ſponge fixed round the mouth of the ſaid tube, cauſe the water to iſſue forth in an even ſtream, without leaping, through the ſponge: and the ſame is evident from another experiment, in which the ſame thing happens, by injecting the meſenteric arteries with an alternate impulſion of water; for then the water flows out through the veins, in one continued even ſtream.

166. The *pulſe* is, therefore, the meaſure of the powers which the heart ſpends on the blood; becauſe it is the immediate and full effect of thoſe powers. Hence, all things conſidered as alike, the pulſe is *ſlow* in the moſt healthy people, where there is no ſtimulus, nor any unnatural reſiſtance to cauſe the effect of a ſtimulus, but the heart is at liberty to ſend forwards the blood with eaſe. You muſt except thoſe caſes where there is ſome obſtacle, by which the blood is prevented from entering the aorta. For this reaſon, the pulſe in aſthmatic people is ſlow: the ſame thing alſo happens from a debility or inſenſibility of the heart, which the uſual ſtimulus is not capable of exciting to contraction. A *large* pulſe is cauſed by fulneſs of the artery, joined with a ſtrong force of the heart; a ſmall pulſe by the emptineſs of the artery, and a leſſer wave of blood ſent from the heart. A *hard* pulſe denotes ſome obſtacle or ſtimulus; or elſe, that the heart's force is increaſed with a greater thickneſs of blood, or a greater rigidity of the artery. A *quick* pulſe denotes ſome ſtimulus, obſtacle, or greater ſenſibility or irritability of the heart. It is beſt felt where the artery lies expoſed bare to the touch,

touch, upon ſome reſiſting bone; but obſtructions ſometimes render the pulſe perceptible, where it is never ſo naturally.

167. The pulſe is ſlower in animals as they are larger or more bulky; becauſe the heart is proportionably bigger in the ſmaller than in the larger animals, and, as well as the other parts of the body, is more irritable in the former than in the latter; and becauſe the heart is obliged to drive the blood to a greater diſtance; whence the reſiſtances or frictions ſeem to be increaſed, in the more bulky, over the force of the heart. Hence, ſmall animals are more voracious; and large ones, as the whale and elephant, eat leſs. The pulſe of a healthy perſon riſing in the morning, beats 65 in a minute; but, after the fatigue of the day, it will beat 80 in that time; and again, by the night's reſt or ſleep, it will become gradually leſs frequent, till in the morning you will find it returned to its primitive number of 65. For the motions of the muſcles, and actions of the external and internal ſenſes, the warmth of the atmoſphere, and the action of the aliments taken into the ſtomach, urge the venal blood on to the heart, which, being thereby oftener ſtimulated, makes more frequent contractions. This is the cauſe of thoſe paroxyſms or fits of increaſe obſervable in all fevers towards the evening. For ſleep not only retards the motion of the blood, but of all the other humours and actions in the body whatever.

168. A frequent pulſe is different from a ſwift one; and it is poſſible for the pulſe to be at the ſame time ſwift and unfrequent. But it is difficult to obſerve a ſwift pulſe. The frequent pulſe is what is commonly called a *ſwift* one. It takes place in children, and becomes afterwards ſlower in perſons as they grow older. The ſalient point beats 134 in a minute: new-born infants have their pulſe 120 in that time; and from thence down to old age it grows ſlower, to 60 in a minute. A feveriſh pulſe begins from 96 per minute; and we count the pulſe has but a moderate celerity in fevers, or labo-

rious

rious exercifes of adult perfons, if it does not exceed above 110 or 120 in a minute: but it is exceffive at 130 or 140, with which number people feldom recover; nor have I ever obferved it exceed that number. The pulfe beats flower in winter, and quicker in fummer, by about 10 ftrokes per minute; and under the torrid zone, it grows quicker to 120. The different paffions of the mind varioufly accelerate, retard, and difturb the pulfe. Whatever obftructs the circulation is alfo found to accelerate the pulfe; not from the laws of hydroftatics, or on account of the canal being made narrower, nor from the action of the foul; only the heart being with more difficulty freed from the ftimulating blood, contracts itfelf more ftrongly, and at fhorter intervals. An irritation from an acrid blood is the caufe of the frequent pulfe in fevers.

169. Through the leaft veins the blood moves on very flowly, partly by force of the heart, and partly by the contractile force of the arteries. The firft is proved by a renewal of the motion of the blood, in perfons drowned; where, merely by exciting the action of the heart, the whole mafs is driven forwards. But the contractile force of the artery is proved by what is faid (160.) But, after death, the blood continues to move, in part, alfo by its own gravity, and by the elafticity of the air generated or extricated by putrefaction.

170. But the blood moves on fafter in the larger veins. For whenever the impelling powers remain fufficient, and the conveying fmall veffels are rendered narrower, the motion of their contained fluids muft of courfe be accelerated; fince the fection of the venal trunk is much lefs than that of all its branches, in the fame manner as that of an artery is lefs than the fum of the branches into which it divides. Therefore, if the motion of the venal blood lofes nothing in its way, the proportion of its celerity in the vena cava, to its celerity in the veins of the thirtieth divifion, will be thirty times greater in the former, in proportion as the conjunct lights of all the fmall veins exceed the light of the cava.

cava. In like manner too, the friction or attrition of the blood in the veins, and its contact with their ſides, diminiſh.

171. But ſince the blood moves thus ſlowly in the leaſt arterial veſſels and incipient veins, and as the weight of the blood itſelf, in many places, wonderfully hinders its return to the heart, while, at the ſame time, the very thin coats of the veins have but little contractile power to be expected from them; therefore, nature has uſed various precautions, leſt, from the ſlowneſs of its motion, it ſhould any where ſtagnate or concrete. To obviate this, ſhe has ſupplied the veins with more watery vapours and fluxile lymph than ſhe probably ſent by the arteries, if we conſider the great exhalation that is made from the arterial blood in the lungs.

172. She has, therefore, likewiſe placed the veins near the muſcles, that, by the turgeſcence or contractions of the latter, the veins may be preſſed; and ſince any preſſure upon the veins muſt be determined towards the heart (63.), therefore all this force muſt be entirely employed in accelerating the return of the blood to the heart. From hence proceeds that wonderful quickneſs of the pulſe (167.), heat, and redneſs of the body, with a ſhort and laborious breathing, that attend muſcular motions or violent exerciſes.

173. Moreover, thoſe muſcles, which conſtantly urge or preſs violently the contiguous viſcera on all ſides, that are contained in any of the common cavities, do all of them powerfully promote the return of the venal blood to the heart. Such an effect has the conjunct preſſure of the diaphragm with the abdominal muſcles, in reſpect to the abdomen. Laſtly, the pulſations of the arteries, which run every where contiguous and parallel by the ſides of the veins, have no inconſiderable effect in promoting the return of the venal blood; ſince, as we have before ſhewn, any impulſe acting on the veins can determine their blood to the heart only.

174. To theſe is added a force not yet ſufficiently known, by which the blood is brought from a place

where it is more compreſſed to one more lax, and where it meets with leſs reſiſtance. In this matter alſo reſpiration is of great efficacy; in which the motion of the blood into the lungs when relaxed is accelerated by the power of derivation from all parts of the body: and again, in exſpiration, it is driven into the trunks of the veins in the head and abdomen. Hence the ſwelling of the veins, and likewiſe of the brain, in the time of exſpiration. The circulation is not indeed aſſiſted by theſe cauſes, but the blood is agitated and preſſed. The anaſtomoſes of the arteries contribute to the ſame end; for they render the paſſage of the blood more eaſy from thoſe places where it is obſtructed, to ſuch as are more free.

175. By theſe means, the blood in a healthy perſon, uſing ſufficient exerciſe of body, moves on with ſuch a velocity, as ſuffices to deliver as much of the purple fluid in every pulſe by the vena cava to the heart, as is equal to what is ſent out by that great artery the aorta. But reſt or inactivity of body, and a weakneſs of the contracting fibres of the heart and other muſcles, frequently render this motion of the venal blood more difficult. Hence follow varices and the piles in women with child; which latter is much occaſioned from the deficiency of valves in the vena porta. And from hence ſpring even the menſes themſelves. And when the veins too ſlowly return their blood to the heart, the ſubtle vapours from the leaſt veſſels irrigating the parts, being thus reſiſted, or ſcarce able to return to the heart, are obliged to ſtagnate; whence proceeds that frequency of œdematous and pitting ſwellings of weak people.

176. The time in which an ounce of blood, ſent out from the left ventricle of the heart, returns to the right, and which is commonly reckoned the time in which the greater circulation is performed, is uncertain, and different in every different portion of the body. If, however, you want to know about the ounce of blood propelled in that quantity which we have mentioned, the amount of it will be about 7½ ounces in an hour, with

4500

4500 pulſes; and the amount of the perfect circulations will be about $23\frac{1}{3}$.

177. The effects which follow from the motion of the heart and arteries upon the blood are various, which may be deduced and eſtimated from the cauſes themſelves of thoſe effects, if we compare together the blood of a living and of a dead animal, that which is healthy with that which is diſeaſed, and that which is inert or too little moved, with that which circulates too ſwiftly. For we obſerve, that, in the living, the blood is, (1.) Conſiderably warm or hot. (2.) It looks red, with a ſort of purple florid hue. (3.) It ſeems to be homogeneous or uniform, and alike in its parts; though they are really mixed, and of different principles. (4.) It is made up almoſt entirely of globules. (5.) It flows very readily through the leaſt veſſels; from whence being drawn, (6.) It exhales a volatile vapour, which we have already deſcribed particularly. In the dead animal, which has not yet begun to corrupt or putrefy, we obſerve, (1.) That it has loſt a great deal of its redneſs. (2.) That it ſeparates into a more denſe and a more thin ſubſtance. (3.) That it exhales no vapour. (4.) Being drawn out from the veins, it congeals either all or the greateſt part. But even in the living animal, when very weak, where there is ſome pulſe or reſpiration, though ſmall, we find the blood cold, even to a conſiderable degree. If, again, you compare the blood of a human perſon unactive both in body and mind, with the blood of one that is addicted to violent exerciſe, you will obſerve the latter has, (1.) A greater heat. (2.) A more intenſe redneſs. (3.) A ſubſtance more compact, and ſpecifically heavier. And, (4.) The volatile parts more abundant. All which appearances ſeem manifeſtly the effects of the motion of the heart and arteries, ſince they proportionably increaſe and diminiſh with that motion, and diſappear when that ceaſes.

178. That we may underſtand the manner in which theſe appearances are produced in the blood, we muſt conſider what are the effects of the heart impelling the

ſame, and of the arteries alternately compreſſing and urging it forward. And firſt we ſee, that the heart drives the blood into the arteries with a very great celerity (123.) With a confuſed or vortical motion, the heart thus throws the blood into the crooked or inflected arteries, in ſuch a manner, that the right globules, expelled through the opening of the aorta, ſtrike againſt the left ſide of the artery; from whence being repelled, they incline towards the right ſide, whereby all the particles of the blood are agitated with a confuſed or turbulent and whirling motion. The blood thus impelled againſt the flexile and curved ſides of the arteries, of neceſſity dilates or diſtends them into a greater convexity; and laſtly, in the ſmaller veſſels, capable of receiving only one or a few of the blood-globules, all the ſaid globules come ſo intimately into contact with, and grate againſt, the ſides of the ſaid artery in all their points, that they are even obliged to change their figure in gaining a paſſage into the veins.

179. But the arteries, by their elaſtic force, reacting upon the impinging blood, repel the ſame from their ſides towards the axis of their light or capacity; and, at laſt, tranſmit every ſingle particle of it through the circular mouths of the leaſt veſſels, by which the arteries and veins join together.

180. There is, therefore, a moſt prodigious degree of friction, as well of the blood-globules againſt the ſides of the arteries, as of the arteries themſelves, contracting round the blood like an obſtacle; to which add, the attrition of the particles of the blood amongſt each other by the confuſed and vortical motion with which they are propelled. The effects of this friction may be computed from the viſcid and inflammable nature of the blood itſelf, from the narrowneſs of the veſſels thro' which it runs, and from the ſtrong impulſion of the heart, joined with the powerful reaction of the arteries; to which add, the weight of the incumbent parts raiſed by the force of the arterial blood. This friction generates a fluidity in the blood, by perpetually removing the

the points of contact in its globules, resisting their attraction of cohesion, mixing together particles of different kinds, which become more fluid upon mixture, as we have an instance in oil when triturated with water. It also augments the sphericity of the particles, by breaking off their protuberances and little branchings. But even these very small particles themselves, which are broken off from the large particles of the blood, put on a round figure by their friction against the sides of the canals, and their rotatory motion among the rest. By deficiency herein, the blood coagulates in the vessels before death; and from hence, the lost fluidity of the blood is again restored, by recovering the motion of the heart, as we are taught by experiments made on living animals. It is a question whether this motion of the blood, and the density proceeding from it, is the cause of the red colour of the blood, seeing the redness is in proportion to the density, and increases or decreases from the same causes. This seems to arise from a mixture of the ferruginous with the oily part of the blood.

181. We may also ask, whether the heat of the blood does not also proceed from its motion; seeing we observe heat to arise from the motion of all kinds of fluids, even of air itself, in our experiments; but much more does this attrition produce heat in the elastic and combustible animal juices, which are denser than water, and compressed with a considerable force by contractile and converging tubes. Is not the truth of this sufficiently evidenced, by the blood's being warm in those fish which have a large heart, and cold in such as have a small one? the generation of heat being in proportion to the size of their bodies: from the more intense heat of birds that have a larger heart, and more frequent or quick pulsations? from the increase of animal heat, that ensues from exercise of all kinds, and even from bare friction of the parts? from the congelation of all the humours of the human body in a certain degree of cold, in which a man grows stiff, though

though he yet retains ſome warm blood and is alive? and from the coldneſs of ſuch people as have their pulſe weak and obſcure? Nor does the heat at all ariſe at firſt from any degree of putrefaction in the blood, ſeeing the humours themſelves, when left at reſt, generate no heat. Nor muſt we explain an evident appearance from the action of ſuch an obſcure being as the *vital power;* and though ſometimes the heat may be greater when the pulſe is ſlow, and leſs when it is more frequent, the difference may ariſe from the different diſpoſition of the blood, from the different denſities of the veſſels, or the increaſe or diminution of perſpiration.

182. The ſame cauſe alſo hinders putrefaction, by not ſuffering the inteſtine motion to be diminiſhed, and by diſſipating ſuch particles as have already begun to be corrupted.

183. But the different natures of the ſeveral particles themſelves, which conjunctly make up the maſs of blood, are the cauſes whereby, from one and the ſame impetus of the heart, different effects or conſequences are produced in different particles of the blood. Namely, thoſe particles move quicker, whoſe greater denſity makes them receive a greater impetus, and whoſe apt figure or leſs extended ſurface makes them meet with leſs reſiſtance in the fluid in which they move. Thoſe alſo are driven along more ſwiftly, which, either from their weight, or from the direction in which they paſs out from the heart, are urged chiefly into the axis of the veſſel. Thoſe again will ſtrike againſt the convexities of the flexures in the arteries, which have the greateſt projectile motion; while the other parts of greater bulk and tenacity, having leſs projectile motion, will move ſluggiſhly along the concavity of the veſſel. And in this manner is the blood prepared or diſpoſed for the ſeveral ſecretions.

184. The *ſyſtole* of the arteries renders the parts of their contained fluids more denſe or compact, while they contract round the blood as round a ſolid obſtacle, which being in ſome parts viſcid and compreſ-

ſible

ſible, they drive and expel the more liquid parts into the lateral mouths or ducts, at the ſame time increaſing the points of contact betwixt the globules themſelves, uniting together their more large and denſe ſpherules, and compacting the flat particles into denſer bodies. But the denſity of the blood is partly as the number of globules, and partly as the denſity of the materials whereof theſe globules are compoſed.

185. Moreover, the mouths of the leaſt veſſels, pervious to only one globule at a time, ſeem to be a ſort of moulds to figure and break off the angular eminences of the particles in the blood, and bring them to a ſpherical figure; which at length they put on, and change into perfect ſpherules. Laſtly, from hence ariſes the denſity of thoſe particles; ſince, of all figures, ſpheres contain the moſt within a given ſurface.

186. The *reticular* diſtributions and inoſculations of arteries remove any danger of obſtruction; ſince in any part of the artery, where the blood cohering begins to form an obſtruction, a contrary flux is admitted, whereby the obſtructing matter is repelled to a larger part of the trunk, and thus betwixt the reflux and the direct torrent of the blood the ſaid matter is broke and attenuated. This mechaniſm alſo ſupplies the deficiency from an irremoveable obſtruction or the loſs of a veſſel, by cauſing a greater diſtenſion or enlargement of the next adjoining or anaſtomoſing veſſel; as is proved by experience in ſurgery, after tying and cutting a great artery. The colliſion of theſe oppoſite torrents of blood take ſomething from its velocity; and the reticular diſtribution augments the friction of the globules.

187. As the quicker motions of the blood in the trunks conduce to ſanguification, ſo the ſlower motions of it, in the leaſt veſſels, have their effects towards the ſecretions. In the larger arteries, we ſee the different particles of the blood are whirled about amongſt each other, with a rapid and confuſed motion; but, in the leſſer ramifications, the progreſſive motion of the blood being diminiſhed, the more looſe colourleſs particles

depart

depart laterally from the more denſe and red globules, while the latter, keeping on their courſe more firmly along the axis of the veſſel, expel the former laterally and to the circumference. Thus the attractive powers of the particles in the blood increaſe, as their progreſſive motion abates; hence, the oily or fat particles are drawn one to another, and go off by the open lateral ducts which lead to the cellular ſubſtance, which particles we know are both groſs and ſluggiſh: and again, other thinner juices are ſent off through lateral branches of a much ſmaller orifice, till at length little more than the red blood alone remains to paſs through the evaneſcent artery into the incipient vein. But all theſe particulars, whereby the blood is diſpoſed for the ſecretions, we ſhall conſider diſtinctly in the following chapter.

CHAP. VIII.

Of the Secretions.

188. THE claſſes or tribes of humours which, being depoſited or ſtrained off from the blood into other veſſels, are ſaid to be *ſecerned* or *ſecreted*, ſeem reducible to four: of which the *firſt* includes all the viſcid and lymphatic juices, which are coagulated by a heat of about 150 degrees, by alcohol, and by acids; although generally, in the living animal, they are capable of flying off in form of a vapour, and after death are within the ſame veſſels compacted into a gelatinous thickneſs. To this claſs belong the vaporous juices of the ventricles of the brain, of the pericardium, pleura, peritoneum, vaginal tunic of the teſticle, of the amnios, joints, and probably of the womb, with the juice of the ſtomach and inteſtines, of the renal capſules, and laſtly the lymph itſelf commonly known and called by that name.

189. The *ſecond* claſs is of thoſe juices, of which ſome

ſome are exhalable, like the former (180.), but, being more ſimple and aqueous, are neither to be coagulated by fire nor by rectified ſpirits of wine; and others do not exhale, but, being depoſited in their reſpective excretory ducts, are expelled by ſome common outlet, proper to a part of ſome gland. To the former of this claſs belong the perſpirable matter of Sanctorius, and probably the internal perſpirable matter of the epithelium and cellular ſubſtance, with part of the tears and watery humours of the eyes. To the latter of this claſs belong the remaining part of the tears, the ſaliva and pancreatic juice, that of the renal capſules, and the urine. The ſweat ſeems to be a mixture of the perſpirable matter and the ſubcutaneous oil.

190. The *third claſs*, differing from both the preceding, includes the viſcid, ſluggiſh, or ropy juices; but ſuch as are of a watery diſpoſition, and not congealable into a jelly, but hardening into a cruſt-like or ſcaly ſubſtance, by exhaling their water. Theſe do not effervеſce with any ſalt, and are contracted and made thicker by acids. By lixivial ſalts they are diſſolved. By fire they are reſolved into water, a little volatile ſalt, and a little oil. Of this ſort are all the kinds of *mucus* in the human body, ſpread through all the internal paſſages for air, aliments, or urine, and the cavities of the genital parts, liquor of the proſtates, and ſeed.

191. The *fourth and laſt* claſs is that of the inflammable juices, which, at their firſt formation, are indeed thin and watery, but, by time, ſtagnating and exhaling their more watery parts, become a thick, oily, inflammable liniment, often very bitter. To this claſs we refer the bile, ear-wax, ſebaceous and oily liniment of the ſkin, the marrow in the bones, and all the fat of whatever conſiſtence or in whatever part ſeated throughout the human body. To this claſs alſo belong caſtor and the yolk of an egg. And the milk itſelf, ſo far as it is butyraceous and inflammable, belongs to this claſs.

192. Other humours, which we have deſcribed as

ſimple, are compounded of the foregoing ones; as milk is compoſed of butter and water, and the liniment of the joints of lymph and fat.

193. Thoſe who conſider, that in the blood are found a coagulating ſerum (137.), an exhaling water (142.), a ſort of viſcid mucus (138.), and laſtly an oil (142.), may thence begin to perceive the poſſibility of a ſeparation to be made from the blood of all the foregoing claſſes (188. to 191.) of humours; in as much as we thus ſee their conſtituent principles are already in the maſs of blood itſelf. But in what manner it is brought about, that oil is ſeparated from the blood in one part, a watery liquor in another, or a gummy mucus in a third, is a taſk that ſtill remains to be explained, and requires a previous deſcription of the ſecretory organs themſelves.

194. The coagulable juices are ſeparated almoſt every where, from the arteries themſelves, into continuous excretory canals, without any intermediate organ or machine betwixt them. The proof of this we have from injections of fiſh-glue, water, and thin oils, which very readily paſs the red arteries, and are poured out like unto ſweat into all the cavities of the body in which that coagulable vapour is naturally found; nor do the injections in this courſe meet with any intermediate knots or ſtops from any hollow cavities or cells. Finally, the blood itſelf, being ſo readily poured out into moſt of theſe cavities, without any permanent damage, when its courſe is either much obſtructed, retarded, or urged with a greater impetus through the arteries, ſhows plainly that there is a ſhort and open way betwixt the red blood-veſſels and thoſe excretory ducts.

195. Another liquid, coagulable by acid ſpirits and alcohol, is the albuminous humour of the joints. This being compoſed of fat, medullary oil, and the exhaling liquor, conſtitutes an exceeding ſoft liniment, very fit for lubricating the cartilages, and leſſening the friction. For ſecreting this, there are appointed certain conglo-

conglomerate glands of a peculiar ſtructure, which are ſituated in the articulations of the bones, ſo that they may be moderately compreſſed, but cannot be cruſhed.

196. The ſtructure of theſe glands is peculiar to themſelves. The larger cluſters of glandular kernels adhere, for the moſt part, to the bone by a broad baſis wrapped up in fat. From thence, being drawn out into a kind of creſted edge, they pour out their liquor from an exceedingly thin border, by open ducts, which however I do not find very evident. Other leſſer ones, placed every where in the capſules of the tendons, and between the diverging fibres of the ligamentary capſules of the joints, ſeem to be much of the nature of ſimple glands, and are turgid with yellow mucous ſerum.

197. The uncoagulable juices (189.) of the firſt ſort are ſecreted in the ſame manner with thoſe which harden (188.); to wit, from the exhaling arteries, which ariſe from the red ſanguineous arteries, without any intermediate follicle or cavity betwixt them. Thus the veſſels, which pour out the perſpirable matter through the ſkin and lachrymal ducts of the firſt ſort, ſuffer a watery or thin gluey injection to tranſude ſo readily from the arteries, as leaves no room to doubt of this truth. And theſe ſecretory ducts have alſo a conſiderable degree of irritability; whence, by any ſtimulus or contact of acrid particles, they diſcharge more juice in a given time, than what they diſtil in a ſtate of health.

198. But in the latter ſalival kind of that claſs, the ſecretion is made by means of *conglomerate* glandules, which the ancients ſo called from their cluſter-like fabric, and eſteemed them almoſt the only proper glands. Theſe are compoſed of roundiſh lobules or cluſters (ſomewhat like thoſe in bunches of grapes, currants, barberries, &c.) looſely conjoined together into larger maſſes by the yielding cellular ſubſtance, which, at laſt, often forms a denſer coat or covering to the whole, like as we ſee in the parotid and maxillary glandules. Through the intervals, betwixt theſe glandular cluſters

or grape-like bunches, run the arteries and veins, which are here large or confiderable enough. But moft of the conglomerate glandules feparate their juices in fuch a manner from the blood, and from thence dif-charge it fo, that each kernel fends out an excretory duct, which, joining with others of the fame kind, form larger trunks, which at laft, in the manner of a vein, end in one canal, which conveys the humour, feparated by the gland, to the part for which it is de-figned, as the cavity of the mouth, inteftines, furface of the eyes, &c. There are, indeed, fome of thefe glands in which the faid excretory ducts are either not prefent, or at leaft not yet difcovered; as we obferve in the thyreoideal glandules, thofe called *capfulæ renales*, and the thymus, unlefs we fuppofe thefe to approach to the nature of conglobate glands.

199. The *acini* or kernels of thefe conglomerate glands are each of them circumfcribed and limited by a harder ftratum of the cellular fubftance; by which fubftance they are alfo fubdivided into leffer acinuli, as is evident to the eye and by the microfcope. But it may be queftioned, How does this fubdivifion end? Whether or no is every fimple acinus or kernel hollow in its middle, that, by receiving the humour tran-fuding from the arteries into the follicle or cell, it may be fent out thence by the excretory duct? Whether or no are we perfuaded to believe fuch a fabric obtains from the fmall fhot-like ftones and hydatides bred in thefe glands, with the round fcirri that fometimes fill the kidneys? Whether are the larger vifcera, appointed for fecretion, of the nature of conglomerated glands? Whether is this opinion made probable from the morbid round concretions formed in the liver, fpleen, kidneys, tefticles, and cortex of the brain; or from the bunch-like divifion or appearance which thofe vifcera have in younger animals? Whether the cellular fubftance, that furrounds the extreme vafcules in all parts, does not communicate by open areolæ or cells, in which a fecreted humour is poured by thefe glandules?

200. In

200. In ſhort, none of theſe arguments appear true or concluſive. For the acini, which are found in the viſcera of brute animals, are component lobules, and not elementary parts; but are large and compounded, for the conveniency of each beaſt. The morbid concretions are almoſt all of them a ſort of placentulæ formed in the loculi of the cellular ſubſtance, and take up their ſeat even in the limbs themſelves, where there is not the leaſt room to ſuſpect any thing of a glandular fabric; and are compoſed, as to their matter, of oil, earth, and vaporous particles, extravaſated into ſome of the leaſt interſtices of the cellular ſubſtance, where, ſtagnating and compreſſing the adjacent follicles, they form to themſelves proper membranous tunics. On the contrary, the watery and fluid nature of the juice ſecreted in theſe glands (189.) is an argument that it meets with no arreſtment in the ſeparation, nor places of ſtagnation in its way. For all the juices that reſt any time in the warm cavities of the human body, which are full of abſorbing veſſels, are each of them more or leſs inſpiſſated, and approach either towards a mucous or an oily diſpoſition. Moreover, if there were any ſuch arreſtments, anatomical injections would meet with more difficulty in paſſing from the arteries into the excretory ducts of thoſe glands; which, under ſuch circumſtances, would be impervious to thick injections, and thin ones they would exhale into their cellular fabric. Yet we ſee that the ſuperlative art of great anatomiſts has not only conveyed injections, but even thick ones like wax, directly from the arteries of the ſalival glands, liver, &c. into their excretory ducts; and this without filling up any intermediate knot-like cavities, which, according to the foregoing hypotheſis (199.), they ought to exhibit.

201. Therefore the *acini* or kernels of theſe glandules appear compoſed merely of arteries and veins divided and ſubdivided, parted and connected by the intervention of a good deal of cellular ſubſtance, whoſe ſtrata growing gradually more compact or firm as they

enlarge, at length ſhow their contents moulded into a ſort of globular nut-like figure. In the belief of this, we are confirmed by analogy in the lobes of the lungs, the lobules of the thymus, and from the ſtructure of inſects; but more eſpecially the fabric of the teſticle, in which we plainly ſee, that the lobules are formed of excretory ducts, connected together in faſciculi by a very ſoft membrane. But they ſeem not to pour their juices into a cellular fabric, which would intercept or make difficult the paſſage to an excretory duct. The late experiments alſo of very eminent anatomiſts have ſhown very ſmall, white, cylindric veſſels, to be the real elements of the viſcera; and it is to be hoped that this diſcovery will be confirmed by future obſervations.

202. Thin watery juices, neither coagulable nor wholly evaporating, are likewiſe in other parts generated without the aſſiſtance of conglomerate or kernelly glandules. For thus the urine is depoſited from the red or ſanguineous arteries into membranous pipes, with which they are manifeſtly continuous, and form an eaſy way, admitting air, water, and mercury, to paſs in like manner. And after the ſame manner, though leſs evidently, the nervous juice ſeems to be ſeparated in the brain.

203. The third claſs, or *mucous* juices (190.) are indeed almoſt every where ſeparated into, and diſcharged from, ſinuſes or hollow glands. Theſe true glands or follicles have, in general, ſuch a fabric as makes up an ample cavity, every where circumſcribed by a membrane; but in ſuch a manner, that the fleſh itſelf of the part, to which the gland adheres, is often taken for another cloſe hemiſphere of the follicle. The ſaid cavity or follicle is for the generality round: but ſometimes it is oblong, and obliquely creeping betwixt the adjacent parts; as for example, in the urethra of the male, and in the follicles of the ſinus muliebris. They are irritable; and when ſtimulated by acrid ſubſtances, increaſe the quantity of their ſecretions.

204. Into theſe follicles or cells the leaſt arteries (or the

the vafcular flefh furrounding each crypta or cell, and compleating its convexity) open by producted extremities within the cavity of each crypta, into which they diftil or exhale their refpective juice; where, being retained from the narrownefs of the excretory duct, the more watery parts are drawn up by the abforbing veins, which correfpond to and refemble the exhaling arteries; and thus the follicular or cryptal juices receive a confiderable degree of thicknefs. The truth of this we are taught from the ftructure of the fimple follicles obfervable in the tongue, in which both the importing arterial ducts or pores, and likewife the excretory mouths, are vifible to the eye; and from the velvet-like tubuli lining the ftomach of birds, in which a fecretory villofity manifeftly hangs in the cavity; and laftly, from injections, which difcharge a colourlefs wax into the fimple glands.

205. Whether the mucous cavity of fuch a glandule be long or round, it has always an excretory duct, which, for the moft part, is none of the leaft; altho', in the round mucous glandules, the difcharging duct or orifice be lefs, in refpect to the referving cavity, than in others. This difcharging orifice often opens into the common large cavity, into which the mucus is to be poured, without any intermediate duct; for thus it is in the back of the tongue, and in the fimple glands of the ftomach and inteftines, where they have been denominated *cryptæ* or cells by Ruyfch. The finufes have often the like fabric, opening without an intervening duct, as in the urethra of the male.

206. Another kind of thefe glandules is, where fimple follicles are folded up together in one common covering, and open with their gaping orifices into one common finus, without forming any true excretory duct. This fabric we obferve in the tonfils.---Thefe are called *conglutinated* glands.

207. Other fimple glands of this clafs have an *excretory duct*, by which they expel their mucus; namely, a narrow, membranous, cylindric, fmall veffel, opening with

with its posterior orifice into the cavity of the glandule, and with its anterior orifice opening into the common cavity for which its mucus is designed. These excretory ducts are of considerable length in the subcutaneous and sebaceous glands, and in those of the palate and wind-pipe. In some parts also, the pore or orifice, and its duct, are more easily demonstrable, than the follicle or body of the gland itself; as in the nostrils, larynx, rectum, &c.

208. In others, again, an assemblage of these ducts, arising each from its respective follicle, run together into one, like the branches of a vein, so as to form a considerable excretory canal, common to a number of follicles. To this kind belong the compound mucous glands of the intestines, some of the larger in the cavity of the urethra, with the blind or impervious duct or sinus at the root of the tongue; to which, in brutes and birds, add the fringe-like tubuli of the stomach. The glands of this sort may be called *simple ones compounded or continuous:* but where they lie only contiguous one to another, they may be called *simple aggregate* or congregated glandules; as are those of the fauces, stomach, intestines, &c.

209. The inflammable juices (196.) are separated by organs differing in their fabric. The fat and marrow are deposited, without the intervention of glands, from the small mouths of the least arteries into the cellular coat or rather substance; and the same fat again escapes from under the skin by small pores or ducts, without the assistance of any glandular follicles. But the ear-wax, and the waxen or suety liniment of the skin, are separated by glands of divers kinds. Most of the sebaceous glandules are visible enough, with an open or naked mouth in the skin, that leads immediately into the follicle, without any duct of considerable length; as we see in the external ears, nose, rings about the nipples, in the female nymphæ, and the valley or groove that runs betwixt them and the external labia, in the clitoris, and in the male glans and prepuce. These

differ

differ but little from the cryptæ (205.), except in their contained matter, which they ſeparate.

210. There are others of the ſebaceous glands, which have an excretory duct of a conſiderable length, like moſt of thoſe in the ſkin, which, being ſeated in the cellular ſubſtance, have conſequently a duct long enough to perforate the ſkin. Thus we ſee it is in the face more evidently, where the length of the duct is often to be meaſured by the concreted maggot-like ſubſtance preſſed out; the bulk of which demonſtrates, that a follicle or cell lies under the narrower pore.

211. There are ſtill other ſebaceous glands of the kind mentioned 208. in which many cryptæ by ſmall ducts meet together in one larger excretory duct. Thus in the face, in ſeveral places, there are large pores in common to a number of ſubjacent cryptæ. And of this kind are thoſe ſebaceous ſinks or little inteſtines in the eye-lids: and thus it is in the ſecretory organs of the muſk-goat, beaver, hyæna, civet-cat, and muſk-rat, which gather their ſebaceous matter into one common receptacle.

212. The milk, being a humour of its own particular kind, formed of oil and watery juices intermixed, is ſeparated by conglomerated glandules, whoſe fabric we deſcribed at 198. Whether the ſecretion of the bile be glandular, is controverted; but there are many arguments to perſuade us, that the liver is a mere vaſcular fabric, whence the bile diſtils immediately from the extremities of the porta into the *pori biliarii*, or roots of the biliary ducts, without paſſing any cells or follicles by the way: and in this we are more eſpecially confirmed by the Ruyſchian art of injection, in which the wax paſſes directly from the porta into the biliary ducts, without exhibiting any intermediate knots or ſtoppages; and therefore we ſee the milk and bile are both of them much thinner and more watery than the fat, or the ſebaceous matter which thickens in follicles.

213. It now remains for us to inquire, how, from one common maſs of the blood, the ſame variety of pe-

culiar juices are conſtantly ſeparated, each in its reſpective place; ſo that we never ſee milk ſecreted in the kidneys, bile in the thymus, or mucus in the ſebaceous glandules. This problem, indeed, may be ſolved by one who ſhall have previouſly acquired a thorough knowledge of the intrinſic fabric that obtains in each ſecretory organ. In the mean time, we ſhall here propoſe what has been hitherto advanced with certainty on that ſubject from any known principles whoſe truth we are convinced of.

214. And, firſt, the blood itſelf, from whence any liquid is to be ſecreted, in the various parts, puts on ſuch a character or diſpoſition there peculiar to itſelf, that more particles, of a like nature with the humour, abound in that portion of the blood, which *nature* intends to ſeparate from it. In the liver, the venous blood arrives with a very ſlow motion, full of oil, and full of the ſemiputrid vapours of the inteſtines. To the teſticles, the blood is brought ſlowly through very long ſlender and inflected canals, ariſing at very ſmall angles, and paſſing out of the abdomen through a cold tract under the ſkin. In the carotids, it is probable that the ſtronger, ſpirituous, and denſe parts of the blood aſcend; while whatever is more watery deſcends into the abdomen and to the kidneys; alſo to the forming of the ſalival juice of the pancreas, and the liquor of the ſtomach and inteſtines.

215. Another preparation of the blood, towards ſecretion, is from its retardation in the leaſt veſſels: whereby the red and denſer parts go on by themſelves along the axis of the canal; while the other lighter and more ſluggiſh or leſs moving particles recede to the lateral openings or branches, ſo as to enter the ſecretory orifices, which paſs out from the ſides of the ſaid veſſels; and to theſe they adhere by their viſcoſity.

216. Theſe orifices, though of different diameters, are yet always ſmall enough, in their healthy and natural ſtate, to refuſe the red blood. Hence, therefore,

we

we may conclude, that, being enlarged by an increafed force of the heart, they every where admit a good deal of the red blood from the fanguineous artery, which they arife from, and open into, as we cannot with probability fuppofe them to be much lefs than the red globules. And hence the fame fecretory orifices or ducts, which refufe thick injections of wax or fuet, do nevertheless generally admit thinner liquors injected into the arteries. Therefore this is the firft and moft fimple mechanifm of fecretion; viz. that the light or opening of the excretory duct may admit only fuch particles as have their greateft diameter lefs than the diameter of the faid opening. From this reafon only it is, that the yellow arteries convey off a pure liquor from the blood, and that the uriniferous ducts exclude both the red blood and coagulable ferum. But this is not the fole caufe, fince the fame juices are generated by large as by fmall animals.

217. Merely by this law, the fecreted juices may be of many different forts: for thofe whofe lights or tranfverfe fections are the leaft, will receive only the thinneft juices, as in the fmall veffels of the brain; and the larger ducts will admit water and jelly, while the thickeft fat will enter the biggeft of all. Moreover, if a number of fecretory organs are formed in a fucceffion from one fecerning artery, each of them having large mouths or ducts; in that cafe, the laft which come out from the faid artery will receive only the thinneft juices. But if thofe, which are firft formed in order from the fecerning artery, have fmaller ducts, then the laft only will receive the groffeft juices. It may be objected, that though the veffels in a fœtus are vaftly lefs than in an adult, yet the humours are the fame. But thefe humours which are called fat, bile, lymph, and urine, in the fœtus, are vaftly different from the fat, bile, lymph, and water, of a man.

218. From hence only it is, that the fecretions are generally made immediately from fanguineous arteries, without paffing the ferous lateral ones, (45.) Thefe

all ſeparate groſs juices; thick, coagulable, or watery; as the fat, urine, juice of the ſtomach and inteſtines, &c. But the ſecretions of the other thinner juices are made not from ſanguineous, but from ſmaller pellucid arteries ariſing from the former; to the ſecerning mouths of which, not only no red blood, but no ſerum, fat, or other groſs juices, can have admittance. Thus the more thin and pure humours muſt neceſſarily be ſeparated; as for example, in the eye.

219. Perhaps *the angle*, which the ſecretory branch intercepts with its trunk, contributes ſomething to ſecretion. For it is eaſily demonſtrated, that at right and retrograde angles, only the viſcid and ſluggiſh juices are expelled by the ſtronger force of the particles keeping the middle of the canal; but the liquids which are about to go off at half-right angles, are thoſe which preſerve their velocity. For, in living animals, the velocity of the blood is greateſt in veſſels of the acuteſt angles, and leſs in thoſe of right angles, as men of veracity have obſerved. That the effect of theſe angles in the veſſels is conſiderable, with regard to the ſecretion, we are perſuaded from the ſtructure of the body itſelf; ſince they form different angles in different parts with reſpect to their trunks, and in ſome parts compoſe net-works. For the ſmalleſt veſſels, in general, reſemble the branchings of little trees or ſhrubs, the trunks and arms of them every way ſending out branches, but in different angles; ſmall in the large inteſtines, but larger in the ſmaller inteſtines. Thus, in the ſpleen, the ſmaller red arteries ariſe ſo thick from their trunks, that they reſemble a wiſp or ſprinkler; in the inteſtines, they reſemble pencil-bruſhes; ſerpents, in the kidneys; ſtars, in the liver; a radiated circle in the uvea; and, in the teſticle, a lock of hair curled up into a button. But we deſervedly receive it as a rule, that the Creator never made this diverſity of fabric to no purpoſe. We have not as yet, however, any account of theſe net-works that can be ſufficiently depended upon. Neither does there ſeem to be any affinity between

the fabric of the veſſel, and the nature of the liquor which it ſecretes: and, indeed, theſe net-works are almoſt ſimilar to the veins, as if made rather for ſhortening the paſſage of the blood in ſome meaſure, than for diverſifying the nature of the ſecretion.

220. The *inflexions* of the ſmaller veſſels, as well arteries as excretory ducts, greatly retard the motion of the blood; in which, therefore, the greater part of the force received from the heart is evidently ſpent in changing the figure of the veſſels. The repeated inflexions, therefore, of the ſecretory arteries increaſe the viſcidity of the juice, by delaying the flux, and giving the parts more time to cohere or attract each other. But a ſtraight courſe of the veſſels increaſes the celerity of their fluid, whence a copious and eaſy ſecretion; but then it makes the ſecretion more impure, as we ſee in the urine.

221. That the ſmaller arteries have different *degrees of denſity* or firmneſs, there is no reaſon to doubt; ſince we actually find it ſo by experiments in the larger branches. But the denſer the capillary arteries, the more they reſiſt the light and ſlowly moving particles, and yield only to the more denſe ones that have a greater impetus. Irritability produces almoſt the ſame effects; for if the ſecretory ſtrainer has a very acute ſenſation, it will reject the groſs humours, and tranſmit the more fluid ones: inſtead of mucus in the urethra, it will ſeparate a thin yellow ſerum; and almoſt the ſame, inſtead of the ſebaceous matter that lies under the ſkin: the quantity of ſecreted liquor will alſo be increaſed; as for example, in the tears.

222. Again, the velocity is greatly increaſed, if the heart is near; if the artery is ſtraight, or if it is produced with a ſmall angle; alſo, when the excretory duct ariſes before the extremity of a larger arterial branch: and it is diminiſhed, when the ſmall ſecretory artery runs a long way capillary, whereby the blood loſes the greater part of its motion in friction. Finally, from whatever cauſe the diverſity may ariſe, a greater velo-

city

city increaſes the quantity of ſecreted liquor, and produces heavy, more groſs, impure liquids; it alſo gives a degree of fluidity to the ſecreted liquors, as it prevents the ſtagnation, by which they might contract a viſcoſity: but ſlowneſs increaſes the attraction and viſcidity, and renders the ſecreted juice more pure; as the ſimilar particles, when brought together, can better attract and join each other under a ſlow motion, ſo as to retain the larger canal, while the thinner parts go off by the leſſer lateral branches. From hence it is, that, only the impulſe of the heart being too much increaſed, all the ſecretions are confuſed.

223. Theſe conditions nature is able variouſly to join together or ſeparate, and impart to every ſtrainer in greater or leſſer degrees; and thus, by various methods, to modify the ſecreted humours. Anatomy furniſhes an example, if you ſhall compare the ſtrainer of the bile or ſemen, which are thick juices, with the ſtrainer of the urine and tears, which are fluid ones.

224. From all that has been hitherto advanced, we may now begin to perceive, that, ſince the blood contains particles of various kinds; ſome ſluggiſh; others mucous; others coagulable, but fluid; ſome denſe and red; ſome watery and thin; others fat and groſs (188. *et ſeq.*): among all theſe particles, thoſe which are the largeſt and moſt denſe, as the cruor, will go on moſt towards the axis of the veſſel, ſo as to paſs on in a continued courſe from the artery into the trunk of the ſanguineous vein (39.)

225. Thoſe particles which are groſs and ſluggiſh, as the fat, muſt needs go off laterally by larger orifices from the ſanguineous artery, by ſhort ducts; for long ducts would make a ſtop to ſuch a ſluggiſh juice as oil. The phenomena of the adipoſe ſecretion (19.) agree with this deſcription. Such parts as are coagulable, but ſpecifically heavier than thoſe which are merely watery, kept fluid only while the powers of life are in action; theſe paſs off laterally from the red arteries, into the arteries which are not red, but continuous to the red

red ones, and ſmaller; whether theſe pellucid ones are continued on in the nature of trunks, ſending off other ſmaller branches, like the leaſt arteries (41.); or whether they exhale their contents by a ſhort extremity, like the veſſels of 170.

226. Thin watery juices may evidently paſs off by any veſſels continuous with the ſanguineous ones, or the leſſer ones (44.), provided they be only ſmall enough to refuſe the groſſer juices: and this, whether they come out from the ſides of the larger arteries; or whether by a long continued courſe, and ſending off all the groſſer juices by large lateral branches, they, at length, end in a ſmaller pellucid canal inſtead of a trunk; as for example, in the eye. To the production of theſe juices, the moſt ſimple fabric is ſufficient; even a direct continuation of the ſecretory artery itſelf into an excretory duct, as we ſee in the urine. Therefore, the ducts and veſſels have here a ſtraight and ſimple courſe, with few or no inflexions; and a proportionable velocity as yet holds in the courſe of their contained juices.

226*. Such juices as, being watery, light, but viſcid at the ſame time, are conſequently ſluggiſh and leſs moveable; theſe may be eaſily ſecreted by ſhort narrow ducts of a leſs diameter than to admit the fat, and appended to the ſanguineous arteries: and, therefore, it is evident, theſe will be ſeparated from the blood more abundantly in ſome parts of the body than others; namely, where the velocity received from the heart's impulſe is leſs, the flexures of the artery more frequent, and where the extent of the capillary artery ſhall be carried to a greater length.

227. Whether or no ought we to aſcribe to each particular part, the ferments, pores, ſpecific weights, or filters filled with their own peculiar humour, and admitting nothing that is analagous to it, which determine the nature of the humours to be generated? One who admits of theſe, ought to conſider the great difference there is in one and the ſame juice, ſeparated in the ſame part of the body, according to the difference

of

of age, courſe of life, &c. The bile in a fœtus is generated ſweet; the ſemen thin, and without vermicles; the milk either none or watery; the urine watery, mucous, and inſipid; the uterine mucus very white; the cutaneous veſſels full of red juices; the watery juices reddiſh; and the fat gelatinous. By the ſame organs, in an adult perſon, the bile ſeparated is ſharp or acrid; the ſemen thick; the milk butyraceous; the urine yellow, thin, and alkaleſcent; the womb diſcharges a menſtrual blood, and the aqueous humour very clear. But, even in the adult perſon, how different is the urine? at one time watery; at another, thick or concocted; in a fever, high-coloured and heavier, full of ſalts and oils. The paſſions of the mind, which make no other change in the body than that of ſtrictures in the nerves, yet wonderfully change the face of the ſecretions, and expel even the blood and bile through the veſſels of the ſkin. Add to this, the frequent diſturbance of the ſecretions, and the changes to which they are liable from ſlight cauſes; ſo that only an increaſed celerity ſhall cauſe ſeveral differing liquors to be ſecreted by one and the ſame organ: for blood has been known to paſs into almoſt all the paſſages of the ſecreted juices; into thoſe of the ſweat, tears, mucus of the noſtrils and of the womb; and into the lactiferous, ſeminal, and urinary ducts, as well as the fat. A true milk has been ſeen ſeparated by glands in the thigh. When the urine has not been excreted by its natural courſe through ſome defect of the kidneys, ureters, or bladder, it has paſſed by the ſkin, exhaled into the ventricles of the brain, or even into the whole cellular fabric. The perſpirable matter of Sanctorius, however thin, is often by cold driven through the noſe or kidneys; or, by the ſame cauſe, by fear, or by medicines, is depoſited through the excretory villi of the inteſtines. That exhaling viſcid juice, ſecreted by the ſame organ with the fat, from which it ſo much differs, into the cellular ſubſtance, is depoſited, takes place of the fat, is re-abſorbed, and alternates again with the ſame, (18, &c.) A ſalivation

ſupplies

ſupplies the place of the Sanctorian or cutaneous exhalation externally, and of the cuticular exhalation internally. The bile, re-abſorbed, appears evidently flowing in the veſſels of the eyes. Nor does there appear any thing in the fabric of any of the viſcera or glandules that can fix or maintain the nature of the ſecerned fluid. The ſpecific gravities of the viſcera and ſtrainers neither anſwer, according to the authors who treat of of them, to the ſpecific gravity of the humours which they ſecrete; nor are they at all known by experiments that can be depended on.

228. It now remains for us to diſcover, how the ſecretions, in a healthy perſon, become pure or uniform. For all the juices that have been lately ſecreted (without excepting any, even the oil or fat itſelf) have a great many watery particles intermixed; ſo that none of the thicker juices ſeem capable of being formed, without having a mixture of the thinner watery ones: how then do the ſemen, bile, fat, mucus ,and other thick juices, depoſite their firſt watery ſtate, and acquire their proper viſcid condition and other qualities?

229. For this end, therefore, nature has framed glands, with large and ſmall follicles or reſervoirs, for retaining the ſecerned juices, from which the watery parts are required to be ſeparated, to render the remaining part more ſtrong and viſcid. The mucus, at its firſt depoſition, is thin and watery as yet, but little differing from the perſpirable vapours or tears, in which ſtate it diſtils into the cavity of the noſtrils, wind-pipe, and inteſtines. This is not continually diſcharging, becauſe the excretory orifice is leſs than the retaining cell or follicle (196.); and the excretory duct being ſometimes long and ſlender, at others repeatedly bent, and turning backwards and forwards, or tranſmitted thro' a hard cellular texture, or cloſed by ſome force equivalent to a ſphincter, ſo retards the juice that it cannot paſs out but by the aſſiſtance of a preſſure; or perhaps, not without being irritated by the quantity or acrimony of the juice, the follicle preſſes out the liquor which

incommodes it, by a kind of periſtaltic motion. This appears from the morning diſcharges of mucus by blowing the noſe, coughing up from the lungs, and by ſneezing after the nocturnal ſtagnation. In the mean time, the patulent veins, extended into the cavity of the follicle, abſorb the more aqueous parts from the thin mucus, that it may become thicker as it is retained longer; but if, by the force of ſome ſtimulus, it be directly diſcharged after it is ſecreted, it comes out thin and watery. Examples of this we have in the urethra, in the noſtrils, and in the ear-wax; as alſo in the bile, which, at its firſt ſeparation in the liver, is watery, and has but little yellowneſs or bitterneſs. It is, therefore, retained by a large follicle or gall-bladder; and there digeſted or exalted by the vital heat, and its more thin or watery parts exhaled or abſorbed by the veins; whence the remainder becomes more thick, bitter, and oily. The ſame mechaniſm takes place in the ſemen; which, being reſerved in the ſeminal veſicle, is there thickened, ſo as to be very viſcid after long chaſtity; but in repeated venery it is expelled very fluid. In ſome places nature has made this receptacle two or three times folded together in one and the ſame organ, when her deſign was to form a very thick juice. Thus the ſeminal paſſage is in the teſticles reticular; in the end of the epididymis, one large canal ending in a larger veſicle: whence the veſſels at the teſticle are narrow, and ſo again are the vas deferens and the proſtatic duct. Hence there are nowhere real glandules, except for ſecreting a viſcid liquor. And if a viſcid liquor has been ſeparated from the arteries without a follicle, it always ſtagnates in a large follicle. The ſemen, bile, liquor of the joints, and fat, afford examples of this.

230. A ſecerned juice may be likewiſe changed in its receptacle by the affuſion of ſome new liquor. Thus the ſemen thickens by an affuſion of the proſtatic liquor; the chyle is thinned by mixture with the ſaliva and pancreatic juice and that which diſtils from the villi of the ſtomach and inteſtines, and by an affu-

ſion

ſion of the bile it becomes alkaleſcent; and again the ſynovia or albumen of the joints is tempered by the two kinds of fat (195.)

231. Laſtly, whatever is abſorbed, can be of uſe to the animal according to its nature, after it is taken into the blood; as the ſemen gives a ſurpriſing ſtrength to male animals. For the moſt part, likewiſe, an acrimony ſimilar to that of lixivium is generated, and which alſo hath its uſes, as in the bile and ſemen.

232. But the great uſe of the follicles and receptacles of glands is to preſerve the juice, of whatever kind it be, for thoſe times in which it is moſt neceſſary to be employed in the actions of life. Thus the bile is reſerved for the time of digeſtion, the ſemen for due and lawful venery, and the mucus of the noſe is accumulated in the night to temperate the force of the refluent air in the day.

233. Therefore, as nature has in this way framed machines by which the juices are retarded in the large and ſmall follicles, ſo ſhe has made others to expel them at ſuch convenient times. To ſome glands ſhe has given particular muſcles for this uſe; as in the teſticles of brutes, the urinary bladder, and the gall-bladder: or elſe ſhe has placed other muſcular machines round them, which, by acting at convenient times, expel their contained fluids; as, for example, in the muſcular coat of the ſtomach and inteſtines. In other parts ſhe has added contiguous and incumbent muſcles to promote the diſcharge, as in the biventers and maſſeters of the lower jaw: or elſe ſhe has again joined to them a kind of nervous irritability, which, being excited to action by an unavoidable ſtimulus, opens the ſhut paſſages to the milk, ſeed, tears, &c.; or being touched by ſomething acrid, as already mention'ed, diſtils the liquor more quickly; as happens to the bile, liquor of the ſtomach and inteſtines, and to the ſebaceous matter.

CHAP. IX.

Of Respiration.

234. THE bags of the pleura (77, 78.) are exactly filled by the *lungs;* for ſo we call the two viſcera, which are diſtinguiſhed into right and left, in figure anſwerable to that of the bags themſelves which they fill, having a broad baſis below, and being terminated above at the firſt rib by an obtuſe point or cone. The anterior face of them is flat, their ſides convex or round, internally or in the middle concave, forming a concavity ſufficient to contain the heart. The right lung is larger than the left; and more frequently divided, or half cut through, into three diſtinct lobes or portions; but the left lung is not ſo often divided into three. They are freely ſuſpended by the great blood-veſſels, at liberty on all ſides; unleſs you call that a ligament which is made by the external membrane of the pleura, departing to the lungs and to the baſis of the diaphragm. Betwixt the lungs and pleura is found a watery or rather ſerous vapour, of a coagulable nature, like that of the pericardium (82.); which vapour tranſudes from the ſurface of the lungs, continually in the fetus, and not unfrequently in the adult. This is ſometimes increaſed to a dropſy, or thickens to a kind of ſebaceous matter; or laſtly, concreting into fibres, joins the lungs to the pleura.

235. The external membrane of the lungs is ſimple, and thinner than the pleura, although continuous to it. It is ſpread all over them, from the adheſion of the great blood-veſſels of the heart; yet ſo as to be capable of retaining wind eaſily, without breaking, after being ſeparated from the lungs. The ſame membrane covers the interſtice or mediaſtinum of the lungs, like a bridge. It is joined to the lungs by a cellular texture.

236. The

236. The ſtructure of the lungs is a heap of lobes ſeparated from each other by intermediate intervals, in which is extended a looſe cellular ſubſtance. The firſt diviſion of them is into two extreme lobes, which are larger; and one middle one, which is leſs; yet cohering together: although afterwards they are again ſubdivided internally, through a long ſeries, into leſſer lobules down to the leaſt, till at laſt the ſmall lobules terminate in very ſmall membranous cells, which, in adults, are variouſly figured, and full of air, and communicate on all ſides with one another. Theſe veſicles of the lungs, therefore, do not receive the air by a ſingle orifice from the wind-pipe, as into an oval grape or vial; but the air, exhaling from the leaſt branches of the ſaid wind-artery, is admitted in ſuch a manner into their irregular ſpaces, that it freely ſpreads through them from any one part of the lungs into all the reſt, and returns again in like manner. This is demonſtrated by inflation, which drives the air even through the leaſt branches of the wind-pipe into the ſmalleſt lobes; from whence it readily paſſes into all the reſt. Nor, in man and ſmaller animals, is the cellular fabric of the intervals ſhut up from the veſicles of the lungs, nor are the lobes ſurrounded by any peculiar membrane; for in the largeſt, as between the air-veſicles and thoſe cellular ſpaces ſurrounded with lobules, there is no commerce.

237. The air is driven into theſe veſicles thro' the wind-pipe, which ariſes from the larynx (hereafter to be deſcribed), and from that only receives its air. The firſt part of this wind-pipe is ſingle, and deſcends along the ſmooth bodies of the vertebræ of the neck, partly fleſhy and partly cartilaginous; namely, within the cellular ſubſtance that ſurrounds the wind-pipe, follows a canal, made up by a ſucceſſion of cartilaginous and muſcular rings. Theſe are thin and elaſtic; flatter and thicker in their foremoſt part, but thinner in their poſterior extremities, which are conjoined together by ſtrong

transverſe

tranſverſe muſcular fibres, which, adhering firmly to each extremity of the cartilage, complete the circle. But the lowermoſt circles are leſs; the uppermoſt often augmented by an appendix, the next again perpendicular to the diviſion.

238. The fleſhy rings, alternately placed with the cartilaginous ones, are made up of red muſcular fibres. Some of theſe are tranſverſe, connecting the detached ends of the annular cartilages; others deſcend from each upper to the next lower ring. But other muſcular fibres again, deſcending downwards from the cricoide cartilage, and having reached below the firſt diviſion of the bronchia, vaniſh within the lungs. The tranſverſe fibres contract or leſſen the diameter of the wind-pipe; the longitudinal ones render it ſhorter. Alſo within the lungs, betwixt the imperfect rings, is found a ſort of muſcular fabric, but leſs uniform.

239. In the cellular coat which ſurrounds the muſcular one, but eſpecially in the back part of it, along the poſterior interval that is betwixt the cartilages, are placed numberleſs ſimple glands, which open by very ſmall ducts, like pores, into the cavity of the wind-pipe: by which pores they depoſite a watery and pellucid mucus into that cavity; which mucus, being without the leaſt acrimony, not coagulable into a hard ſubſtance like the humour of the eye, is of the greateſt uſe in defending theſe moſt ſenſible membranes from being injured by an impure air, full of particles, which, by their mechanical figure or chemical acrimony, might be very troubleſome. Laſtly, the internal tube of the wind-pipe is compleated or lined by a membrane, which is continuous with that of the mouth, ſmooth, ſoft, and very irritable. The ſame cellular texture ſurrounds it which anſwers to the muſcular coat.

240. The veſſels of this part of the whole wind-pipe, in the neck, come from thoſe of the lower thyreoids; in the thorax, from other ſmall branches of the ſubclavian trunks, or the mammaries, or the *bron-*

chials

chials properly ſo called. Its nerves are numerous from the recurrent and intercoſtal ones.

241. In the upper part of the thorax, the wind-pipe is received between the laminæ of the poſterior part of the mediaſtinum; and at the third vertebra, or a little above, is divided into two ſimilar branches reſembling the trunk itſelf, and formed like that of imperfect cartilages, alſo furniſhed with ſimilar glandules; each of which branches enters the lung to which it correſponds, only the right is ſomething ſhorter and larger than the left. Having entered the lungs, the cartilaginous rings change into fragments, which become more and more difform, gnomonic, angular, triangular, and intermixed with a larger portion of the membrane, till, at length, the cartilages decreaſing, the laſt branches of the bronchia become merely membranaceous.

242. Its laſt branches are inviſible, which exhale the air into the cellular ſpaces of adult lungs, and likewiſe receive the watery vapours exhaling from the arteries into the ſaid ſpaces; from whence they are thrown out by exſpiration.

243. The blood-veſſels of the bronchia are the *arteriæ & venæ bronchiales*. The former are almoſt conſtantly two; one coming from the upper intercoſtal of the aorta, which is diſtributed either to the right only, or to both the lungs; the other, from the trunk of the aorta itſelf, goes to the left lung. Sometimes there are more than two bronchial arteries to be ſeen; as when there are three, by the addition of a ſecond from the aorta. But ſometimes again there is only one artery in common. The thoracic part of the bronchi ſituated without the lungs, has its proper veſſels from the aorta, the ſubclavian, mammary, or intercoſtal. The bronchial veins are moſt commonly two; the right from the vena azygos, the left from a peculiar branch of the ſubclavian vein and the left ſuperior intercoſtal. Theſe blood-veſſels travel together with the branches of the wind-pipe; and deſcend into their membranes in ſuch a manner, that the pulmonary arteries, in their way, in-

inoſculate with their contiguous arteries, as the veins likewiſe communicate with each other. There are ſome inſtances where the pulmonary vein itſelf has given ſmall branches to the lungs, to the wind-pipe, and to the ſurface of the lungs.

244. But there are other larger veſſels belonging to the lungs, called the *pulmonary artery* (deſcribed 106. 108.), and the pulmonary vein (110.) The great artery, in the fetus larger than the aorta, and in the adult but little leſs, has two branches; the right larger but ſhort, the left narrower and longer. In the fetus, the trunk itſelf is continued into the deſcending aorta, and is known by the name of *ductus arterioſus*. In an adult, that trunk degenerates into a ſolid ligament. The four pulmonary veins accompany the arterial branches and the aſpera arteria of the wind-pipe in their courſe through the lungs, ſurrounded with a good deal of cellular ſubſtance; which ſubſtance, being increaſed, at laſt compoſes the lungs themſelves. Within this cellular fabric, and likewiſe upon the ultimate ſpaces or cells, the air-veſſels and blood-veſſels are ſubdivided, ſpread, and interwoven like the meſhes of a net; and here the ſmall arteries exhale a plentiful vapour into their cells, and the veins abſorb a watery vapour from the ſame cells. Hence water tinctured, the whey of milk, or a thin waxen injection, being urged into the pulmonary artery, flows with a froth into the wind-pipe; or, on the contrary, being urged from the wind-pipe into the lungs, they penetrate into the pulmonary artery. In like manner, injections paſs from the pulmonary vein to the wind-pipe; or from thence again, they may be forced into the veins. Laſtly, a liquor injected by the arteries, readily enters the pulmonary veins; and the reverſe.

245. The lymphatic veſſels, as in other parts, form a net-work upon the ſurface of the lungs, from whence there are branches conveying the lymph to the cavity at the back part of the mediaſtinum, and to the ſmall glands which lie behind the œſophagus, opening at laſt

laſt into the thoracic duct. The anterior pulmonary nerves are ſmall, but the poſterior ones ſomewhat larger: they come from a nerve of the eighth pair; and there are alſo ſome ſmall nerves to the lungs from the recurrent, and likewiſe from the cardiac plexus, which enter together with the large blood-veſſels. Hence the lungs have but little ſenſation; that of the little nerves, however, divided after the manner of the bronchia, is very acute. Nor are the lungs of an irritable nature.

246. The quantity of blood which enters into the lungs is exceeding great, equal to (or even perhaps greater than) that which is ſent in the ſame time throughout the reſt of the whole body; which, therefore, demonſtrates ſome very conſiderable uſe proper to this viſcus. And that this uſe depends manifeſtly upon the air, appears from the univerſal conſent of nature, in which we ſcarce find any animal without breathing; alſo from the ſtructure of the lungs in the fetus, in which, for want of air, they are uſeleſs, receiving only a ſmall portion of the blood, which the pulmonary artery conducts from the heart. We are now, therefore, to ſpeak of reſpiration, by which the air is drawn into and expelled from the lungs.

247. The element of air appears, from the principles of philoſophy, to be an elaſtic and ſonorous fluid, with a ſpring which cannot be deſtroyed. But the atmoſpherical air, which we commonly receive into the lungs, is impure, filled with a great quantity of watery and other vapours, alſo with ſalts and the univerſal acid, with the ſeeds of plants and animals, and other foreign matters, but in very minute particles; ſo that it weighs 859 times leſs than water, and a cubic foot of air weighs between 610 and 694 grains. This air, which ſurrounds the earth on all ſides, being preſſed by the incumbent columns of its own maſs, perpendicularly, laterally, and in all directions, enters wherever it meets a leſs reſiſtance, and with a conſiderable force, as appears from experiments made with empty or exhauſted veſſels, and by the air-pump, ſo that its preſſure on the human body is not leſs than 3000 pounds weight. It is re-

repelled chiefly by the pores of the membranes, which yet are permeable by water: it likewiſe penetrates oil or mucus with difficulty.

248. This air is excluded from all parts of the human body by the ſurrounding cloſe ſkin, which, even when dried or tanned, is impervious to the air; but more ſo, as under the ſkin is placed the fat, making an equal reſiſtance to the narrow openings of the abſorbing veſſels. It, therefore, now remains for us to inquire, why the air enters the lungs of an adult perſon; for with this they are in a manner conſtantly full, and of courſe are equally preſſed, and reſiſting againſt the weight of the whole atmoſphere: but that the lungs always contain air, is evident; becauſe, however cloſe you compreſs them, they will be ſtill lighter than water; and even in the fetus, after they have been inflated but a few times, they always ſwim; whereas, before breathing, they ſink to the bottom of water, if they have as yet not given admittance to the air.

249. The equilibrium of the air's preſſure being removed in any place, it conſtantly deſcends or flows that way where it is leaſt reſiſted (247.) But air that is denſe and heavy will deſcend more eaſily than ſuch as is light, whoſe force ſcarce overcomes that of the air which is already in the lungs, nor is able by the ſame force to overcome the reſiſtance of the bronchia and force by which the lungs compreſs the air contained in them. Hence an animal lives better in a denſe than in a light air: although that kind of air is always moſt tolerable, which is pure at the ſame time that it is light; ſuch as that of the higheſt mountains of the Alps. Therefore, for the air to enter the lungs, they muſt make a leſs reſiſtance to it than before; namely, the air, which is already in the cellular fabric of the lungs, muſt be rarified: but this effect will follow, if the cavity of the thorax, in which the lungs are contained, and which they exactly fill, be dilated. Thus the air, which is always in the lungs, expands into a larger ſpace, by which, being weakened in its ſpring, it makes

makes a leſs reſiſtance to the external air; and conſequently a portion of the ſaid external air deſcends into the lungs, ſufficient to reſtore the confined and rarefied air, filling the lungs to the ſame denſity with that of the external air.

250. We muſt therefore deſcribe the powers which dilate the thorax to produce this effect. The breaſt or *thorax* is a ſort of cage made up of bones, muſcles, and cartilages; being almoſt of the ſhape of an oval tub, ſomewhat compreſſed before, but behind divided by an eminence, whoſe hoops are the ribs, which are of a remarkable ſtrength. In the lateral parts of this cage are placed the lungs; in the middle and lower part lie the pericardium and heart; after which it is taken up by ſome of the abdominal viſcera.

251. The baſis of the thorax is formed by a column, a little crooked, and gibbous on the upper and back part; and likewiſe, in that part of the baſis which is uppermoſt, the ſame is very much behind the others into which twelve vertebræ coaleſce. They coaleſce, however, by the union of their bodies into a ſingle column, which is prominent in the forepart between the two cavities of the breaſt; divides the right from the left; and is plane in the forepart, and broad towards the ſides. A ſlight ſinuoſity receives the ribs in that place where the arch ſeparates from the body. They are bound together into one column, as well by the elaſtic plate interpoſed between every two bodies, and coaleſcing with both; as by other ligaments and ſpines lying upon one another, and the joining of the ribs, by which means no motion can happen among them without the greateſt difficulty. The ſides of the breaſt are made up of twelve ribs. Theſe are in general bent in the form of an irregular arch, having a great curvature laterally and backwards, but extending in their forepart towards a right line. The bony parts of the ribs lie ſufficiently parallel with each other; the greateſt part of the rib is bony, round, and thick backward, but thin and flat forward. The other part forward is com-

pleted by a cartilage; which in general continues the figure of the rib, growing in a flat broad concavity of a nature different from the bony part; and which does not change into bone, unleſs in extreme old age.

252. The poſterior and bony thick part of each rib terminates in a head; along from which, in the body of the uppermoſt and two lowermoſt ribs, runs a cavity or groove, formed in the other ribs, betwix every two adjacent margins, which lie one towards the other. The vertebræ are tied to the ribs by ſtrong ligaments, of which the principal ſpread from each rib like rays into the next adjacent vertebra, other ligaments tie the tranſverſe proceſs to the tubercle of the rib, and others tie the ribs one to another and to the tranſverſe proceſſes at the ſame time. Moreover, betwixt the angle of incurvation and the juncture with the vertebræ, each of the ten upper ribs ſend out a protuberance, which, being articulated with the plain ſide of the tranſverſe proceſs of each vertebra, are ſo tied by ſhort and ſtrong ligaments to that proceſs, that the rib has liberty to make a ſmall aſcending and deſcending motion, but with a conſiderable degree of firmneſs.

253. Among theſe anterior cartilages, the ſeven uppermoſt reach to the ſternum, and enter into the lateral cavities, which are incruſted with a cartilage in that bone, to which they are alſo made faſt by ſhort ligaments. Of the five remaining ribs, the uppermoſt is faſtened to the ſeventh preceding, and that to the next lower, by a ſtrong cellular texture, by which they form a continuous margin, which is at laſt alſo faſtened to the ſternum. The ſame are connected to one another both by proper ligaments, and cartilaginous appendices joined with them through the celluloſity: the two lowermoſt are free, and connected only with the muſcles. Theſe inferior cartilages are united to one another and to the ſternum by ſtrong ligaments.

254. The firſt rib is the ſhorteſt, but more ſolid than any of the reſt. As they follow in ſucceſſion to the ſeventh and eighth, every two and two ſtretch themſelves

ſelves into longer and more moveable circles. The eighth is the longeſt of all; and from thence, the lower down they are, they grow continually ſhorter.

255. The direction of the upper rib is deſcending; but the ſecond rib joins the ſternum almoſt in a right angle, while the others aſcend both to the vertebræ and to the ſternum, but more to the latter. But the bony part of the ribs is placed in ſuch a direction, that the uppermoſt have their ſides in the fore part very much declined forward, almoſt tranſverſely. In the third ribs it is placed almoſt perpendicularly; in the middle ones, it projects a little outward in the lower part. Beſides, the ſtrength of the different ribs is very different. The uppermoſt, being ſhort, rather grow into the ſternum than form a joint with it; and being tranſverſe, and often as it were welded together, they make a very ſtrong reſiſtance. From thence the mobility increaſes downwards, till the loweſt rib, adhering only to muſcles, has the moſt eaſy motion.

256. The ſternum in general is a thin ſpungy bone altogether, one in adults, but is variouſly divided in the fetus. Its upper and broader part reſembles an octagon; and is articulated with the clavicles, which are jointed very cloſely with the triangular head of the ſternum, and with the firſt rib on each ſide. The other part which is longer and narrower grows broad downwards, and its ſides receive the ribs each into its proper angular cavities. The lower part, which is leſſer and ſhorter, imitates the obtuſe figure of a tongue. This is continued into a detached appendix, partly bony, and partly cartilaginous, of a changeable figure, which they call the *enſiform* cartilage; and which is found of various ſhapes, ſometimes being obtuſe like a little tongue, ſometimes pointed like a ſword, ſometimes bifid, and ſometimes perforated.

257. In order, therefore, to dilate the ſeat of the lungs, and thus to put the body in ſuch a ſtate that the external air may ruſh into the lungs, it is neceſſary for the thorax to be elevated. For thus all the ſections of the

the thorax form right angles, and its capacity is increafed. This motion is performed by various mufcles, which either operate conftantly, or only at certain times. The intercoftal mufcles, therefore, all of them act perpetually in elevating the ribs. By this name we underftand 22 mufcles; of which 11 are external, or next the fkin; and as many internal, feparated from the pleura only by fat or cellular fubftance. The beginning of the *outer intercoftals* is at the pofterior articulation of the ribs (252.); but the termination of them is in the anterior bony part of each rib, at fome diftance from the cartilage, in fuch a manner, that the remaining fpace betwixt the cartilage and fternum to the mufcle is filled by a tendinous expanfion. The direction of thefe mufcles is fuch, that the fibres defcend obliquely forward, from the lower edge of the upper rib to the upper edge of the lower rib. And that their action is to elevate the ribs, all authors unanimoufly agree; becaufe they thus defcend from the upper lefs moveable to the lower and more eafily moveable rib, in fuch a manner, that their lower point lies more diftant or remote from the hypomochlion or point of motion, which is in the coftal articulation with the vertebræ, confidering the rib as a lever.

258. But the *internal intercoftals* arife at fome diftance from the vertebræ, almoft at the outer tubercles of the ribs beforementioned (252.). From thence they proceed as far as the fternum, into which the uppermoft of thefe mufcles are inferted above. The direction of thefe is contrary to that of the former, except the anterior part of the firft or uppermoft of them; fo that they defcend from the lower margin of the upper rib backward, to the upper edge of the lower rib forwards. Therefore fome doubt of their action, becaufe their lower part is inferted into that portion of the rib which is neareft its articulation with the vertebræ, and which therefore feems to be the leaft moveable: however, they elevate the ribs notwithftanding this; for the great firmnefs or immobility of the upper rib, exceeding that of the lower, is evident from the articulation, weight, and li-

ligaments there formed, which ſurpaſſes that mobility, ariſing from the greater diſtance of the center of motion. This appears from the diſſection of living animals; in which we ſee the inner intercoſtal muſcles operate in the elevation of the ribs, and reſt in the depreſſion of them; alſo from a flexible thread fixed to the rib of ſome human ſkeleton, and drawn in the ſame direction with that of the fibres of the inner intercoſtal muſcles, by which means the lower rib will be always approximated towards the upper. The greater firmneſs alſo of the upper ribs proves this, as they ſerve for a fixed point to the lower ones: for the firſt or uppermoſt ribs are from eight to twelve times firmer and leſs moveable than the lower true ribs; but the difference of diſtance in them, from the center of motion, is ſcarcely the twentieth part of the length of their whole lever. Laſtly, the elevating power of the internal intercoſtal muſcles appears plainly by experiment in a dead ſubject, whoſe thorax, being raiſed or inflated, thoſe muſcles ſwell or contract.

259. By the action, therefore, of theſe muſcles, the thorax is elevated, not altogether as one machine, nor would reſpiration be aſſiſted by ſuch a motion; but the ribs turning upon their articulations, though behind they are but little moved, yet the fore-part of their extremities thereby deſcend and form larger angles both with the ſternum and vertebræ; but from thence in the middle of their arches, by aſcending, their lower edges are drawn upward. At the ſame time, the ſternum is thruſt out forward more from the vertebræ and from the ribs. Thus the ribs are both removed farther from the vertebræ, and the right ribs depart from the left; and the diameter on both ſides, betwixt the right and left ribs, betwixt the ſternum and the vertebræ, is increaſed almoſt to two lines: and therefore this enlargement, following in every imaginable ſection of the thorax, will ſufficiently dilate the cavity of the breaſt. This action of the ribs is more particularly complete in women, and in men who have no ſhortneſs of breath.

Theſe

Theſe effects are produced leaſt of all by the firſt ribs, but more by the following ones. In very ſtrong inſpiration, the ribs deſcend both behind and before; and, along with theſe, the ſternum and the ſpaces between the cartilage are leſſened. But this dilatation alone is not ſufficient for healthy breathing: nor is it ſo conſpicuous or evident in men; although, in them, the intercoſtal muſcles, by retaining and elevating the ribs, very much aſſiſt the inſpiration in a tacit manner, while they afford a fixed point to the diaphragm, that the whole force of that muſcle may be ſpent, not ſo much in depreſſing the ribs, as in urging down the abdomen. The greater part, therefore, of the ſpace which the thorax gains in inſpiration, ariſes from the action of the diaphragm.

260. By *the diaphragm* we underſtand a muſcle expanded in a curviſineal plate, by which, in general, the pulmonary bags are ſeparated from the abdomen in ſuch a manner, that the middle and tendinous part of the ſeptum is nearly the higheſt, and ſupports the pericardium: its lateral parts, which ariſe from the ſolid parts of the thorax and loins, are every where lower; but the loweſt of all are thoſe which lie moſt backward. The fleſhy portions of this muſcle ariſe before from the inner or poſterior face of the enſiform cartilage, and from the ſeventh, eighth, ninth, tenth, eleventh, and apex of the twelfth, rib; after which follows an interval, in which the naked pleura lies contiguous to the peritonæum. From thence the muſcular appendices of the diaphragm, which are much the ſtrongeſt part of it, being collected on each ſide into two, three, or four round muſcular portions, ariſe fleſhy from the tranſverſe proceſs on each ſide of the firſt vertebra of the loins, and from the ſide of the body of the ſecond; tendinous from the middle of the body of the ſecond, third, and fourth, and with cartilages placed between them, always higher up in the left ſide, but lower down in the right.

261. All theſe fibres (260.), becoming tendinous, form

form the centre of the diaphragm, which resembles, in figure, an obtuse index of a sun-dial, having the middle of the larger angle supporting the pericardium, while the lateral angles or wings descend backward, the left being narrower than the right. This centre of the diaphragm is more moveable and at liberty than the rest; except in the middle of its tendinous part, near the fleshy margin, where the incumbent heart makes a resistance; but the lateral parts and the fleshy portions belonging to them are the most moveable. The fibres of this tendon form a most beautiful web, principally indeed on the upper part; which stretches from the fleshy part of each muscle to the fleshy part of the opposite one: thence remarkable inferior fasciculi are sent off transversely to the right and left, and also backwards, which last portion is the uppermost.

262. There are two holes in the diaphragm; of which that on the right side of its tendinous part is somewhat square, and circumscribed by four strong tendinous portions; the left, which is elliptical, lies betwixt the right and left fleshy portions, which arise from the middle of the bodies of the vertebræ of the loins: under this opening they decussate and cross each other once or twice, but above they end in the tendon. This left opening is therefore drawn close together in the contraction of the diaphragm, while it is probable that the other opening remains immoveable. The tendons are but little changed in the motion of the muscles.

263. The structure of the parts, and the dissection of living animals, demonstrate, that the fleshy portions of the diaphragm, which on all sides ascend from the firm parts to the middle and more moveable portion of it, do, by their contraction, depress the same, and by that means draw downward the lateral bags of the thorax, which contain the lungs (77.); and, by this means, the perpendicular diameter of the thorax is considerably increased. The fleshy parts are more depressed; the tendon less, both because it is fixed to the pericardi-

um, and becauſe its own ſubſtance does not contract. Even the œſophagus and vena cava are contracted, while the diaphragm exerts its action. So that the diaphragm almoſt alone performs the office of reſpiration in a healthy man who is at reſt; as alſo in that thorax whoſe ribs are fractured, or the ſternum burſt, or where the perſon will not make uſe of his ribs by reaſon of pain. The force of the diaphragm alſo, in dilating the breaſt, is greater, according to the calculations that have been made, than all the reſt of the powers which contribute to reſpiration. A ſtrong inſpiration is confined to this place; becauſe, during the height of the exertions of the diaphragm, the lowermoſt ribs are brought inwards, and thus far the thorax is ſtraitened. Leſt this ſhould always happen, the intercoſtal muſcles interfere in ordinary inſpirations; in very great ones, they are inferior to the diaphragm. The phrenic nerve, which is more eaſily irritated than in moſt other muſcles, forces the diaphragm to perform its office. The lungs themſelves are altogether paſſive or obedient to the action of the air, ribs, and diaphragm; to which they are preſſed into cloſe contact on all ſides, as thro' a large wound; and when the thorax is denudated by the knife, leaving its capacity entire, the lungs appear filling out the pellucid pleura and diaphragm.

264. But in larger inſpirations, which receive a greater quantity of blood driven into the lungs, and when there is any obſtacle or difficulty oppoſed to the action of the lungs themſelves; in thoſe caſes, ſeveral other powers conſpire to elevate the thorax: which powers are inſerted either into the thorax, clavicles, or ſcapulæ; ſuch as the ſcaleni muſcles, trapezii, cervicales deſcendentes, ſerrati ſuperiores, and pectorales; together with the ſmall elevators, of which a more ample deſcription may be had from profeſſed ſyſtems of anatomy.

265. We have hitherto ſurveyed the powers which are able to increaſe the capacity of the thorax in all its three dimenſions (263 and 259.) By theſe the cavity of the breaſt is dilated, ſo that it compreſſes the lungs

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leſs than before: the lungs then ſtrive to diffuſe themſelves over that ſpace, ſeeing they are never deſtitute of air, which expands itſelf by its elaſticity as ſoon as the preſſure is taken off. Without that muſcular force, the lungs have no proper power of their own by which they are capable of attracting air: and, even when they are moſt full of air, by having the aſpera arteria cloſed, the animal vehemently attempts to inſpire, by the efforts of its intercoſtal muſcles and diaphragm. It therefore remains, that the air (247.), which is a heavy fluid, and preſſed on all ſides by the incumbent columns of the atmoſphere, muſt now enter the thorax by that greater force which it has over the little rarefied air already in the lungs; or yet more powerfully, if they contain no air at all: but none if the air admitted through a wound in the breaſt preſſes upon the ſurface of the lungs. In this action, therefore, which is called inſpiration, the bronchia are every way increaſed, both in length and diameter; becauſe all the diameters of the thorax are increaſed: but, in this act, the inflated lungs always follow cloſely contiguous to the pleura, without leaving any intermediate ſpace. At the ſame time, the pulmonary blood-veſſels, which are wrapped up, together with the bronchia, in a covering of the cellular ſubſtance, are likewiſe with them extended in length, and ſpread out from ſmaller into larger angles; by which means, the circulation is rendered eaſier through them. While this is performing, the veſicular ſubſtance, or fleſh of the lungs themſelves, filled out with air, increaſes thoſe ſpaces through which the capillary blood-veſſels of the lungs make their progreſs; whereby the veſicular preſſure, upon each other, and upon thoſe veſſels adjacent, is leſſened: thus, therefore, the blood will flow with greater eaſe and celerity into and through the larger and ſmaller veſſels of the lungs. Hence, a dying animal is revived by inflating its lungs, and facilitating the paſſage of the blood to the left ventricle of the heart; and thus people ſeemingly dead by being kept a long time under water, are again recovered. But as for the preſſure of the air upon the blood in the lungs in this action, it is ſo inconſiderable as not to deſerve our notice, as being 300 times leſs than the force of the heart; nor can it ever urge the air into the blood, as it eaſily may be forced by art with a ſyringe.

266. It is by ſome queſtioned, whether there be not air betwixt the lungs and the thorax? and whether this air, being rarefied in inſpiration, is not afterwards condenſed, ſo as to compreſs the lungs, and cauſe exſpiration? And they again aſk, whether this opinion be not confirmed by the inſtances of birds, in which we find this matter to be truly ſo? But we ſee every thing concurs to confute this opinion: for, immediately behind the pleura, in living quadrupeds, as well as in dead human bodies, the lungs are contiguouſly viſible to the naked eye, without any intermediate ſpace betwixt them; but the pleura being perforated, the lungs are immediately, by the contiguous air that enters, preſſed together towards the vertebræ. In birds, indeed, the lungs, being pervious to the air, admit it into the cavity of the thorax through large holes in their ſubſtance. But in theſe there is a manifeſt ſpace betwixt the lungs and the pleura. Large wounds, admitting the air only into one cavity of the thorax, diminiſh the reſpiration; but ſuch wounds, as let the air into both cavities, quite ſuffocate or ſuppreſs the reſpiration. The thorax being opened under water, ſends out no bubbles of air through the ſaid water; but in birds it does, becauſe they have air in their thorax. The imaginable ſpace betwixt the lungs and the thorax is always filled up by a watery or ſerous vapour, or elſe by the ſame vapour condenſed into a watery lymph. If the lungs adhere, they injure the reſpiration but in a ſmall degree; which ought entirely to ceaſe, if it required an intermediate air betwixt the lungs and thorax. Finally, the external air, being admitted to any of the internal membranes of the human body, deſtroys their texture, if they are not defended by a plentiful mucus; of which we can find none upon the ſurface of the pleura.

267. But

267. But respiration, whether by the admixture of a subputrid vapour, or by some other method, certainly vitiates the air, and renders it unfit either for inflating the lungs or supporting flame; and lastly, it deprives that element of its elasticity. It is probable that this happens from putrefaction, seeing the air is rendered pestilential by a crowd, and fevers of the most malignant kind are thus generated in a few hours. Seeing this is the case, we are certain that the air is vitiated in the lungs; loses its elasticity; and thus cannot keep the lungs distended, so as to transmit an increased quantity of blood through the dilated pulmonary arteries into the veins. Nor can the will dilate the breast beyond certain bounds, or assist that passage of the blood in an unlimited manner. A state of body therefore will take place, in which the blood cannot pass through the lungs.

268. Thus a new resistance to the blood continually coming from the heart is generated: and in long retentions of the breath, as in making violent efforts, the venous blood, especially of the head, stagnates before the right ventricle of the heart when shut, because it cannot evacuate itself into the lungs; and thus swells up the face with redness, sometimes bursts the veins of the brain, neck, intestines, kidneys, and lastly of the lungs, and right auricle of the heart. This is the cause of prodigious anxiety of mind; this also is the cause of death in compressed air, in drowned people, and such as are strangled, which is much more sudden than is commonly imagined. A living person therefore, that he may remove those inconveniences which flow from an obstruction of the passage of the blood, slackens the powers of inspiration, and excites those of expiration, which free the breast from an air too greatly rarefied.

269. These powers are, first, the elasticity of the ribs, which being drawn upwards out of their natural situation, as soon as the powers which elevated them cease to act, spontaneously place themselves so as to

make

make more acute angles with the ſternum and vertebræ. To this end conduces likewiſe the elaſtic force of the bronchia and veſicles diſtended with air, which ſtrive to contract themſelves. Hence exſpiration is performed more eaſily and quickly than inſpiration; and hence it is the laſt action of dying people.

270. To this alſo contribute the oblique muſcles of the abdomen, together with the ſtraight and tranſverſe ones. The former of theſe are, in one part of them, faſtened to the lower ribs; and, in another part, they are attached to the os pubis and ilium, as a fixed point with reſpect to the breaſt. Therefore the ſtraight muſcles, being contracted, depreſs the arch or convexity into which the abdominal viſcera are thruſt by the diaphragm, and bring the ſame nearer to a ſtraight line: at the ſame time, the abdominal viſcera are preſſed by thoſe muſcles upward and backward againſt the diaphragm, which alone is able to give way; and yield up into the thorax, which at that time is rendered ſhorter. The oblique muſcles, for the ſame reaſons, compreſs the lateral parts of the abdomen, and urge the liver and ſtomach backwards, and preſs them towards that place where there is the leaſt reſiſtance. Laſtly, they draw down the ribs, which were before elevated by the intercoſtals. The tranſverſe muſcles, indeed, do not draw down the ribs; but they pull the cartilages of the falſe ribs a little inward, and render the whole capacity of the abdomen leſs, while at the ſame time they preſs the viſcera againſt the diaphragm. Along with theſe we may reckon the powers of the ſternocoſtal and long intercoſtal muſcles, which are called *depreſſors*. By this joint force the ſuperior ribs deſcend; but the middle ones more, the uppermoſt leſs, the loweſt moſt of all; and the ſame are brought inwards by their margin: the cartilages aſcend, and return into acute angles with the ſternum; and the ſternum itſelf returns backwards with the ribs. By theſe means the thorax, contrary to its former ſtate (259.), is every where rendered narrower and ſhorter,

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ſo as to expel as much air out of the lungs as is ſufficient to relieve the uneaſineſs cauſed by its retention (268.)

271. In more powerful reſpirations, when the inſpirations are made greater, the exſpirations are likewiſe increaſed by the aſſiſtance of ſome other powers, as of the ſacrolumbalis, longiſſimus and quadratus muſcles of the back and loins. This force, by which the air is blown out of the lungs through a tube, is ſufficient to carry a leaden bullet, weighing above a dram, to the diſtance of 363 feet; which force is equal to a third part of the preſſure of the atmoſphere. But, in a healthy perſon, the muſcles of the abdomen alone ſuffice to an eaſy exſpiration, in which the lungs are not ſo much emptied of air as they are by a violent efflation.

272. The effects of exſpiration are a compreſſure of the blood-veſſels in the lungs, a reduction of the bronchia into more acute angles, a preſſure of the reticular ſmall veſſels by the weight and contact of the adjacent larger veſſels, an expulſion of the corrupted blood from the lungs; by which means part of the blood, heſitating in the capillary arteries, is urged forward through the veins to the left ſide of the heart, while at the ſame time that part of the blood is reſiſted which flows in by the artery from the right ventricle. Exſpiration, therefore, will ſtop the eaſy paſſage of the blood through the lungs; and, when the whole thorax is compreſſed together, repels the venous blood into the veins of the head, and fills the brain and its ſinuſes.

273. In this manner a freſh neceſſity follows for repeating the reſpiration; becauſe the collapſed veſſels of the lungs reſiſt the blood repeatedly expelled from the right ventricle of the heart. And this makes another cauſe of death, in thoſe animals which expire in veſſels exhauſted of air: for, in ſuch, the lungs having the air drawn out from them, appear denſe, ſolid, and heavier than water, whence they are rendered impervious to the

the blood. Of the ſame kind is the death of thoſe who are killed by lightning, and perhaps by the noxious vapours of caverns. Thus, therefore, by the power of a moſt wiſe fabricature, the organs of exſpiration are relaxed ſo ſoon as that uneaſineſs is perceived which ariſes from the hindrance of the blood's courſe thro' the lungs; and thereupon the powers of inſpiration are excited into action, whereby the courſe of the blood through the lungs is rendered free and quicker.

274. It is by ſome queſtioned, whether or no there are not other cauſes of alternate reſpiration? whether or no we may hope for any diſcovery in this matter, by compreſſing the vena ſine pari, the phrenic nerve, or intercepting the blood ſent to the brain? But thoſe are repugnant to comparative anatomy; by which we always find the ſame alternation in the breathing of the animal, independent of any ſuch nerve or vein. Whether or no reſpiration is from the alternate contraction of the antagoniſt muſcles, among which thoſe of exſpiration relax the others of inſpiration, and the reverſe? But in this manner, all the muſcles of the human body are perpetually in an alternate motion.

275. From what has been hitherto ſaid, it appears, that reſpiration is unavoidably and abſolutely neceſſary to life in a healthy adult perſon; becauſe, whether the lungs remain long in a ſtate either of exſpiration or inſpiration (273. 278.), we ſee death will be the conſequence. Therefore no animal, that has lungs like ourſelves, after it has once breathed, and received the air into the inmoſt parts of the lungs, and by that means brought a new and large quantity of blood to that viſcus, can ſubſiſt longer than a few minutes without the uſe and benefit of a free air; but it will either periſh, or at leaſt fall into ſuch a ſtate as differs from death only in its being recoverable again by certain powers or actions. In an animal lately born, this neceſſity for air does not take place ſo ſuddenly.

276. But the uſe of reſpiration is different from this neceſſity; which nature might have avoided, either by uſing

uſing no lungs at all, or elſe by diſpoſing them in a manner reſembling thoſe of the fetus. This uſe, therefore, of reſpiration muſt be very conſiderable, ſince all animals are either made with lungs, or with gills as in fiſh, or elſe with a windpipe diſperſed through all parts of the body.

277. In order to diſcover this uſefulneſs of reſpiration, let us compare the blood of an adult perſon to that of a fetus, and alſo with the ſame vital fluid in fiſh. It appears then in a fetus, that the blood is deſtitute of its florid redneſs and ſolid denſity; and in the blood of fiſh, we obſerve, there is neither heat nor denſity, and but little craſſamentum contained in it; and, therefore, all theſe properties, we are, by the nature of things, perſuaded, the blood acquires in the lungs.

278. It may be aſked therefore, Whether the blood does not acquire its heat principally in the lungs? But does not this ariſe from the alternate extenſion and contraction, relaxation and compreſſion, of the pulmonary veſſels (265. and 272.), by which the ſolid parts of the blood are perpetually rubbed together, and cloſely compreſſed and ground together? The lungs therefore will add to the office of the reſt of the arteries, becauſe in them the blood is alternately relaxed and compreſſed more than in any other part of the body. But even when the lungs are obſtructed, ulcerated, and almoſt deſtroyed, a morbid heat ſeizes upon the body: but in the lungs the cold air very nearly touches the blood.

279. The denſity of the blood is, indeed, again promoted in the lungs, partly by the copious diſcharge of the watery vapour which is there ſeparated, by which the reſt of the maſs becomes ſpecifically heavier. But the ſame effect ſeems to follow here, as in other arteries, namely, from the attrition and preſſure which the blood here ſuffers in being alternately retarded, accelerated, and figured in its courſe through the modulating tubes of the leaſt veſſels, which give a ſphericity and denſity to the particles; hence it becomes denſer, as having more of the weighty globules, and leſs of the

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lighter fluid. And, in this refpect, the pulmonary vein, being fmaller than its correfponding artery, is of no fmall ufe towards increafing the attraction of cohefion betwixt the parts of the globules, fo as to comprefs and bring them clofer to each other. Neverthelefs, cold animals, which have very fmall lungs, have denfe and coagulable blood; as alfo a chicken before it is hatched. The blood alfo has a fhort paffage through the lungs: through the whole body the paffage is longer, and the artery weaker; the heart, by which the blood is driven forward, is alfo weaker.

280. It is, therefore, queried by fome, Whether the air itfelf is not received by the blood in the lungs, fo as to excite neceffary vibrations therein? Whether this does not appear from the refiftance of bodies to the heavy external air; and from the air found in the blood-veffels, in the cellular fubftance, and in certain cavities of the human body; alfo, from the craking obferved by an extenfion of the joints; to which add, the air manifeftly extravafated from the windpipes into the hearts of certain animals, as in the locuft; from air coming out of the blood and humours of animals in Mr Boyle's vacuum; together with a neceffity of a vital ofcillation in the blood itfelf; and, laftly, the increafed rednefs of the pulmonary blood?

281. But that no elaftic air is here received into the blood, is demonftrated from the impoffibility of forcing air into blood, if it retains its elafticity; from the inutility of its reception, if the fpring of it fhould be loft in the blood; from the perfect immutability of the blood by cold; from the minutenefs of the inhaling veffels, with the mucus that perpetually lines the fides of the veficles in the lungs: to which add, the nature of the elaftic air itfelf, which is very unapt to pafs through capillary veffels; with a repulfion of it by water, that hinders it from paffing through paper, linen cloth, or fkins that are wetted by water. Again, the air being driven into the windpipe, never paffes to the heart; or whenever it does, it is forced thither by fome great or unnatural

violence: but the permanent air in the veſſels and humours of the human body, from a ſtate of inelaſticity, may become elaſtic by putrefaction, froſt, or an external vacuum. But ſuch permanent unelaſtic air is incorporated with all liquors; and taken into our bodies with the aliments, and with abſorbed vapours, mixing ſlowly and with ſome difficulty. But there never were any elaſtic bubbles of air obſerved in the blood of a living animal; and ſuch air being inflated into the blood-veſſels of any living animal, kills it certainly and ſpeedily. Nor is there any great certainty of the blood in the pulmonary veins being of a brighter red colour. Laſtly, though air indeed is abſorbed by moſt of our humours, yet that abſorption is performed ſlowly, and takes up the ſpace of ſeveral days after the former air has been exhauſted by the pump. It then likewiſe lays aſide its elaſtic nature; nor is there any reaſon produced why the air ſhould either be more ſpeedily abſorbed by the blood, or why it ſhould retain its elaſticity after it is ſo abſorbed.

282. Whether or not the blood is cooled in the lungs; and whether or no this ſeems to be true from the death of animals in air which is hot to ſuch a degree as equals the heat of the hotteſt breezes in the moſt ſultry dog-days? Whether the pulmonary veins are not, therefore, leſs than the arteries; and whether the deſire of cold in people that are working hard does not ariſe from thence? That the blood is cooled in the lungs, is thus far true, in that it there warms the contiguous air, and therefore loſes ſomething of its own heat. But that this was not the principal deſign of nature here, upon the blood, is evident; ſince no one will ſay, that the venous blood is hotter than the arterial, although ſome pronounce the former to be ſomewhat cooler; but nobody ever obſerved the left ventricle of the heart cooler than the right. Since, therefore, the venous blood enters the lungs; if it be there cold, it will follow, that the arteries muſt receive it ſtill colder. But then here the de-

grees of heat, which the blood communicated to the air, are again recovered by it. And, indeed, a perſon may live in an air much hotter than the blood itſelf, of which we have a familiar example in baths, and the warm countries. The pulmonary artery in a fetus, which does not reſpire, is greater; and the larger area of the right auricle and ventricle of the heart is likewiſe much greater in a fetus; which ſeems neceſſary to reſerve and retard the blood, as the pulmonary vein, being narrower, accelerates it.

283. Whether or not is the redneſs of the blood from the air? This is contradicted by what we ſee in cold animals, which, though they are almoſt entirely deprived of the uſe of air, have blood equally red with that of warm animals; from the certain connection of redneſs in the blood of frogs with their having plenty of food, and a paleneſs of it with a want of food; and from the air, as we have juſt now ſaid, being denied acceſs to the blood. Nevertheleſs, redneſs is produced when the air has acceſs to the blood, by which means it is alſo reſtored after it has been loſt; and, on the other hand, it is deſtroyed by the denial of the acceſs of air. Whether or not may not a more ſubtle element from the air penetrate the blood, and be the cauſe of its colour, as light is required for the colours of plants?

285. Whether the uſe of the lungs is to abſorb a nitre from the air to the blood? or whether the florid colour, obſervable in the ſurface of a cake of blood, be owing to the ſame cauſe, while the bottom part looks of a dark and blackiſh colour? and whether or not this is a preſervative againſt the putrefaction of the animal? remain as queſtions with ſome. That there is a kind of volatile acid in the air is certain, ſince that meeting with a ſuitable earth forms nitre; for a nitrous earth, being exhauſted of its ſalt, and expoſed again to the air, becomes re-impregnated with more nitre. But the ſame univerſal acid, we know by certain experiments, meeting with a different ſort of earth, forms a vitriolic ſalt, or alum, or elſe ſea-ſalt. For the caput mor-

mortuum of ſea-ſalt, which remains after the diſtillation of the ſpirit, recovers ſo much ſtrength from the air, as enables it to yield more ſpirit by diſtillation; even in ſnow there is a cubical ſalt: but marcaſite ſweats out a true vitriol; and colcothar recovers again the acid ſpirit, which was drawn from it; alſo fixed alkali, expoſed to the air, turns into a vitriolated tartar. This, therefore, cannot be the uſe of reſpiration, becauſe thoſe ſalts abound in too ſmall a quantity in the air for ſuch uſes; and air is fitteſt for breathing when pure in high mountains, where thoſe ſalts are the leaſt to be found; nor is there any nitrous ſalt as yet known to be found in our blood.

286. If it be aſked, Why tortoiſes, frogs, lizards, ſnails, ear-wigs, and other inſects, live long without air? we anſwer, That in them the lungs are given not ſo much for the preparation of the blood, which they receive but in a very ſmall quantity, as for the uſe of ſwimming in the water: and from hence it is that their lungs are immediately joined with the vena cava and aorta. But inſects, we know, draw the air in, and exhale it again, through points in the ſkin. If it be aſked, why all animals periſh in air that is confined or not renewed, although the animal be ſmall, ſuch as little birds? we anſwer, Becauſe the air, which has once entered the lungs, and been fouled by watery vapours, is rendered leſs elaſtic, and unfit for reſpiration, by alkaline vapours: not becauſe it becomes lighter; for the mercury falls but little in air which has not been renewed, and which has killed an animal. Hence it is that the animal ſurvives longer in air that is more compreſſed than that of the atmoſphere: for in that caſe there is a greater proportion of the elaſtic element, which takes up a longer time to corrupt it. But, even in other caſes, confined air is rendered deſtructive only by ſtagnation, and filling it with vapours. But the reaſon why animals ſwell in an exhauſted veſſel, is, from the extrication and expanſion of the unelaſtic air lodged in the blood and other juices.

287. There

287. There is a certain consent or proportion between the pulse and respiration; so that, according to the common course of nature, there are three or four pulses counted to one respiration. But if more blood is sent to the heart in a given time, the numbers both of the pulse and respiration are increased. This is the reason of the panting or short breathing in a person that exercises his body with any considerable motion; whereby the venous blood is returned faster to the heart (142.) But if the blood meets with a greater resistance in the lungs, so that it cannot pass freely from the right into the left ventricle of the heart; then the respiration is increased, both in the number and magnitude, to forward its course: and this is the cause of sighing, yawning, and wheezing; of which the first is a deep inspiration; the second slow, and very great; and the third, a frequent and imperfect one. The number of respirations, however, does not always increase with the pulse; of which we have an example in those fevers where the lungs are not affected.

288. The mucus, which lines the sensible membranes of the air-vessels in the lungs, may become troublesome both by its quantity and acrimony; it has been even known to cause suffocation in a dropsy of the lungs. Therefore its quantity, adhesion, or acrimony, excites a cough; namely, an irritation of the respirative system, by alternate large inspirations, succeeded by large and quick exspirations, together with sudden shocks of the abdominal muscles; by which the mucus, and sometimes calculous matters, are expelled from the lungs.

289. Laughter differs from coughing in its cause, which resides commonly in the mind, or at least consists in a certain titillation of some of the cutaneous nerves; and, moreover, because it is made up of imperfect quick exspirations through the contracted glottis, lest the air should be totally evacuated from the lungs. Hence laughter, in a moderate degree, conduces to health; because, in the time of one full inspiration,

ſpiration, many ſhort inſpirations and exſpirations happen, and thus the concuſſion is greater. Hence its danger of ſtagnating the blood; becauſe the exſpiration is not full or entire, whereby the blood is admitted into the pulmonary artery without being ſuffered to paſs through it. Weeping begins with a great inſpiration, after which follow ſhort alternate inſpirations and exſpirations; and the ſame is finiſhed with a deep exſpiration, that is immediately joined by a large inſpiration: hence it has nearly the ſame good and bad effects; and, when moderate, it conduces to relieve the anguiſh ariſing from grief. An hickup is a very great, ſonorous, and ſudden inſpiration. Sneezing conſiſts of one large or deep inſpiration, which is followed immediately with a powerful and ſudden exſpiration; and the acrid matter is blown out by it in ſome quantity from the noſtrils.

290. The additional or ſecondary uſes of reſpiration are very many. It exhales, as an emunctory, parts redundant, or even noxious, from the blood, which would ſuffocate if they remained in the air; and the breath of many people ſhut up in a cloſe place, impregnates the air with a ſuffocating quality. On the other hand, it abſorbs from the air a thin vapour, of which the uſe is perhaps not ſufficiently known. It is by this force that the abdomen and all its viſcera are continually compreſſed; by virtue of this, the ſtomach, inteſtines, gall-bladder, receptacle of the chyle, bladder of urine, inteſtinum rectum, and the womb itſelf, diſcharge their contents; by this action the aliments are principally ground or diſſolved, and the blood is urged through the ſluggiſh veſſels of the liver, ſpleen, and meſentery. It excites a kind of flux and reflux in the blood, ſo that it is alternately preſſed back towards the extremities of the veins, and a little after is propelled towards the heart by an accelerated velocity, as into an empty ſpace. Moreover, inſpiration ſerves to convey odours with the air to the organs of ſmelling. By this, the air is mixed with the aliments; which it conduces very much to

break

break and diſſolve towards a perfect digeſtion. But even ſucking, ſo neceſſary to the new-born infant, is made by the uſe of reſpiration, and forming a larger ſpace in the mouth, in which the air is rarefied; ſo that, by the greater preſſure of the outward air, the milk is driven into that part where it is leſs reſiſted. Laſtly, the voice itſelf is owing to the air which we breathe; therefore it may not be inconvenient for us, in this place, to deſcribe it more particularly.

CHAP. XI.

Of the VOICE *and* SPEECH.

291. THE principal organ of the voice is the *larynx;* for, that being injured, the air paſſes through the windpipe without yielding any ſound. By the larynx, we underſtand an aſſemblage of cartilages, joined into a hollow machine, which receives the air from the fauces, and tranſmits it into the windpipe, having its parts connected together by ligaments and muſcular fibres. Among theſe cartilages of the larger kind, thoſe called the *annular* and *ſcutiform* are, in adults, frequently changed into bone. The anterior and larger part of this larynx, which lies almoſt immediately next to the ſkin, is compoſed of two cartilages; one called *thyreoides*, the other *cricoides*; to which laſt, the lateral parts of the larynx are ſo joined, that the portions of the cricoide cartilage are always ſo much larger as they are higher ſeated. The back part of the larynx is firſt made up by the ſaid annular cartilage, after connected by the arytænoide muſcles. The epiglottis is looſely connected above the larynx with the thyreoide cartilage, in ſuch a manner, that it may be able to riſe up and ſhut down. The blood-veſſels of this part are from the upper thyreoids; and the nerves, below, are numerous from the recurrents; as above, alſo, there are nerves coming from the eighth pair variouſly inoſculating;

lating; ſome alſo from the intercoſtal. The former of theſe nerves is remarkably famous for its ariſing in the thorax, and being afterwards inflected round the aorta and right ſubclavian; and for the origin which it gives to ſome of the nerves of the heart, as well as for the experiment by which a ligature upon the recurrent is found to deſtroy the voice.

292. All theſe cartilages are connected together by various muſcles and ligaments, with a certain degree of firmneſs, to the adjacent parts; and yet ſo that the whole is eaſily moveable together, as are alſo its ſeveral parts upon each other. Particularly the *ſcutiform* cartilage, or the thyroidea anterior, is compoſed of two plates, which are almoſt quadrangular, and inclined to each other in an obtuſe angle, which is foremoſt. Upon theſe cartilaginous plates are ſometimes found two apertures, one on each ſide for the blood-veſſels of the larynx; but are not very often to be obſerved. The upper proceſſes of this cartilage, terminating without any protuberance, are inclined upward and backward, to their connection with the horns of the os hyoides, by ſtrong ligaments, ſometimes mixed with bone. The lower parts of theſe cartilages are ſhorter, and adapted almoſt with a flat ſurface to thoſe of the cricoide cartilage; to which they are connected with a very firm articulation, by a ſtrong and ſhort cellular ſubſtance, uniting them on each ſide. The middle parts before, being perforated with ſtrong ligaments, are connected by the inſertion of them to the middle of the annular cartilage; and likewiſe by other ligaments above, deſcending from the horn of the ſcutiform cartilage into the upper part of the annular cartilage.

293. The croicoide cartilage is before thick, and ſtrong: it is increaſed backwards, in form of a ring unequally truncated or cut through; and, in its middle part, is divided into two cavities by a protuberant line. This is firmer than the reſt of the cartilages, and, in a manner, the foundation of them: from this there are longitudinal muſcular fibres and ligaments, which deſcend into

the windpipe (238.) The pharynx likewiſe is connected to the ſurface of theſe cartilages by many muſcular plates, and receives the larynx as it were into its bag. From this a ſhort ligament comes in both ſides to the arytænoide cartilage.

294. The two arytænoide cartilages are of a very complex figure, ſpontaneouſly dividing into two parts. Of theſe the lower is larger; and is connected by a moveable juncture with the protuberant cricoide cartilage, by a baſis moderately hollow; and the ſame ſends forth a proceſs forwards, which ſeparates the glottis, and ſuſtains the inferior part of the ventricle of the larynx. They aſcend upwards, of a triangular figure, with the poſterior angle hollow, the anterior convex, divided by three furrows or ſulci, and extenuated upwards, till they are at laſt finiſhed or terminated by a pretty thick, oval, cartilaginous head fixed on them. The lower part of theſe cartilages is connected by numerous muſcular fibres, partly tranſverſe, and partly oblique; of which the different directions are viſible enough, but the ſeparation of them impracticable. Theſe are called arytænoide muſcles. In the upper part, the arytænoide cartilage departs from its companion or fellow cartilage, leaving a cleft perpendicularly betwixt them, which has been (not very properly) by ſome called the glottis.

295. The arytænoide cartilage is connected with the thyreoideal by tranſverſe ligaments, ſufficiently ſtrong and elaſtic, but covered with the common mucous membrane of the larynx, which ligaments are inſerted into the flat angle of the thyreoid cartilage (292.) Theſe ligaments may be drawn out or ſtretched from each other, by removing the contact of their arytænoide cartilages, and may be again conjoined together by placing the cartilages one to another: and this is the true glottis, which is continuous, but at a right angle with the above-mentioned cleft (294.)

296. From the ſame angle of the thyreoid cartilage, under a notch, from a firm ligament, and an erect ſlender ſtalk, is extended an oval cartilage, in its fore-

part

part convex, behind concave, and raiſed up in ſuch a manner, by its elaſticity, as to project conſiderably behind the tongue; but is ſo flexible or inclinable downward, whenever the root of the tongue is preſſed backward, that, by its tranſverſe poſition, it ſhuts up all paſſage into the larynx, and defends it in ſuch a manner, that whatever is contained betwixt this part, called the *epiglottis*, and the arytænoide cartilages, paſſes over downward into the pharynx. The epiglottis is conjoined to the tongue by pale membranous fibres, and to the os hyoides it is connected by many membranous expanſions. But as for muſcular fibres from the thyreo-arytænoidal and arytænoidal muſcles, it has either none at all, or elſe ſuch as are too minute to have any effect upon its elaſticity.

297. By the ſides of the ligaments of the glottis (295.), there are two other upper and ſofter ligaments, which go out parallel from the arytænoide cartilage to the ſcutiform one, which ligaments are ſomewhat leſs tendinous and leſs elaſtic. Betwixt theſe two ligaments, on each ſide (295.), a peculiar cavity or ventricle deſcends, having the figure of a compreſſed parabolic ſinus extended downward betwixt the double membrane of the larynx, opening conſtantly with an elliptical mouth by the ſide of the glottis in the larynx.

298. Laſtly, all the internal cavity of the larynx is lined with the ſame ſoft, ſenſible, or irritable and mucous membrane, as we before deſcribed in the windpipe (239.) But this membrane is watered by a great number of ſmall glands. The uppermoſt are ſmall ſimple glands, aſſembled together in a heap (208.), ſeated on the anterior and convex part of the epiglottis, upon the hollow ſurface of which they ſend out various openings, large ſinuſes, and productions; and others are, in like manner, continued there in ſmall hard kernels. Moreover, upon the hollow anterior ſurface and back of the arytænoide cartilages (294.), there are ſmall glandules placed on each ſide of a looſe conglo-

merate fabric, compofed of little round kernels, doubtlefs muciferous, having fome of their loofer parts extended on each fide as low as the annular cartilage. In the cavity of the ventricles, there are very many mucous finufes. Laftly, all the internal furface of the larynx is full of large mucous pores. All thefe glandules feparate a thin watery mucus, which yet has a confiderable degree of vifcidity.

299. It may be afked, If the thyreoide glandule has a like ufe, and is of the conglomerate kind, but foft and lobular, with many coverings, confiderably large or broad in its extent, but of a more tender fubftance than the falival glands, feated upon the thyreoide cartilage, and in part upon the cricoide cartilage and windpipe, along their fore-part, fo as to incompafs the lateral horns and fides of the thyreoides, joined to its companion, which is narrower, by an ifthmus, which is emarginated on the lower part, but afcending upwards by a very thin procefs before, in its middle part, as far as the os hyoides? This gland is full of a ferous, yellowifh, and fomewhat vifcid humour: but whether it emits the fame into the windpipe or into the œfophagus, is a queftion; at leaft there are no ducts certainly known to open into either of them. Whether or not the juices are altogether retained in this gland, and afterwards poured into the veins in a manner refembling the fabric of the thymus, or whether it is of the conglobate kind, is uncertain. Yet that the ufe of this gland is very confiderable, may appear from the largenefs of the arteries which it receives from the carotids and lower fubclavians. The veins thereof return their blood into the jugulars and fubclavians. It has a peculiar mufcle, not conftantly to be found, arifing from the edge of the os hyoides, and fometimes from the lower margin to the left of the thyreoide cartilage, which defcends without a fellow, fpreading its tendinous fibres over the gland. Upon which alfo the fternohyoidei and fterno-

ſternothyreodei muſcles are likewiſe ſpread or incumbent.

300. The whole larynx is ſuſpended from the os hyoides by the ligaments proceeding towards the ſuperior horns of the thyreoide cartilage, and perfecting that cartilage from the middle of its baſis to the conjunction of its plates. The ſame, together with the conjoined os hyoides, is capable of being raiſed conſiderably, at leaſt half an inch above its mean altitude. This is performed by the biventer muſcles, together with the geniohyoidei, genioglоſſi, ſtyloglоſſi, ſtylohyoidei, ſtylopharyngei, thyreopalatini, hyothyreoidei; all or ſome of which conſpire together in that action. In this elevation the glottis is preſſed together or made narrower, and the ligaments beforementioned (295.) approach nearer together. But thus, by the aſſiſtance of the action of the arytænoide muſcles, together with the oblique and tranſverſe ones, the glottis may be accurately cloſed, ſo as reſiſt with an incredible force the preſſure of the whole atmoſphere.

301. The ſame larynx may be, in like manner, depreſſed to about half an inch beneath its ordinary ſituation, by the ſternohyoidei, ſternothyreoidei, and coracohyoidei, as they are called; and, when theſe are in action, alſo by the joint force of the anterior and poſterior cricothyreoidei. In this motion the arytænoide cartilages depart from each other, and render the glottis wider, which is alſo drawn open laterally by the muſcles inſerted into the ſides of the arytænoide cartilages, together with the crico-arytænoidei poſtici and laterales, and thyreo-arytænoidei: theſe may alſo compreſs the ventricles of the larynx (297.) on which they are incumbent; the particular cartilages which make up the larynx can ſcarce be moved ſeparately.

302. From the larynx the air comes into the mouth and noſtrils. By the mouth, we mean that large and irregularly ſhaped cavity between the ſoft and hard palate, both concave in the middle, and lower down parted between the muſcles which lie under, and the lower

jaw,

jaw. The noſtrils aſcend forwards above the ſoft palate; they are two broad cavities intercepted between the ſeptum medium, the oſſa cavernoſa, and various other bones. They are every where bony and cartilaginous.

303. The tongue lies in the middle of the mouth; and is a broad piece of fleſh eaſily changeable into any kind of figure, and thus readily moved without delay to every part of the mouth; moſt expeditiouſly directed into every ſituation, and made to aſſume any ſhape, by its own fleſhy fibres, and by the muſcles attached either to itſelf or to the os hyoides which is joined to it by many fleſhy fibres and membranes. In the fore-part theſe come from the genioglоſſi and geniohyoidei muſcles; backwards from the ſtylogloſſi, ſtylohyoidei, ceratogloſſi, baſiogloſſi, chondrogloſſi, and biventer; downwards, from the ſternohyoidei and ceratohyoidei; upwards, from the ſtylogloſſi, ſtylohyoidei, from the biventers, and likewiſe from the mylohyoidei.

304. Hitherto we have given the anatomy. It remains, therefore, that we demonſtrate what action the air produces when it is driven by the foreſaid powers (269, 270.) from the lungs in exſpiration through the windpipe into the larynx, and from them urged out through the glottis into the mouth variouſly configured. The conſequences or effects of this are, voice, ſpeech, and ſinging. The voice, indeed, is only formed, when the air is expelled with ſo great a velocity through the contracted glottis, that it ſplits or makes a colliſion upon the glottid ligaments, ſo as to put the larynx into a tremor, which tremor is returned and continued or increaſed by the elaſticity of theſe parts. Sound, therefore, ariſes from the conjunct trembling of the ligaments (295.) together with the cartilages of the larynx at one and the ſame time, which we then call the voice, and is of a peculiar kind or modulation in every ſingle claſs of animals, depending entirely upon the difference of the larynx and glottis. But when a trembling is not excited, the exſpired air cauſes a whiſper.

305. The

305. The ſtrength of the voice is proportionable to the quantity of air blown out, together with the narrowneſs of the glottis; and, therefore, a large pair of lungs eaſily dilatable, with an ample cartilaginous and elaſtic larynx and windpipe, and the free echo of the noſtrils, joined with a powerful exſpiration, all conduce to this effect. But acute and grave tones of the voice, we obſerve to ariſe from various cauſes. The former proceeds from a tenſion and narrowneſs of the glottis, and the latter from a relaxation and expanſion of it. For thus, in the former, a greater number of air-waves are ſplit in the ſame time upon the ligaments of the glottis, whence the tremors excited at the ſame time are more numerous; but when the glottis is dilated, the contrary of all this follows. And from the greater tenſion of the ligaments, the tremors in like manner become more numerous from the ſame ſtroke. Therefore, to produce an acute and ſhrill voice, the whole larynx is drawn upwards and forwards; and ſo much the more as the voice is required to be ſharper, inſomuch that the head itſelf is inclined backwards, by which the powers of the muſcles elevating the larynx are rendered more full and effectual. The truth of this is confirmed by experience, by applying the fingers to the larynx when it forms an acute ſound; for then, to raiſe the voice an octave, you will eaſily perceive it to aſcend near half an inch. Alſo the ſame is evident from comparative anatomy, which demonſtrates the narroweſt glottis and the cloſeſt approximation of cartilages in ſinging birds, but an ample or broad glottis in hoarſe animals and ſuch as bellow or bleat. An inſtance of this we have in whiſtling, where the voice manifeſtly becomes more acute by a contraction or narrowneſs at the mouth: alſo in muſical inſtruments, in which a narrowneſs of the mouth or opening that expels the air, with a celerity of the wind blown out, are the cauſes of an acute or ſhrill tone.

306. Gravity of the voice, on the contrary, follows from a depreſſion of the larynx by the cauſes (301.) already

ready described; to which add a broad glottis and a very ample larynx. This is evident to the touch of the finger applied to the larynx when a person sings, by which the descent of it is manifestly perceived to be about an inch for every octave: hence the voice of males is more grave; and hence the lowest degrees of the voice degenerate into a muteness or whispering.

307. Is the whole difference of tone owing to the length of the ligaments of the glottis, which is augmented when the scutiform cartilage is drawn forward, and the arytænoide ones backward? Is it according to this rule, that the most acute tones are produced, which arise from the ligaments being exceedingly stretched, and thus vibrating with great celerity? This has been confirmed by repeated experiments made by eminent men; and some late anatomists have observed, that, when the chords or ligaments of the glottis are tense, the peculiar voice of every kind of animal is produced by blowing air into its larynx: that this voice was more acute as the ligaments were more tense, and more grave as they were slackened: that by shutting the whole ligament, the voice was suppressed; by shutting the half, the voice was rendered an octave higher; by shutting a third part, a fifth higher, &c. There are not wanting, however, doubts concerning this new theory, arising from the cartilaginous and bony structure of the glottis of birds, which of consequence must be immoveable, and not extensible; from the voice most certainly becoming more acute, in whistling, from the mere contraction of the lips; from the example of women, in which the larynx is softer, but the voice more acute, than in men; from experiments which show, that more acute sounds are produced by bringing the ligaments of the glottis nearer into contact with each other; from the perfect want of machines, by which the ligaments can be stretched, and which may bring the scutiform cartilage forward from the annular one. But seeing it appears from experiments, that a tension of the ligaments suffices for producing acute sounds, without the con-

contraction of the glottis, we may believe that the different tension of the glottis contributes more to the diversity of voice than the different diameter of it.

308. *Singing* is when the voice, modulated through various degrees of acuteness and gravity, is expelled through the larynx, while it is trembling and suspended betwixt two contrary powers; and herein lies the principal difference betwixt the chanting of simple notes, and the expression of words. Hence it appears to be a laborious action, by reason of the continual contractions of the muscles, which keep the larynx at an equilibrium: and hence it is, that singing makes a person hot; because in acute tones the narrower glottis much retards the exspiration, while at the same time a great deal of air is required to give strength to the voice (305.); towards which, again, deep inspirations are necessary. Hence likewise the windpipe is rendered very dry, from the quicker passage or current of air: to prevent which, a great deal of mucus is required; and therefore it is that there are such numbers of mucous receptacles in the larynx, amongst which I am firmly of opinion the ventricles before described (297.) ought to be numbered.

309. *Speech* is performed by the larynx at rest, or held in the same place, in tones of voice differing but little in acuteness and gravity: but then the voice is variously changed or modulated by the organs of the mouth. Canorous speech has a variation in the tone or cadence of the voice, together with a modulation of it by the organs of the mouth at the same time.

310. All speech is reducible to the pronunciation of letters, which differ in various nations; but most of them are alike all the world over. Of these, some are called *vowels*, which are made only by an expression of the voice through the mouth, without any application of the tongue to certain parts of the mouth. But consonants are formed by a collision of the tongue against certain parts of the mouth, lips, and teeth. But to be more particular in these matters is beside our purpose,

which will not permit us to expatiate upon the beautiful art of pronunciation. That art, as an extraordinary inſtance of mechanical knowledge, has ſo accurately determined all the corporeal cauſes concurring to each letter, that, by inſpection only, with the aſſiſtance of touch, letters pronounced are underſtood without hearing them, and the attentive perſon is thereby taught to imitate the ſame ſpeech by a like uſe of the organs.

CHAP. XI.

Of the BRAIN *and* NERVES.

311. THE remaining actions of the human body we ſhall conſider according to the order by which they receive the blood. The coronary arteries we ſpoke of before, when we gave the hiſtory of the heart. Next to thoſe, the carotids paſs out from the aorta.

312. The aorta, which comes out from the anterior part of the heart (157.), in order to bend itſelf towards the vertebræ of the thorax, forms there a conſiderable arch, by which it is bent backward, and towards the left, in an angle that is round, but not very large. From the convexity of this arch, three conſiderable branches ariſe. The firſt aſcends towards the right ſide, and is immediately ſubdivided into two large arteries, of which the lowermoſt goes on in the direction of its trunk, under the denomination of the *ſubclavian*. The other aſcends according to the courſe of the windpipe to the head, and is called the *right carotid*. The *left* carotid ſprings next from the ſame arch, a little inclined to the left ſide; and the third, which is ſtill more inclined to that ſide, is called the *left ſubclavian*, which is ſomething leſs than the right. About the origination of theſe arteries, the next continuous margin of the aorta is a little thicker and more protuberant. But variations from this courſe are rarely obſerved.

313. The

313. The carotid artery, furrounded with a great deal of denfe cellulofity, together with the jugular vein and nerve of the eighth pair, commonly afcends as high as the upper part of the thyreoide cartilage, without fending off any branches. There it divides into two trunks. The anterior, called the *external* carotid, which is rather larger and more in the direction of its trunk, fends off a branch called the fuperior *thyreoidea*, alfo the inflected arteria *lingualis*, and then the *labialis;* and from the pofterior face of the carotid, the next artery which arifes is the pharyngea afcendens, which, befides the pharynx and mufcles of the moveable palate, fends likewife a confiderable branch in common with the nerve of the eighth pair through the foramen of the jugular vein to the dura mater, very near to the great foramen of the occiput, at the bafis of the os petrofum, and which is divided at the cuneiform procefs of the multiform bone.

314. Again, from the edge of the external carotid, fprings the *occipital* artery; which fends branches not only to the mufcles which give it a name, but likewife fends a branch through a peculiar foramen of the dura mater in the angle which the os petrofum forms by departing from the mamillary procefs, which artery is fpread through the feat of the cerebellum; another branch paffes over the atlas to the dura mater under or into the fkull; and a third fometimes goes through the foffa jugularis to the dura mater. The next artery, which is the *auricularis*, goes to the back part of the ear, to the temple, and to the membrane of the tympanum.

315. What remains of the external carotid artery, afcends through the parotid gland, to which having given fome branches, as well as to the face and eye-lids, it fends out the *temporalis*, which is confiderable. The trunk of the carotid, being inclined, conceals itfelf behind the lower jaw, under the denomination of *maxillaris interna*.

316. In that place, it directly fends off a large trunk, which paffes to the dura mater through a peculiar open-

ing of the broad and pterygoide wings, feated at the middle foffa of the brain; from whence they are largely fpread through the temples and forehead within the dura mater, as far as the falciform finus. Sometimes this artery is double, and often gives out a branch that is confpicuous to the lachrymal gland of the eye. In the fame place, likewife, the maxillary artery enters the upper part of the nares, by a threefold trunk, where it is fpent, after having given off the branches called *maxillares inferior* and *fuperior* to the teeth, with the infra orbitalis to part of the face and eye-lids, and the palatina to the bone of the palate, with fmall branches to the dura mater, and others through the fmaller pores of the great wings, with fuch as accompany the third and fecond branch of the fifth pair of nerves; and laftly, together with the dura mater, filling up the lower orbital fiffure.

316. But the other pofterior trunk, commonly called the *internal carotid* (313.), afcends without a branch. This artery, having firft made a confiderable ferpentine flexure, enters through a peculiar foramen in the os petrofum, where it is furrounded with a capfule from the dura mater, like that which comes out through all the openings of the fkull: from thence it afcends upwards and inclined forwards, till, having penetrated into the cavity of the fkull, it rifes up inflected and in a curvature, according to the direction of the fella equina, in the middle of which there is a cavernous or hollow finus retarding the blood: from thence, having given fmall branches to the fifth pair of nerves, it fends others to the infundibulum and dura mater, with one larger to the eye; part whereof returns again through a peculiar hole into the dura mater, which lies upon the middle of the orbit. This is the rete mirabile of beafts, but not of man.

317. But the trunk of this internal carotid paffes over the anterior part of the fella equina; and being incurvated backward, and received by the arachnoide membrane, giving branches to the pons and crura of the brain,

brain, with a circle to the choroide plexus, and one that accompanies the optic nerve, it then divides into an anterior and poſterior branch. The former, being conjoined with its fellow artery of the other ſide by a ſhort inoſculating branch, which ſometimes ſprings from the trunk itſelf, is then incurvated backward and upward, according to the direction of the os calloſum, and ſpreads itſelf about the middle and hinder part of the brain; where it ſometimes ſends branches to the falciform proceſs, and from the very origin of the third ventricle to the fornix and thalami. The latter, being conjoined by a ſmall inoſculating branch with the vertebral artery, unleſs that ariſes from the undivided trunk of the carotid artery, afterwards aſcends a long way upon the ſide of the brain through the Sylvian foſſa; and the ſame ſends branches to the choroide plexus. All the branches of the carotid, contained within the ſkull, are made up of more thin, ſolid, and brittle membranes, than the other arteries of the body.

318. But the *vertebral artery*, commonly ariſing from the ſubclavian of the ſame ſide, (though the left has been ſometimes ſeen to ſpring from the trunk of the aorta,) paſſes on without giving branches, through a place of ſecurity, till it enters a foramen in the tranſverſe proceſs of the ſixth vertebra of the neck; after which, it continues with alternate flexures to aſcend through the oblique proceſſes of the other vertebræ of the neck; from whence, at each interval, it ſends off ſmaller branches to the muſcles of the neck, and communicates with the lower thyreoideal: other branches, again, ſomewhat larger, go from it backward, together with each of the nerves, to the pia mater of the ſpinal medulla; but before, the branches are larger, though leſs numerous, to the ſame ſpinal medulla, and communicate by an anaſtomoſis with its ſpinal artery anteriorly. Laſtly, growing leſs about the ſecond vertebra, and being inflected with a large curvature round the tranſverſe proceſs of the firſt vertebra, it there ſends off conſiderable branches to two of the muſcles of the neck;

alfo fmall branches it fends off in its courfe through the great foramen of the occiput or fkull to the dura mater, and the adjacent cavities that contain the cerebellum; after which, it goes on through the faid foramen into the cavity of the fkull. There afcending, according to the courfe of the medulla oblongata, the right trunk by degrees approaches nearer to the left, and is conjoined together with it (in an extraordinary manner, hardly to be found in other parts) into an artery called the *bafiliaris*, which is fufpended in the pia mater all along under the pons Varolii. From the vertebral arteries, before they are conjoined together, or from the trunk produced after the common manner, pafs out branches, which go to the lower furface of the cerebellum, and are deeply inferted under the fourth ventricle to the inner fubftance of the cerebellum. Thefe fend off the fpinal arteries. But there are fome inftances where they arife conjunctly from a fingle trunk; or from the trunk in one fide, and a branch in the other. Then the bafiliaris, befides branches to the medulla oblongata and crura of the brain, gives the other lower arteries of the cerebellum. Amongft the forefaid branches alfo arifes an artery, which accompanies the auditory nerve. Finally, the bafiliaris, at the forepart of the pons, divides into two branches. One of thefe goes to the upper part of the cerebellum, to the fourth ventricle, to the crura of the medulla of the cerebellum, the nates, teftes, and pineal gland: in place of this, alfo, there are two trunks. The other is divided to the loweft part of the brain at its pofterior lobe, the choroide plexus, the plexus incumbent on the pineal gland, that gland itfelf, the thalami, corpora ftriata, fornix, and whole anterior ventricle of the brain.

319. From the foregoing hiftory of the arteries belonging to the brain, it appears, that a very great quantity of blood is in every pulfation fent to this organ, infomuch that it makes above a fixth part of the whole blood that goes throughout the body, and derived from trunks that are very near the heart, fpringing from the con-

convexity of the aorta. From hence it is probable, that the ſtrongeſt parts of the blood go to the head, and ſuch as are moſt retentive of motion. Is not this evident from the effects of mercurials exerting themſelves almoſt in the head only; from the ſudden force and action of inebriating ſpirits upon the head; from the ſhort ſtupor which camphor excites; from the heat, redneſs, and ſweat, which happen oftener in the face than other parts of the body; to which add, the more eaſy eruption of volatile and contagious puſtules in the face? The well guarded paſſage of theſe great and important veſſels, in their aſcent to the head, defends them from any great injury. The frequent inoſculations of one trunk, with the other going to the head, as well as the frequent communications of their branches among themſelves, leſſen any danger that might enſue from obſtruction. Hence, when the carotids are tied, the animal neither dies, nor ſeems to be very uneaſy. The conſiderable flexures of the vertebral and carotid artery ſerve to moderate the impulſe of the blood coming to the brain, ſince a great part of the velocity, which it receives from the heart, is thus ſpent in changing the figure of the inflections. To which add, that ſome authors do not improperly obſerve that the arteries here grow larger or ſomewhat wider.

320. The hiſtory of the brain deſervedly begins from its integuments. Such a tender part, ſo neceſſary to life, we obſerve providently ſurrounded on all ſides, firſt by a ſphere of bones, conſiſting of many diſtinct portions; by which means it is rendered extenſible, at the ſame time that it is effectually guarded againſt external preſſure. To the internal ſurface of this bony ſphere, on all ſides, grows a very ſtrong membrane, compoſed of two plates ſufficiently diſtinct, which are firmly attached by an infinite number of ſmall veſſels, as by ſo many foot-ſtalks, to the whole ſurface of the ſaid bones, ſo as to be nowhere eaſily ſeparable in a healthy perſon; theſe, being very thin and ſmooth, adhere leſs firmly to the bones, but more ſtrongly to the *futures*, ſo called from

from their figure, which join the bones of the ſkull one to another. In younger ſubjects, the adheſion of the dura mater to the ſkull is ſuch, that the ſeparation of it pulls off the fibres of the bones to which it is connected. In adults, many of the veſſels which it inſerts, being effaced, renders it more eaſily ſeparable: yet it is not without ſome force, even in thoſe, that the dura mater can be ſeparated from the ſkull. From the rupture of theſe veſſels, which enter the bones of the ſkull, appear thoſe bloody drops which are obſervable after removing the cranium. Hence appears the vanity of all that has been advanced concerning the motion of the dura mater. As to the motion which is remarked by the writers of obſervations upon wounds in this part; that, being preternatural, was the conſequence of the beating of the arteries, (in a part where the reſiſtance of the bone was now removed, while the reſt of the dura mater next to the ſkull ſuſtained the force of the heart without motion;) or of the brain ſwelling during exſpiration. Alſo that part, which is properly the dura mater, has neither nerves, nor ſenſation or irritability.

321. The *outer plate* of the dura mater, which adheres to the bones of the ſkull, is to them inſtead of a perioſteum, and ſupplied with ſmall nerves and blood-veſſels coming through all the holes of the ſkull; from whence, and from its coheſion with the perioſtia of the head, ſpine, and whole body, it has received the name *mater*. The *internal plate* of the dura mater is, in moſt parts, continuous with the former: but, in ſome ſubjects, it recedes a little from it, as in the great ſphenoidal wings; and at the ſides of the ſella equina, where a good deal of blood is poured betwixt them; and they likewiſe recede thus upon the ſella equina itſelf: the ſame plate, having left the outermoſt, adhering firmly to the bones of the ſkull, deſcends doubled together to form the falx, which ariſes firſt from behind the proceſſes criſtæ-galli of the multiform bone, afterwards from the criſta itſelf, and from the whole junctures of the bones of the forehead and

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the parietals; and laſtly, it ariſes from the middle of the back part of the occipital bone, and, growing broader backwards, is interpoſed betwixt the hemiſpheres of the brain; the more remote part of it forward hangs over the corpus calloſum, and that which is next in the back-part is extenuated to an edge in the ſame place. That there are ſhining fibres in this part, diſperſed towards the longitudinal ſinus from the conjunction of the tentorium, in the ſhape of branches and palm-twigs, is certain; but it does not therefore follow, that they have any muſcular motion; and betwixt theſe fibres frequently there is no membrane, only natural foramina are interpoſed. The falx is both joined to, and continued from, the middle tentorium, which is extended laterally. In the ſame manner, with ſome difference of ſituation, the ſaid falx ſends out a ſhort plate downward, which divides the cerebellum, together with the ſtrong tentoria or lateral productions, which, ariſing from the cruciform protuberance of the occiput, are interpoſed tranſverſely betwixt the brain and cerebellum, extended as far as the limits of the os petroſum, and connected to the anterior clinoide proceſſes, leaving an oval aperture for the medulla oblongata to deſcend freely. Theſe productions of the dura mater ſerve to prevent the parts of the brain from preſſing one another, in all ſituations and poſtures of the body; and they likewiſe hinder one part of the brain from bruiſing the other, by any ſhock or concuſſion. Hence it is, that in the more active quadrupeds, where a concuſſion is more likely to happen, the brain and cerebellum are divided by a bony ar tition.

322. In the external ſurface of the pia mater, not far from the ſinus of the falx, are placed ſmall glandules, ſeated in the reticular texture of the hard membrane, partly looking towards the ſinus, to whoſe cavity they are oppoſed, in ſuch a manner, that ſome of them are contiguous to the hollow of the ſinus; others are ſo placed at the inſertion of the larger veins into the pia mater, that, together with the former, they make up a

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continued range or ſeries; ſome are alſo obſerved in the tentorium of the cerebellum, which are ſometimes ſoft, oval, and white, ſometimes red, hard, and in appearance like wrinkles. But the vapour, which exhales from the ſurface of the pia mater, is not ſeparated by theſe glands: for it is every where exhaled, even into the ventricles, where there are none of thoſe glandules; and it plentifully tranſpires every where from the mouths of the leaſt arteries, as we ſee, by experience, when water or fiſh-glue are injected, which ſweat out through every point in the ſurface of the dura mater.

323. The next covering of the brain, which is more cloſe to it, and preſſes the whole ſurface of the brain, as that does the cavity of the ſkull, has been denominated from its tenuity, *arachnoides*, i. e. like a ſpider's web. This very thin or tender membrane, being pellucid like water, every way ſurrounds the brain, whoſe inequalities it climbs over, and according to its extreme thinneſs is pretty ſtrong, and ſurrounds the larger veſſels in ſuch a manner that the ſaid veſſels ſeem to run betwixt the pia mater and arachnoides; which laſt is, therefore, no part or lamella of the pia mater, from which it differs by ſituation, and is connected to it by a cellular texture after the manner of the ſpinal marrow, although it is reſolved into a cellular nature between the hemiſpheres of the brain.

324. The third or innermoſt covering of the brain, which is ſoft and cellular, is properly the *pia mater*. This immediately inveſts the whole ſurface of the brain and ſpinal marrow on all ſides, is tender, and made up of a vaſt number of ſmall veſſels which are joined together by a cellular texture: but theſe veſſels it ſends into the brain in a regular order, like little roots. This deſcends betwixt every furrow and fiſſure of the brain and cerebellum, and even inſinuates itſelf into the ſpinal medulla, and is the bond by which the little protuberances of the brain are joined together. This, being received into the cavities of the brain, changes its fabric, ſo as to become ſoft and almoſt of a medullary conſiſtence,

ence, more especially when the subject that comes under the examination of the knife has lain dead some considerable time, yet then it is able enough to demonstrate the vessels themselves in its fabric.

325. The *veins* of the brain are not disposed in the same manner with those in other parts of the body. For neither have they any valves, nor do they run together in company with the arteries, nor have their trunks the structure which is commonly observed in the other veins. The veins, therefore, which come out of the innermost cavities of the brain, those which are spread upon the striated bodies, the veins of the choriode plexus, with the lucid septum and the anterior ventricles, are collected together into trunks which at last meet in one great vein, or often two, which, being accompanied with many small arteries of the choroide plexus, descends backward to the partition of the brain and cerebellum. In that place, it receives veins arising from the posterior and lower part of the brain, and some of the cerebellum, from whence the blood passes into a sinus, which is a kind of vein included in a reduplication of the inner plate or membrane of the brain, into which the veins, to shorten their length, are generally inserted; and this sinuous vein generally descends to the greater sinus on the left side, though sometimes it ends bifurcated, one branch on each side. This is called the *fourth sinus*.

326. The upper and superficial veins of the brain are large, and spread in the windings with which the brain on all sides abounds. With those veins, through the whole surface of the brain, are inserted other veins of the dura mater; and others, which enter by peculiar orifices into the falciform sinus. From thence the veins, gradually collected together, pass along, most of them forward, some few of them in a straight direction, and others backwards; of which those forward are the largest, and open themselves, their extremities being obliquely cut off, into the long *falciform sinus* which is formed by the right and left plate of the internal membrane of the

dura mater, which meet together below upon the upper part of the back of the falx. From thence it is of a triangular figure, convex in its upper ſide, beginning with a ſlender origin at the ſeat of the foramen cæcum, that is placed above the criſtagalli; from whence it aſcends and follows in the courſe of the falx, until that joins the tentorium: it is generally inclined to the right ſide, and takes the name of the *right tranſverſe ſinus*, which then goes by a peculiar channel in the occipital and temporal bone, tranſverſely to its incurvation at the opening of the jugular vein; in which place being much enlarged, it receives the lower ſinus petroſus, together with the occipital ones, which are hereby diſcharged into the jugular vein. But the left tranſverſe ſinus reſembles the former; and is, like that, conveyed in a ſimilar courſe to the jugular vein, into which it is rather inſerted on the right ſide, than continued as it were in a trunk. Into it the fourth ſinus (325.), together with the occipital one, uſually inſert themſelves. But there are ſome inſtances, where all theſe are diſpoſed in a different manner, by an inſertion of the longitudinal into the left tranſverſe ſinus; and then the right tranſverſe ſinus receives the fourth and the occipital one. At other times it is equally divided into two tranſverſe trunks; and ſometimes the middle ſinus joins the tranſverſe ones. The two ſinuſes alſo have been found ſimilar and parallel to each other.

327. There is a ſlender and rounder ſinus, which runs along the lower and thicker margin of the falx, ſomewhat of an irregular figure, more reſembling a vein, receiving veins from the falx itſelf, and communicating likewiſe with the upper ſinus; it alſo receives veins from the adjacent hemiſpheres of the brain, and from the corpus calloſum. Where the tentorium joins with the fore-part of the falx, this is commonly there inſerted into the fourth ſinus.

328. The *lower veins* of the brain, which lie next to the baſis of the ſkull, are variouſly inſerted. The foremoſt of them coming from the foſſa ſylviana, col-

lected together into ſome trunks, are inſerted into the cavernous ſinus, or triangular interval, that lies at the ſide of the ſella equina, betwixt the external and internal plate of the dura mater. Other veins, from the pons itſelf, lead into the upper ſinus petroſus. Other poſterior veins, which come from the poſterior lobes of the brain, are inſerted in great numbers into the tranſverſe ſinus that is ſeated within the tentorium.

229. The upper veins of the cerebellum, meeting together in large trunks, partly open themſelves into the fourth ſinus, and in part into the tranſverſe ſinus. The lower veins, from the cerebellum and medulla oblongata, inſert themſelves into the upper ſinus petroſus; the latter alſo into the tranſverſe proceſs very near the place where it goes out.

330. There are many ſinuſes, beſides thoſe beforementioned. The moſt anterior of them, which is commonly *like a circle*, is larger behind than in its fore-part, which is ſlenderer, and ſurrounds the pituitary glandule betwixt the clinoide proceſſes, communicating with the cavernous and with the lower petroſe ſinuſes; likewiſe communicating betwixt thoſe proceſſes and the carotid artery, and again, by the way of the ſixth pair, with the upper petroſe ſinuſes behind the fifth nerve. There are ſome inſtances where this ſinus receives the ophthalmic vein; and ſometimes the tranſverſe, joining to the cavernous ſinus, ſupplies the place of this circular ſinus, or elſe is preſent with it at the ſame time.

331. The *upper petroſe ſinus* is conveyed backwards in a cavity of the os petroſum, and takes its origin from the extremity of the anterior ſulcus of the os petroſum, where it communicates with the cavernous ſinus, and receives the inſertions of the veins of the dura mater, and ſometimes of the anterior veins of the brain itſelf, mentioned before (328.); then it is inſerted into the angle of the tranſverſe ſinus, where it begins to be bent; ſometimes alſo it joins the inferior ſinus of the

peos petroſum. Another vein, likewiſe deſcending by the os petroſum, is in like manner inſerted into the angle of the tranſverſe ſinus. The *lower ſinus petroſus*, which is larger, goes round the root of the bone of this name, and communicates with its fellow behind the clinoide proceſs; alſo twice it communicates with the cavernous ſinus, and with the upper ſinus, and is conjoined under the nerve of the fifth pair, being finally inſerted into the jugular foſſa or cavity. Moreover, it receives ſome veins of the dura mater from the baſis of the vertebræ. To the ſame outlet alſo the *occipital ſinus* leads on each ſide, which being pretty large, goes round the margin of the foramen, till, arriving at the falx of the cerebellum (321.), it is ſooner or later inſerted, together with its fellow, for the moſt part into the fourth ſinus, and with that into the left tranſverſe one, or into the longitudinal ſinus itſelf, or laſtly by a divided extremity into each of the tranſverſe ſinuſes. This ſinus receives the lower and poſterior veins of the dura mater, and ſome others from the vertebræ.

332. The *anterior occipital ſinus* is irregular or multiform, partly tranſverſe, and partly deſcending to the great foramen, being variouſly conjoined with the lower petroſe ſinuſes: from whence it paſſes with the nerves of the ninth pair; and either communicates, through a peculiar foramen, by emiſſaries into the outer vertebral vein; or other branches, paſſing out below, open into the venous circles of the ſpinal medulla. But the *cavernous ſinus* of the dura mater (325.), being ſurrounded with a good deal of cellular ſubſtance, receives, beſides the forementioned ſinus (329, 330.), large veins already deſcribed; alſo the ophthalmic, and principal vein of the dura mater; and tranſmits them with peculiar veins, together with the firſt and ſecond nerve, and third branch of the fifth pair, with a large artery of the dura mater (316.) and the internal carotid (316.): alſo it ſends out other emiſſaries through a foramen, which is not conſtant in the great wing, which form in-

inoſculations with veins placed on the outſide of the ſkull leading to the jugulars, and eſpecially with the largeſt pterygoidal plexus of veins belonging to the noſe. In the ſame manner, the veins of the pericranium paſs through ſmall holes in the parietal bones into the longitudinal ſinus, as the occipital veins paſs thro' the maſtoide hole into the tranſverſe ſinus through the anterior channel of the occipital bone, and the external vertebral veins are inſerted into the jugular ſinus; and others of the anterior occipital veins accompany the nerve of the ninth pair. Thus there are an infinite number of ways open to the blood; by which it may paſs from the ſinuſes, wherein it is often collected in too great quantity, by various directions, according as the part is more lax, or has a greater declivity. Hence no violent ſymptoms follow upon tying either or both of the jugulars or other large veins.

333. The great quantity of blood which goes to the brain, the greater impulſe with which it is ſent into the carotid arteries (319.), and the immunity of this part from every kind of preſſure by a ſtrong bony fence, joined with the ſlower motion of the blood through the abdominal viſcera and lower extremities, alſo the perpetual exerciſe of the brain and ſenſes, do all determine a copious flux of blood to theſe parts, and ſome other cauſes ſerve to fill the head ſurpriſingly with blood. Hence it is that a redneſs of the face, a turgeſcence and ſparkling of the eyes, with a pain and pulſation or throbbing of the arteries in the head, are ſo frequently followed with a bleeding at the noſe, by violent exerciſes or motions of the body. From hence, therefore, it is evident, that, if the veins were of a thin and round ſtructure in the brain, they would be unavoidably in greater danger of breaking, whereby apoplexies (to which, in their preſent ſtate, they are often liable) would be much more frequent. To avoid this, therefore, nature has given a different figure to the veins which carry out the blood from the brain, by which they are more eaſily and largely dilatable, becauſe they make an unequal re-
ſiſtance;

ſiſtance: their texture is likewiſe very firm, and more difficultly broken, eſpecially in the larger ſinuſes, which perform the office of trunks; for as to the ſinuſes of the leſſer ſort, they are either round, half cylindrical, or of an irregular figure. Beſides this, nature has guarded the ſinuſes by croſs-beams, internally made of ſtrong membranes, and detached from the right to the left ſide within the ſinus, which, in greater diſtentions, they draw towards a more acute angle, which is capable of a larger dilatation, ſtrengthening and guarding it from a rupture at the ſame time. She has likewiſe, in theſe veins, provided numberleſs inoſculations, by which they open mutually one into another, and openly communicate with the external veſſels of the head and with thoſe of the ſpinal medulla, by which means they are capable of freeing themſelves more eaſily whenever they are overcharged with blood, (332.)

334. It is by ſome queried, Whether a part of the arterial blood is not poured into the ſinuſes of the brain; and whether they have not a pulſation excited from that blood? That they have no pulſation, is paſt doubt; becauſe the dura mater every way adheres firmly to the ſkull, but much more firmly in thoſe parts which are the ſeats of the ſinuſes. Indeed they receive liquors injected by the arteries; but whether thoſe tranſude through the ſmall exhaling arterial veſſels, or whether they firſt make a complete circle through the veins, as indeed is much more probable, we are not yet furniſhed with experiments enough to determine.

333. Thus all the blood of the brain is finally conveyed into the jugular veins, which are very dilatable, and for that reaſon guarded with valves to prevent a return of the venous blood from the right auricle, being at the ſame time ſurrounded with a good deal of cellular ſubſtance. For as to the blood which goes to the head by the vertebral veins, it is a very inconſiderable quantity; but the ample jugulars anſwer in ſuch a manner to the great upper vena cava in a direct courſe, that they afford the highway for the blood

to

to return back to the heart. The branches of theſe are commonly the ſame with thoſe of the brain; namely, the veins of the brain, and thoſe of the face.

336. The external jugular is a cutaneous vein of the neck, which produces the temporal one, and is united with the internal jugular at the baſis of the lower jaw; and the ſame ſends a branch through the os maxillare into the tranſverſe ſinus. The internal vertebral empties itſelf through the tranſverſe proceſſes of the neck into the tranſverſe ſinus as often as the canal belonging to it is opened.

337. The two lateral ſinuſes of the ſpinal marrow run along its whole length, are joined to each vertebra by a ſemicircular arch, and at laſt are united with the jugular and occipital ſinuſes: they ſend branches, however, to the ſpinal marrow, joined with the anterior and poſterior ſpinal vein.

338. The veins form innumerable anaſtomoſes with one another, that the blood may return with the greateſt eaſe from the head, of which the repletion is very dangerous. The brain is alſo more eaſily evacuated in the time of inſpiration, and ſubſides during that period when the ſkull is opened, but ſwells during the time of exſpiration. Hence, blowing the noſe, ſneezing, and coughing, are dangerous to thoſe whoſe brain is ſwelled by retained blood.

339. Whether or not there are lymphatic veſſels to be ſeen in the brain, is by ſome queſtioned. Indeed, we read deſcriptions of them in the pia mater, and in the larger choroidal plexus; but, for my own part, I have never been able to ſee them, and poſſibly there are none to be ſeen, ſince there are no conglobate glands in the brain, which are always near at hand wherever any of theſe veſſels are to be found. As for the various accounts which are given of the pituitary glandule, of the infundibulum, and of the ducts which lead from thence into the veins of the head, abſorbing and tranſmitting a water from the ventricles of the brain, they are not ſupported by anatomical experi-

 ments:

ments: which make it more probable, that the vapour which is ſecreted into the ventricles of a healthy perſon is, in like proportion, abſorbed again by the inhaling veins; or, if any part abounds, that it deſcends through the bottom of the ventricles to the baſis of the ſkull, and from thence into the looſe cavity of the ſpinal medulla. That this is the caſe, appears from palſies which enſue on one ſide of the body after apoplexies; and from the bifid ſpines or watery tumours in the lower part of the ſpinal medulla, following in thoſe who have an hydrocephalus.

340. It now remains for us to ſpeak of the encephalon itſelf. But many are the parts included under this general denomination. By the *brain*, properly ſo called, we underſtand that upper and ſoft viſcus which is contained in the ſkull, and which is lodged by itſelf in its fore-part; but backward it is incumbent over another conſiderable part, called the *cerebellum*, which lies in the poſterior and lower cavities of the occipital bone, under the membranous tentorium, which parts it from the brain. Its lower, middle, and white portion, deſcending before the cerebellum, is in part called the *pons*, and in part the *medulla oblongata*.

341. The *figure* of the brain reſembles that of half an egg, which is deeply divided longitudinally, but not cut through above half way, into hemiſpheres reſembling the fourth part of an egg. Both the upper and lower ſurfaces are full of many gyri or convolutions, which pretty deeply cut or divide the brain with round ends or angles into undulated portions. But the largeſt is that which aſcends on both ſides outwards from the ſides of the ſella turcica, and divides the hemiſphere into two lobes. Upon the ſurface of the ſaid lobules or portions lies the *cortex*, extremely ſoft, and inclined from a yellow or red to a grey or aſh colour, being the moſt tender of all parts in the human body: this inwardly is filled with the *medulla*, which is almoſt perfectly white, but redder in the fetus; in many places, it is perforated by red arteries, which are more ſimple and

and perpendicular, or ſtraight, than in other parts. This medulla is more ſolid and more capable of ſuſtaining its figure, notwithſtanding it is very ſoft, and abounds in a greater quantity than that of the cortex. The greater poſterior branch of the carotid artery (317.) firſt divides the right and afterwards the left hemiſphere of the brain into an anterior lobe, which is the larger; and a poſterior lobe, which is the leſs.

342. The fabric of the cortex has been a long time controverted; but it is now ſufficiently evident, from anatomical injections, that much the greater part of it conſiſts of mere veſſels, which are every way inſerted from the ſmall branches of the pia mater, detached like little roots into the cortical ſubſtance, and conveying a juice much thinner than blood in their natural ſtate, although in ſome diſeaſes, and by ſtrangling, they often receive even the red parts of the blood, more eſpecially in brutes and birds. The remaining part of the cortex, which is not filled by any injection, is probably either an aſſemblage of veins, or of yet more tender veſſels; for no other diſſimilar parts are apparent in the cortex, whilſt it is in an entire or natural ſtate; from whence one may conjecture ſome part of it to be tubular, and the other part ſolid. As to glandules making the fabric of the brain, that notion has been diſcarded by univerſal conſent; nor indeed has there been any other opinion received with leſs probability than this.

343. In order to gain a knowledge of the nature of medulla, we are to conſider the anatomical ſtructure of this part of the human brain, compared with the brains of brute animals and fiſh. Therefore this part of the brain, which follows immediately under the outer gyri or convolutions of the cortex, is of a white colour, and becomes gradually broader and more abundant; ſo that, at length, it makes up the whole oval ſection of the brain, except only the gyri in the ſurface, which makes the cortex. In this part, the two hemiſpheres of the brain, as before obſerved, are

divided but half way through; which hemiſpheres here continue their coheſion with the medulla in the middle. That part of the medulla which is extended under the falciform proceſs, but at ſome diſtance from it, is called *corpus calloſum;* in the ſurface of which run two parallel white ſtripes, formed by the pulſation of the arteries: theſe ſtripes diverging forwards, and terminated at the place where they mingle together in the fore-part, are thence divided backwards. But the anterior extremity of this callous body is loſt in the ſubſtance of the crura, coming from the anterior lobes of the brain: the poſterior, which is broader, with a ſhorter curvature in the ſhape of a nail, is brought inwards; and the other column deſcends into the inferior horn of the ventricle, whence it is continued along with the longer one into the hippocampus. Moreover, the whole ſurface of this callous body is ſtreaked with tranſverſe fibres, which are continued, but extenuated, into the next adjacent medulla of the brain itſelf. Even the interior ſubſtance of this body is of a ſtriated nature, and its lower ſurface has its ſuture and fibres tranſverſe.

344. As to the remaining parts of the brain, a ſcrutiny is more difficult to be made into them: for the brain is not a ſolid body, but begins to be hollow internally from the lower part of its medulla, which is incumbent upon the multiform bone, at which place the greater crus of the brain paſſes out from it; and in this cavity the medulla is only covered with the pia mater, which aſcends backward, and then turning continues its courſe forward and upward. Next, the brain divides itſelf near the poſterior extremity of its callous body; and, at the ſame time, ſends one of its ſhorter poſterior portions into the poſterior lobe of the brain, turning its extremity inward. But the anterior portion is continued a long way by the ſide of the callous body, parallel to the horizon; and turning its horn outward, which there grows broader, it is terminated in the anterior lobe of the brain. This cavity, of which there is one in each hemiſphere of the brain, is called its triangular

or

or anterior *ventricle;* and it is naturally filled with a vapour, which is frequently condenſed into water or jelly.

345. This cavity is full, without any intermediate ſpace, by the cloſe meeting together of the ſides of the upper and lower medulla. The lower ſide or pavement of this part is variouſly figured. In its forepart, it forms a horn; below which there is a riſing moderately convex, and of conſiderable length, diverging backwards, covered with a membrane that is extremely vaſcular; and, being outwardly of an aſh or grey colour, is called the *corpora ſtriata;* becauſe inwardly they exhibit to the view, together with much cortex, alternate white oval ſtreaks, parallel to one another, longer on the back part; beſides, as it were, leſſer medullary ſpots and micæ. More inwardly and backward, there are two other ſimilar eminences, more of an egg-like ſhape, towards the third ventricle and other parts, moſtly cinereous on the outſide, obſcurely ſtriated, and ſo incumbent together, that they frequently cohere on the upper part, where they are confounded with the cortex: and theſe, continuing their courſe through the horn of each anterior ventricle, deſcend to the baſis of the ſkull, and there generate the optic nerves, of which they are called the *thalami.* Betwixt the ſaid ſtriated bodies and thoſe thalami, lies an intermediate, parallel, white, and ſtreaked medullary portion, called the double ſemicircular centre, produced from the *anterior commixture,* and frequently from the crura of the fornix; but eſpecially from the medulla itſelf, before the thalami of the brain. This commixture is broad, ſtrong, and joins together the anterior part of the brain before the thalami. The double centre, which is broadeſt behind, ariſes with many fibres, from the junction of the foot of the hippocampus with the medulla of the brain. But the corpora ſtriata, with the thalami, conſtitute the medullary crura of the brain; which, in the baſis of the cerebrum, lie over the medulla of the cerebellum, and are joined together at the extremity

extremity of the bridge above-mentioned. At the place where they approach neareſt to one another, each ſends out an hemiſpherical mamillary eminence. The fibres of the medulla of the brain itſelf, mixed together with the medulla of the cerebellum, deſcend into the medulla oblongata; and, being then collected into a bundle, they go to the corpora pyramidalia.

346. It is to be obſerved, that the corpus calloſum medium projects or riſes up in the common axis or middle of thoſe ventricles. Behind, this body lies contiguous and incumbent on the fornix; but, before, there are two ſimilar medullary partitions, which deſcend from this body the whole length of the corpora ſtriata; and this part, which in its middle includes an anonymous cavity, goes under the name of *ſeptum pellucidum*. This ſeptum is continued to the *fornix;* that is to ſay, the four-horned medullary tracts, which take their anterior origin from the medulla of the brain, and ſometimes the mamillary protuberances, and the commixture which we have mentioned; and behind that, particularly under the thalami, and often from the double centre and crooked line of the thalami. This fornix is incumbent upon an interval of the ſtriated bodies, and upon another interval of the thalami: from whence it degenerates partly into a broad thin fimbria; and partly into another tubercle, which is evidently continuous with the fornix and callous body of an half cylindrical figure, and furniſhed with an appoſite *fimbria*. Theſe deſcend into the lower anterior horns of the ventricles; and at laſt terminate outwards by a ſort of convex ſulcated end, imprinted by the gyri of the brain, and terminated by a foot, having as it were four furrows; whence the name of *hippocampus*, which externally are covered by exceeding thin medullary plates, but are inwardly of a cortical ſubſtance. At the beginning of the diviſion of the foot of the hippocampus, the tænia ends in two white ſtriæ, a long and a ſhort one, inſerted into this foot and into the brain, or one inſerted into the inmoſt part of the unguis. A like protuberance is continued in the poſterior horn of the ventricle,

ventricle, crooked inwards at its extremity like the claw of a bird, to which a continuous column occupies the hinder part of the basis of the horn of the descending ventricle, which is continued with the corpus callosum. Betwixt the departing posterior crura of the fornix, the medullary portion, which is behind the middle plexus of the ventricles, and painted with transverse and palmated streaks, is called the *psalterium* or harp.

347. Within the anterior or lower part of each of the ventricles, begins the vascular *plexus*, called *choroides*, included in the pia mater only, it lying naked in the rest of the cavity of the skull, made up of a great many small arteries (317, 318.), together with little veins originating from the larger trunk (325.); all which numerous vessels, joined together by the pia mater, resemble a curtain variously folded. With these are intermixed many small pellucid glandules of a round figure, resembling hydatids. It ascends from the basis of the brain, through the descending horn of the ventricle, and thus is dilated as it goes upward; but, thence, becoming narrower, it goes on with the optic thalamus, to the posterior extremity of the septum lucidum. When those plexuses have reached the anterior extremity of the thalami, being afterwards reflected and united together into one very large vascular plexus, they gradually descend through the crevice of the third ventricle as far as the pineal glandule, and then are continued into the pia mater of the posterior lobes of the brain. From this plexus, doubtless, proceeds the internal warmth of the brain, with its exhalation and inhalation. But the choroidal plexuses become very broad where the anterior ventricles of the brain begin to descend; and thence, contracting gradually downward, they project their extremities to the ends of the anterior ventricles, covered only with the pia mater.

348. Betwixt the thalami, applied one to the other almost with a plain surface, there is a natural fissure terminating the crura of the brain, which meet together in the basis of the skull; and this is called the *third ventricle*.

tricle. It leads by a declivity, like a funnel, forward into a concave column; which, though hollow in brutes, is yet evidently lefs tubular in man, and connected to the pituitary glandule.

349. This is compreffed on both fides, fimple, of uncertain ftructure; in the anterior part almoft round, and of a reddifh colour; the pofterior part lefs, cinereous, broad tranfverfely, covered with the pia mater of the brain: it lies upon the proper impreffion of the fella turcica, and feems to be a kind of appendix to the brain.

350. Backward, the thalami are conjoined together in the bottom of the ventricle, by a medullary fafcia, or pofterior commixture, and by a fmaller tranfverfe chord; from which a crooked white ftreak goes out on both fides in the upper part, which lofes itfelf in the double centre, in the anterior commixture, and fometimes in the crus of the fornix. On the fore and upper part, the thalami fpring out of a protuberance, which is formed by the triangular fornix lying between the two thalami.

351. This little eminence feparates the upper triangular cavity of the third ventricle, filled up with the fornix in fuch a manner, from the inferior calamus fcriptorius, that the cavity is continued both from the anterior and pofterior extremity of the third ventricle, from the top to the bottom. But even the anterior commixture is a medullary ftreak which unites the thalami before the anterior crura of the fornix.

352. Again, behind the thalami, thofe tranfverfe figured eminences of the medulla meet together, which conjoin the medulla of the right and left pofterior lobes of the brain. In this part, backward, are cut out four oval eminences, which are outwardly fmaller, called the *nates* and *teftes*, and which are of a fubftance inwardly cortical, but outwardly medullary. Upon thefe is feated a cortical glandule, fomewhat oval and conical, fpread with many fmall veffels, into which the choroide plexus here degenerates: this is the *pineal glandule* fo much cele-

celebrated, and ſo frequently diſeaſed, and joined to the brain by ſmall foot-ſtalks ſent into the linea alba thro' the thalami in their paſſage forwards. Between this eminence, on which theſe four protuberances are cut out, and the crura of the oblong medulla, paſſes a groove or channel in the ſame direction from the third to the fourth ventricle, manifeſtly open, reſembling an aqueduct.

353. The whole medulla of the brain is, in its lower part or baſis, collected together into two very thick compreſſed columns, diſtinguiſhed in their ſurface by a line running according to their length; which have internally a cortical ſubſtance, and are the *crura of the brain*. Theſe, meeting together backwards, are covered by the ſubjacent crura of the cerebellum, and are inſerted by apparent ſtrata of fibres into the pyramidal bodies of the medulla oblongata; and with the other deeper fibres, which ſeparate the inner tranſverſe fibres that come from the cerebellum from the preceding, meet together with the medulla cerebelli to make up the beginning of the medulla oblongata.

354. The *cerebellum*, as it is leſs, ſo it is more ſimple than the brain. It has two lobes, but no where deeply parted, united above and below in their centre to a ring of the ſame fabric with itſelf, called the *vermis*, at the ſide of which there is a ſmooth eminence of the ſame nature with the cerebellum itſelf. This part of the encephalon contains a great deal of the cortex, with a leſs proportion of medullary ſubſtance. And here, likewiſe, the cortex is placed in the circumference, but marked with gyri or convolutions, which are rather parallel to each other, ſo as to form circles. Thus the ſmall lobules or portions are diſtinguiſhed, but not deeply, and afterwards ſend out each of them their medulla; which is, by degrees, ſo collected together in rays or branches, meeting in one trunk, that the whole reſembles the figure of little trees. This medulla, collected together into the large crura of the cerebellum, and marked in the inner part with ſerrated cortical lines,

interwoven with one another, hath a threefold termination. One part aſcends towards the baſis of the nates, where it joins with the medulla of the brain under the teſtes; but the right and left parts of it are joined to each other by a tranſverſe medullary ſtria behind the nates. From this, ſome diſtinct fibres aſcend outwards, and join themſelves to the tranſverſe ones of the bridge. Between theſe firſt proceſſes of the cerebellum, is ſtretched a medullary lamina, behind the fourth ventricle, ſending forth fibres beyond the proceſs. Another portion deſcends into the ſpinal medulla, and terminates in peculiar nail-like protuberances, which are both anonymous, and have other cortical portions near them. A third portion, which is larger, and ſituated in the middle, goes tranſverſely downward under the crura of the brain, which it embraces; and by twice intermixing alternately with their tranſverſe medullary fibres (352.), it is in a great meaſure confounded together with them.

355. Thus is produced from the crura of the brain deſcending above thoſe of the cerebellum, and from the medulla of the cerebellum tranſverſely ſurrounding that of the cerebrum, the *pons*, at firſt almoſt oval, but more blunted on both ſides, depreſſed in the middle, and inſcribed on all ſides with tranſverſe fibres. Then the *medulla oblongata*, continuous to the pons, is internally variegated and ſtreaked with a ſubſtance like the cortex, and deſcends of a conical ſhape, inclined to the great foramen in the occiput. This medulla has two pair of tubercles before the pons; the outermoſt of the figure of an olive, and the innermoſt of a pyramidal ſhape, for they leſſen downward like a cone; and theſe are immediately divided by a ſulcus, through which the pia mater enters. But betwixt that medulla and the worm-like proceſs of the cerebellum, is formed a cavity, limited by the four leſſer proceſſes, which as they aſcend or deſcend is at firſt narrower; but above the tubercles (354.) it grows broader, and is of a rhomboidal figure: it is called the *fourth ventricle*,

tricle. It is ſhut in its back-part by the valvula magna, or a medullary velum, uniting the proceſſes going from the cerebellum to the nates and vermis, and tranſverſe ſtria lying under the teſtes, and ſhutting the ventricle behind, (354.) This ventricle has a moderately large ſulcus or furrow, having ſwelled lips on each ſide inſcribed on the medulla oblongata, and anſwering to the canal that is covered by the nates and teſtes, called the *aqueduct* (348.) In this laſt ventricle, as well as in the foregoing, is lodged the plexus choroides, only leſs in bulk, together with an upper ſulcus called *calamus.* Each of theſe ſulci is continued down along the medulla ſpinalis, both in its anterior and poſterior ſide; more evidently in the former, but leſs ſo in the latter. Tranſverſe fibres are detached in its upper part from the right to the left ſide, both of the medulla oblongata and ſpinalis. But two or three of the tranſverſe ſtreaks that ariſe from the eminences which intercept a ſulcus, are inſerted into the ſoft part of the acouſtic nerve; others go to the eighth pair, and others of the ſame kind aſcend to the crus of the cerebellum.

356. All the medulla of the brain and cerebellum goes out from the ſkull, through particular openings towards certain parts to which it is deſtined. The ſmaller bundles of this medulla we call *nerves;* but the larger, deſcending through the ſpine, we call the *medulla ſpinalis*, which is a continuation of that called *oblongata* (355.) But the nerves, which are bundles of the medulla, and very ſoft in their origin, are compoſed of ſtraight parallel fibres in diſtinct threads. Theſe nervous cords, after they have gone forward ſome length, covered with the firm pia mater of a reddiſh colour, are afterwards united into a more tough or permanent ſtring; and then, conjoined, divided, and in the neighbourhood of others like themſelves, they haſten through a cellular texture to their proper opening in the dura mater, and thence run down through the intervals of the channels formed by that membrane, till they meet with an opening in the ſkull, out

of which they paſs through the membranous funnel of the dura mater. The nerve, having arrived without the ſkull, is commonly ſurrounded by the dura mater, ſo as to become very ſolid and firm. Thus it is in the optic nerve, in the fifth pair, and in others; but in ſome again there does not appear to be any dura mater ſurrounding the nerve, as in the olfactory nerves, in the ſoft portion of the auditory nerve, and the intercoſtal. The nerves now deſcend naked or leſs fenced betwixt the muſcles, detaching their cords or threads of which they are compoſed, and are ſtill made up of the medulla covered by the pia mater. Many ſmall threads of this kind are joined together into larger, by the union of the cellular ſubſtance that ſurrounds them, through which run many ſmall arteries and veins intermixed; and ſometimes fat itſelf is therein lodged. But in general the outer covering, common to the whole nervous bundle, is either derived from the dura mater, or at leaſt is a hard plate of the cellular ſubſtance, wherein all the ſmaller threads are contained and united into one nerve, often reſembling a true membrane.

357. It is common to all the nerves of the head to ariſe and paſs out from the lower part of the medulla of the brain or cerebellum. The *olfactory nerve* ariſes with lateral fibres from the interval betwixt the anterior lobe of the brain, but with direct fibres from the medulla of the anterior lobe itſelf. A great part of the *optic nerve* ſprings from the thalami (345.), but ſome part likewiſe from the crus of the brain, while the nerves decuſſate through its ſubſtance. The third ariſes from the loweſt crus of the medulla of the brain behind the mammillary bodies. The fourth, which is either ſimple or trifid, ſends a proceſs from the ſide of the cerebellum to the teſtes. The fifth ariſes plainly from the peduncles of the cerebellum itſelf. The ſixth out of a ſulcus (354.), deep from the bottom of the pons betwixt that and the medulla oblongata. The ſeventh ariſes with one part ſofter from the medulla oblongata, and by two tranſ-

verſe

verſe ſtriæ, from the fourth ventricle itſelf; and with another part harder from that portion of the crus of the cerebellum which lies next the pons. The eighth nerve ariſes from the interval betwixt the olivary and pyramidal bodies or protuberances; and, according to the obſervation of other eminent anatomiſts, from the fourth ventricle likewiſe. The ninth ariſes from the corpora olivaria and pyramidalia. The tenth, by reaſon of its double root, is reckoned a nerve of the neck, going out with an arch, in company with the upper and lower adjacent nerve. There is, therefore, no nervous branch that ariſes properly from the cerebellum, unleſs it be the fifth; for the anterior nerves, the olfactories, optics, and third nerve, come from the brain only; and all the reſt from thoſe parts where the medulla, both of the brain and cerebellum, are conjoined together.

358. The *ſpinal medulla* is a kind of very ſoft medullary rope or appendix to the encephalon, continued down from the medulla oblongata, as low as the ſecond vertebræ of the loins. In the neck its anterior and poſterior ſides are flat, laterally convex, but in the back it is four-ſquare. It is largeſt where it goes out from the head; from thence it is ſmaller in the top of the neck; in the lower part it is larger; but ſmaller again through almoſt the whole back; thicker in the lower, oval, and conical part of it; and laſtly it ends in tubercles. The pia mater is a proper integument to this part as well as to the brain, ſince it enters the foremoſt fiſſure deeply, and divides the medulla almoſt into two. The cortical ſubſtance which lies within it is obſcure. It has its anterior artery produced in the ſkull, from the branches of the vertebrals. This artery is retrograde, and deſcends through the whole length of the pia mater, perpetually making alternate ſinuous flexures, which form inoſculations about many but not all of the nerves, with branches of the vertebral, intercoſtal, lumbar, and ſacrolumbar arteries; till at laſt, being covered with a peculiar coat from the pia mater, it

goes

goes out and disappears at the coccyx. In like manner the two posterior arteries, which are less, arise and are distributed from the lower arteries of the cerebellum, and are more serpentine, and frequently inosculated among themselves. The spinal veins descend, together with the arteries, from the brain itself, sending out branches in like manner on each side, which accompany the nerves like so many circular sinuses, fixed in the dura mater, and corresponding to the number of the vertebræ, all which so communicate one with another, that each has on all sides a direct consent both with the uppermost and lowermost; and, after having sent out branches that join the vertebral, intercostal, and lumbal veins, they unite with those of the sacrum. The uppermost of these sinuses inosculates with the anterior occipital sinuses (332.)

359. But there is another covering, not spread with any vessels, which surrounds the spinal medulla loosely and at a distance, and is pretty firm, of a watery clearness, called *arachnoides;* and which being longer than the pia mater, is extended to the bottom of the os sacrum, where the nerves, only descending from the medulla, are collected by it into a fasciculus. But in what manner it goes out, together with the nerves, has not been hitherto described. Between that membrane and the dura mater there exhales a vapour, which is frequently condensed into a reddish water, and produces a true dropsy.

360. Lastly, the *dura mater*, belonging to the spinal medulla, and continued from that of the cerebellum, surrounding the arachnoides, and from thence descending to the bottom of the os sacrum, being larger at its beginning, at the bottom of the neck, and at the loins, but slenderer in the back, and being connected ultimately by many ligaments to the os sacrum, it at last disappears in a slender cone. As the nerves pass out through this membrane, it gives them an external covering; and directly thickens or swells with them into a *ganglion*, or hard, oval, reddish-coloured knot. To this

this hard covering of the dura mater internally adheres a ligament denticulated at the interval of each of the nerves, which arifes from the fkull near the courfe or paffage of the ninth pair of nerves, tying the arachnoides to the dura mater by triangular productions in each of the intervals of the nerves, and betwixt the anterior and pofterior bundles of the fpinal nerves down to the bottom, and twelfth vertebra of the back. Externally there is a fort of fat furrounds the dura mater, and alfo lines internally the covering of the vertebræ of the fpine, which by this means are fo adapted like a tube to the medulla fpinalis, that the latter is not liable to be compreffed by the bending of it in any pofition.

361. The fibres of the fpinal medulla, in dropfical fubjects and in brute animals, appear very diftinct. Thefe medullary fibres go out from the whole anterior and pofterior fides of this long appendix; after which, the anterior cords are commonly wrapt up in the pia mater, in which they converge together like rays into a larger fafciculus; to which alfo join fimilar threads in another bundle from the pofterior fafciculi joining together into one nerve, which, paffing out through the holes of the dura mater, produces a nerve betwixt each two vertebræ. Thefe vertebræ are about 30 in number. In the neck, numerous radiated nervous fibres compofe one large and almoft tranfverfe nerve. In the back they defcend, in general, of a fmaller fize; but fo that the lower and larger ones are commonly joined clofe to one another. The large and long lumbal ones join to form the cauda equina. The loweft nerves of the os facrum are the leaft, the uppermoft ones large. Many of the dorfal nerves, together with the lumbal ones, and thofe of the os facrum, covered with their proper membrane from the pia mater, accompanied with their arteries, and inclofed in the arachnoides, make up that rope which is called the *cauda equina*.

362. Thofe nerves are afterwards diftributed to all parts of the body in a manner very complex, and not here

here to be described. But we must not omit to observe, that all the spinal nerves, except one or two in the neck, have both an anterior and posterior trunk. This is only sent to the muscles. It produces a nervous root, which joining the other adjacent nerves, and having given a small circle that proceeds from the sixth nerve of the brain and the second branch of the fifth, comes through the pterygoide canal, and forms one of the principal nerves of the human body; which, communicating with almost all the other nerves of the whole system, sends out nervous branches to the heart and all the viscera of the abdomen. The same has as many ganglia as roots from the medulla, unless where many of them join into one ganglion. It communicates in various places with the crural, brachial, and diaphragmatical nerves, also with the par vagum and ninth pair of nerves. The other primary or capital nerve is the eighth or *vague nerve*, arising from the brain, and joining itself to the intercostal in the bottom of the neck, in the thorax, and in the abdomen; this passes out of the skull in three cords, of which the larger sends branches to the larynx, gula, lungs, and the cardiac plexus itself (99.) also to the œsophagus, stomach, and liver. The third of these is the *phrenic nerve*, arising from most of the lower nerves of the neck and arms; and sometimes, being increased from the root of the spinal nerve, it descends by the side of the pericardium, and inserts itself into the upper face of the diaphragm; but below it receives nerves from the great plexus of the intercostal nerve. Lastly, the *accessory nerve*, arising by many small roots from the six or seven uppermost posterior nerves at the neck, and from the medulla oblongata, joins the nerve of the eighth pair going back again into the skull, and seems, by this means, to make a consent betwixt that important nerve and the spinal medulla. Moreover, the nerves of the limbs have at their origin plexuses or knots, and are, on account of their length, harder and firmer in their substance, and much larger, than the great nerves which go to the viscera: those which

which go to the hand, ariſe from the four lower nerves of the neck and firſt of the back; but thoſe of the lower extremity from the nerves of the loins and os ſacrum.

364. The nerves divide into branches like the blood-veſſels, but in acute angles, and often in a courſe manifeſtly retrograde, growing gradually ſofter and leſs in bulk, though ſometimes they become thicker as they recede from the brain, till at length their ultimate extremities, which are ſeldom viſible, ſeem to terminate in a pulp, by depoſiting the firm integuments with which they were covered, after the manner which we obſerve in the optic nerve. But the rectilineal courſe of the fibres, continued from the brain itſelf, is ſuch, that it is never broken off by the diviſion or ſplitting of a nerve into ſmaller threads, which only recede from each other by an opening of the cellular ſubſtance that tied them together. This appears from the diſorders, which are determined not to all, but only to ſome ſingle parts by injuries of the brain; as a loſs of the voice, deafneſs, dumbneſs, and palſies of particular muſcles. They are connected in their courſe by the cellular ſubſtance to the adjacent parts, but have hardly any elaſticity; whence they do not fly back after being divided, but only expel, by the contraction of their integuments, the ſoft medulla which they include. But though they are irritated ever ſo much, they are neither contracted nor are they rendered ſhorter during the motion of the muſcles which they produce. A great many nerves are ſent into the muſcles; many of them go to the ſkin; but fewer to the viſcera, and feweſt of all to the lungs; none at all to the dura and pia mater, arachnoides, tendons, capſules, and ligaments, and laſtly the whole ſecondary membranes. They make frequent inoſculations with each other, or out of one trunk are parted into many branches: and it is principally in theſe meetings of their branches, ariſing from different trunks, that the nervous ganglia are formed; namely, hard nervous tumours, for the moſt part repleniſhed with blood-veſſels, and included in a firm membrane, but of a uſe and

ſtructure as yet not certainly known, in which the ſtraight courſe of the nervous fibres is interrupted. The nerves of the ſenſes only are excepted from theſe ganglia or knots, together with the eighth pair; but they ſeem in a manner eſſential to the phrenic nerves, to the fifth pair, to thoſe of the limbs, to the ſpinal and to the intercoſtal nerves, which laſt are truly ſpinal nerves.

365. Thus far we are taught by anatomy concerning the brain and nerves; it remains from hence, that we explain the phyſiological uſes of theſe parts. Every nerve, therefore, that is irritated by any cauſe, produces a ſharp ſenſe of pain. But we muſt reckon the mind to be changed when any change happens to the body. It is the medullary part of the nerve which feels the pain. If the nerve was endued with any peculiar ſenſe, that ſenſe periſhes when the nerve is compreſſed or diſſected: the ſenſes of the whole body are loſt by a compreſſion of the brain; and of thoſe parts whoſe nerves originate below the ſeat of preſſure, if you compreſs the ſpinal marrow. If certain parts of the brain are compreſſed from which particular nerves ariſe, then theſe ſenſes only are loſt which depend on the nerves, as the ſight or hearing. Thoſe parts of the body which receive many nerves, as the eyes and penis, have the moſt acute ſenſation; thoſe have leaſt ſenſibility which receive few nerves, as the viſcera; and thoſe which have no nerves, as the dura mater, tendons, ligaments, ſecundines, broad bones, and ligaments, have no ſenſation.

366. It is not very obſcure, that all ſenſation ariſes from the impreſſion of a ſenſible object on ſome nerve of the human body; and that the ſame is then repreſented to the mind by means of that nerve's connection with the brain. But this ſeems to be falſe, that the mind perceives immediately by means of the ſenſoria and branches of the nerves. For this opinion is refuted, by the pains felt after amputation, the ceſſation of all pain when the nerve is compreſſed, and the deſtruction of the ſenſes by diſeaſes of the brain. And that the effect of the ſenſes is preſerved in the brain, is evident from

from the loſs of memory which follows when the brain is injured or compreſſed; alſo from the delirium which happens in ſome diſeaſes, and the ſtupor and ſleepineſs which happen in others. We have already obſerved, that the dura mater has no ſenſation.

367. Another office of the nerves is to excite motions, even the moſt violent ones, in the muſcles. When a nerve is irritated, the muſcle to which it goes is immediately convulſed; or if it ſends branches to ſeveral muſcles, they are all convulſed at the ſame time. This happens during the life of the animal, and a little after its death while all the parts are moiſt. By a great irritation other muſcles are thrown into convulſions, and afterwards the whole body. Nor is it neceſſary that the nerve ſhould be whole; for even when it is cut, an irritation of it will excite ſimilar motions in the muſcles. On the other hand, when a nerve is compreſſed or tied, a palſy follows; for the muſcles which have their nerves from that one lie unmoved, when they are commanded by the will to act. They alſo recover their motion when the compreſſion is removed, provided the nerve has received no hurt.

368. But the medulla of the brain, being vellicated or irritated deeply in its crura, dreadful convulſions enſue throughout the whole; and this without any exception, whatever be the part of the brain ſo affected; nor is there any difference in the brain, cerebellum, or corpus calloſum. The ſame conſequences alſo follow, if the ſpinal medulla be irritated. But if the encephalon itſelf be compreſſed in any part whatever, there follows thence a loſs of ſenſe and motion in ſome part of the body, which muſt be the part whoſe nerves are detached from the affected or compreſſed quarter of the brain. This is clearly evidenced from experiments which have been made on particular parts of the brain diſordered: as from thoſe, for inſtance, in which the origin of the nerves are compreſſed, the voice is loſt; or the motion of one arm or leg, or one ſide of the pharynx, is aboliſhed. But in the injuries of the ſpinal

medulla, it is ſtill more evident, that thoſe parts, which receive their nerves ariſing from the place injured in the medulla, are either convulſed if that be irritated, or rendered paralytic if it be compreſſed. But when any more conſiderable or large portion of the brain ſuffers a compreſſure, either from blood, water, ſcirrhus, an impacted bone, or other mechanical cauſes, the greateſt part, and then the whole, of the body loſes its power of motion; of thoſe organs which obey the will when the malady is in a leſſer degree, and of them all when it is greater; all which diſorders ceaſe upon removing the compreſſing cauſe. Laſtly, if the ſpinal medulla, entering the neck, be injured, death immediately follows; becauſe from thoſe parts principally ariſe almoſt all the nerves of the heart (99.)

369. Theſe things being conſidered, there ſeems to be no doubt, but the cauſe of all motion in the human body ariſes from the brain with its annexed cerebellum and ſpinal marrow; and that it thence proceeds thro' the nerves to all the muſcular parts of the body. The cauſe, therefore, of this motion cannot reſide in the parts themſelves, becauſe otherwiſe the moving cauſe would continue to act after being ſeparated from the brain; nor would it be increaſed by irritating the brain, or weakened by a compreſſure of it.

370. Whether or not is there in the brain any principal part, in which reſides the origin of all motion, the end of all the ſenſations, and where the ſoul has its ſeat? Whether is this proved by the frequent obſervation, that the ſenſes are ſometimes entire, and that motion likewiſe remains tho' the brain is grievouſly hurt. Is it in the corpus calloſum? Or is this ſhewn by the greater fatality of wounds or diſeaſes in the corpus calloſum? Is this body ſufficiently connected with the nerves? Are there any experiments which deduce from thence the fifth, ſeventh, and other nerves? Doth not the ſame or even greater mortality of wounds in the medulla ſpinalis prove the ſame thing? Yet this is not the ſeat of the ſoul, ſeeing, though it is compreſſed or even deſtroyed, the perſon

will

will ſurvive a long time, with the perfect uſe of all his ſenſes. Nay, this opinion is oppoſed by very many facts: birds have no corpus calloſum; and wounds in that body are not in the leaſt more mortal than thoſe in other parts of the brain, as appears from undoubted experiments.

371. But neither is the power of the cerebellum greater in exciting the vital motions, nor are the proprovinces of vitality and animality diſtinct; nor does the cerebellum produce the nerves of the heart and other vital organs, and the brain thoſe which go to the organs of ſenſe and voluntary motion. From the cerebellum the fifth nerve is moſt evidently produced; but that goes to the tongue, pterygoide, buccinator, temporal, and frontal, muſcles, the lap of the ear, the eye, the noſtrils, all which are parts either moved by the will, or deſtined for ſenſe. Again, the ſame nerve, like the eighth, ſends vital branches to the heart and lungs, animal and voluntary ones to the larynx, and ſenſitive ones to the ſtomach. Again, it is not even true, that diſorders of the cerebellum bring on ſo certain and ſpeedy death. For certain experiments, even of our own making, ſhew that it has borne wounds and ſcirrhi, without taking away life; nor is it much different from the brain, only that it is ſofter and more tender; and laſtly, we have known, and that not very rarely, wounds of the cerebellum cured. The power, however, of this part, in exciting convulſions, is ſomewhat greater.

372. Concerning the ſeat of the ſoul, we muſt enquire experimentally. In the firſt place, it muſt be in the head, and not in the ſpinal marrow. For though this is obſtructed, the conſtancy of the mind remains the ſame. Again, it appears, from the experiment of convulſions ariſing when the inmoſt parts of the brain are irritated, that it lies not in the cortex, but in the medulla; and, by a probable conjecture, in the crura of the medulla, the corpora ſtriata, thalami, pons, medulla oblongata, and cerebellum. And again, by another

another not abſurd conjecture, where the origin of every nerve lies, as the firſt origins of all the nerves taken together make up the ſenſorium commune. Are the ſenſations of the mind repreſented there, or do the voluntary and neceſſary motions ariſe in that place? This ſeems very probable. For it does not ſeem poſſible, that the origin of motion can lie below that of the nerve; for although it ſhould be aſſumed gratis, that ſome part of the nerve is immoveable, or inſenſible, yet that is altogether ſimilar to the remainder of the nerve. Nor can the origin of motion (369.) be placed higher than this; for ſo it will fall within the arteries, which have neither the faculty of ſenſation nor of voluntary motion. It, therefore, follows, that the ſeat of the mind muſt be where the nerve firſt begins its formation or origin.

373. We come now to explain the manner in which the nerves become the organs of ſenſe or motion; which, as it lies hid in the ultimate elementary fabric of the medullary fibres, ſeems to be placed above the reach both of ſenſe and reaſon: but we ſhall, notwithſtanding, endeavour to make this as plain as experiments will enable us. And firſt, it is demonſtrated, that the ſenſation does not come through the membranes from the ſentient organ to the brain, nor that motion is ſent through the coverings from the brain into the muſcle. For the brain itſelf lies deeper than theſe membranes, and receives the impreſſions of ſenſe, and when hurt throws the muſcles into convulſions. Moreover, it is certain, that the nerves ariſe from the medulla of the brain; the truth of which is manifeſt to the eye in all the nerves of the brain, more eſpecially in the olfactory, optic, fourth and ſeventh pair of nerves, which continue their medullary fabric a long way before they put on the covering of the pia mater.

374. We muſt, therefore, next inquire into this medulla, what it is. It is a very ſoft pulp, harder in inſects and fooliſh animals; but every where ſimilar to itſelf. It affects, however, to be formed into fibres, or

parallel

parallel threads, lying upon one another lengthwife. That the compofition of it is fibrous, appears from innumerable arguments; more efpecially to the eye in the corpus callofum, in the ftriatum, and thalami of the optic nerves; but ftill more evidently in the brains of fifh, and efpecially in their thalami optici. Again, that the fibres of the brain are continuous with thofe of the nerves, fo as to form one extended and open continuation, appears, by obfervation, very evidently in the feventh, fourth, and fifth pair of nerves. There is a great deal of oil in the medulla, upwards of a tenth part of its whole weight.

375. But here a controverfy begins concerning the nature of this fibril, which, with others of the like kind, compofes the fubftance of the medulla and of the nerves. That this is a mere folid thread, and only watered by a vapour exhaling into the cellular fabric which furrounds the nervous fibres, has been afferted by many of the moderns; but that, when it is ftruck by a fenfible body, a vibration is excited, which is then conveyed to the brain.

376. But the phenomena of wounded nerves will not allow us to imagine the nervous fibres to be folid. For if an irritated nerve is fhaken, (and that happens after the manner of an elaftic chord, which trembles when it is taken hold of,) the nerve ought to be made of hard fibres, and tied by their extremities to hard bodies: they ought alfo to be tenfe; for neither foft chords, nor fuch as are not tenfe, or fuch as are not well faftened, are ever obferved to tremulate. But all the nerves, at their origin, are medullary, and very foft, and exceedingly far from any kind of tenfion: where they pafs through channels where they are well guarded, they retain the fame foft texture, and are not covered with membranes, as in the intercoftal nerves and the fecond nerves of the fifth pair; fome alfo are foft throughout their whole length, whatever fize they may be of: for example, the foft olfactory and acouftic nerves, from which we would moft readily expect a tremor; as in the

the caſe of ſound. Again, though the nerves are hard, they are ſoftened in the viſcera, muſcles, and ſenſoria, before they exert their operations. Therefore, the nervous fibres cannot poſſibly tremulate in an elaſtic manner, neither at their origin, nor where they are tenſe. But the ſame, even in the proper and moſt favourable caſes, cannot tremulate; becauſe, through their whole length, they are firmly tied to the ſolid parts by means of the cellular fabric; for example, the nerves of the heart are tied to the great arteries, and to the pericardium. Finally, that the nerves are very far from all elaſticity, is demonſtrated by experiments, in which the nerves, cut in two, neither ſhorten nor draw back their divided ends to the ſolid parts; but are rather more elongated by their laxity, and expel their contained medulla in form of a protuberance. Again, the extreme ſoftneſs of the medulla in the brain, with all the phenomena of pain and convulſion, leave no room to ſuſpect any ſort of tenſion concerned in the effects or operations produced by the nerves.

377. Add to this, that the force of an irritated nerve is never propagated upward, ſo as to convulſe the muſcles that are ſeated above the place of irritation. This is a conſequence altogether diſagreeing with elaſticity; for an elaſtic cord propagates its tremors every way, from the point of percuſſion, to both extremities. But if neither the phenomena of ſenſe nor motion can be explained from the nature of elaſticity, the only probable ſuppoſition that remains is, that there is a liquor ſent through the brain, which, deſcending from thence through the nerves, flows out to all the extreme parts of the body; the motion of which liquor, quickened by irritation, operates only according to the direction in which it flows through the nerve; ſo that convulſions cannot thereby aſcend upwards, becauſe of the reſiſtance made by the freſh afflux of the fluid from the brain. But the ſame liquid being put in motion in an organ of ſenſe, can carry that ſenſation upwards to the

brain; ſeeing it is reſiſted by no ſenſitive torrent coming from the brain in a contrary direction.

378. It is therefore probable, that the nervous fibres, and the medullary ones of the brain, which have the ſame nature, are hollow. Nor is the objection which ariſes from the ſmallneſs of theſe tubes, not viſible by any microſcope, of any force againſt the propoſed arguments; to which add the abſence of a ſwelling in a tied nerve, which, in reality, is not ſufficiently true; with other arguments of the like kind, which indeed ſhow the weakneſs of the ſenſes, but have not any validity againſt the real exiſtence of a juice or ſpirit in the nerves. If they are tubes, it is very probable that they have their humours from the arteries of the brain.

379. But concerning the nature of this nervous liquid, there are many doubts. Many of the moderns will have it to be extremely elaſtic, of an etherial or of an electrical matter; but the more reaſonable part make it to be incompreſſible and watery, but of a lymphatic or albuminous nature. Indeed it is not to be denied, that we have many arguments againſt admitting either of theſe opinions. An electrical matter is, indeed, very powerful, and fit for motion; but then it is not confinable within the nerves, ſince it penetrates throughout the whole animal to which it is communicated, exerting its force upon the fleſh and fat, as well as upon the nerves. But, in a living animal, the nerves only, or ſuch parts as have nerves running through them, are affected by irritation; and, therefore, this liquid muſt be of a nature that will make it flow through, and be contained within the ſmall pipes of the nerves. And a ligature on the nerve takes away ſenſe and motion, but could not ſtop the motion of a torrent of electrical matter.

380. A watery and albuminous nature is common to moſt of the juices in the human body, and may be therefore readily granted to the juice of the nerves; like the water which exhales into the ventricles of the brain from the ſame veſſels; alſo, from the example of

a gelatinous or lymphatic juice, which flows out in cutting through the brain in fiſh, and the nerves of larger animals; to which add, the tumour which ariſes in tied nerves. But are theſe properties ſufficient to explain the wonderful force of convulſed nerves, obſervable in the diſſections of living animals, and even in the leſſer inſects, with the great ſtrength of mad and hyſterical people? Whether or no is not this difficulty ſomewhat leſſened from the hydroſtatical experiments of attraction in ſmall tubes; which, although it may explain the ſtrength and motion, is nevertheleſs inconſiſtent with the celerity?

381. The nervous liquor then, which is the inſtrument of ſenſe and motion, muſt be exceedingly moveable, ſo as to carry the impreſſions of ſenſe, or commands of the will, to the places of their deſtination, without any remarkable delay: nor can it receive its motions only from the heart. Moreover, it is very thin and inviſible, and deſtitute of all taſte and ſmell; yet reparable from the aliments. It is carefully to be diſtinguiſhed from that viſible, viſcid liquor exhaling from the veſſels in the intervals between the nervous cords.

382. That this liquor moves through tubes rather than through a ſpongy ſolid, we are perſuaded from its celerity, and the analogy of the whole body; of which all the liquids, the fat excepted, run through their proper veſſels.

383. Therefore, upon the whole, it ſeems to be certain, that, from the veſſels of the cortex, a liquor is ſeparated into the hollow pipes of the medulla, which are continued with the ſmall tubes of the nerves, even to their ſoft, pulpy extremities, ſo as to be the cauſe both of ſenſe and motion. But there will be a twofold motion in that humour; the one ſlow and conſtant, from the heart; the other not continual, but exceedingly ſwift, which is excited either by ſenſe, or any other cauſe of motion ariſing in the brain.

384. The ſame nerves moſt evidently preſide over both ſenſe and motion; as we are not allowed the two

ſyſtems

ſyſtems of motory nerves diſtinct from ſenſitive ones. If ſenſe ſometimes remains after motion is deſtroyed, this ſeems to be becauſe much more ſtrength is required for the latter. Dying people hear and ſee, when incapable of motion.

385. If it be aſked, What becomes of this nervous juice, which cannot but be ſeparated and diſtributed in great abundance, from ſo large a quantity of blood paſſing the brain very ſwiftly, in compariſon of the ſlower moving blood, from whence the milk is ſeparated in the breaſt, and the urine in the leſſer renal artery, or by a compariſon with the meſenteric artery? It may be anſwered, It exhales probably through the cutaneous nerves; the laſſitude both with reſpect to ſenſe and motion, which may be overcome by ſpirituous medicines, ſhews that this liquid may be both loſt and repaired. Many have judged, that it alſo exhales into the various cavities of the body; as that of the ſtomach, and inteſtines. We may expect ſome part of it to be reſorbed, that the nobleſt humour of the body may not be too quickly diſſipated. That it nouriſhes the body, is incredible: it is too moveable to expect adheſion from it: that is the office of a ſlow and viſcid humour.

386. But then, what is the deſign of ſo many protuberances in the brain? what are the particular uſes of the ventricles, nates, and teſtes; with the diſtinction of the brain from the cerebellum; and the communication betwixt one ſide of the brain, cerebellum, and ſpinal medulla, with their oppoſite ſides, by ſo many tranſverſe bundles of fibres?

387. The ventricles ſeem to be made of neceſſary conſequence, and towards the greater uſe and diſtinction of the parts. And that the corpora ſtriata or thalami might keep their medullary parts from cohering one to another, it was neceſſary for a vapour to be poured betwixt them; and the ſame is true with regard to the brain and cerebellum. Perhaps, likewiſe, the neceſſity of adminiſtring a degree of warmth to the

cloſe medulla of the brain may be one reaſon for theſe cavities, by which the arteries enter, and are diſtributed in great numbers. Perhaps alſo it was proper, that, in the inmoſt parts of the brain, ſmall veſſels only, without any large ones, ſhould enter. We may alſo ſuſpect, that the ſoftneſs of the fibres of the brain requires ſhortneſs, in order to ſuſtain their own weight.

388. The uſes of moſt of the protuberances we are not acquainted with, but have them yet to learn from diſeaſes, and from anatomical experiments made on animals having a brain like that of mankind. But, in theſe reſpects, we have little hopes of ſucceſs, in parts that are ſo ſmall, ſo deeply, and ſo difficultly ſituated, and hardly ever to be approached but by a wound ſoon fatal. Whether theſe parts are ſo many diſtinct provinces in which our ideas are ſtored up, and whether this be confirmed by the protuberant thalami of the optic nerve, are indeed queſtions. But then moſt of theſe protuberances ſend out no nerves at all.

389. As to the internal communication of one part with the other by ſtriæ or ducts; that ſeems to conduce to the advantage of motion, and probably of ſenſe likewiſe. Some of theſe communications join the brain with the cerebellum; others join the ſpinal medulla with the nerves of the brain itſelf, as in the acceſſory nerve; and moſt of them join the right and left parts together, as in the anterior commixture (345.), and in the two poſterior (350.), in that of the corpus calloſum (343.), in the ſtriæ betwixt a proceſs of the cerebellum and teſtes (354.); to which add the medullary croſs-bars in the medulla oblongata and ſpinalis (355.) For, from this ſtructure, it ſeems manifeſtly to follow, as well as from numberleſs experiments and obſervations, that, when the right ſide of the brain is injured, all the nerves, which belong on the contrary to the left ſide of the body become diſeaſed or paralytic, and the reverſe. Moreover, by this contrivance, nature ſeems to have provided, that, in whatever part of the brain any injury may happen, the nerve that ariſes from thence is, by

this means, not always deprived of its uſe. For if the ſaid nerve receives its fibres by communicating bundles, as well from the oppoſite as from its own hemiſphere of the brain, its office may, in ſome meaſure, be continued entire by the fibres which it receives from the oppoſite ſide, even after thoſe of its own ſide are deſtroyed. Accordingly we have numberleſs inſtances of wounds, and with a conſiderable loſs of ſubſtance from the brain, which yet have not been followed with injury to any nerve, or to any of the mental faculties. Many other leſs inequalities, ſtripes, protuberances, and nerve-like impreſſions, appear in the brain from mechanical neceſſity, with the pulſation of the veſſels, and the preſſure or figure of the continuous incumbent parts.

390. We have before declared, that the nerves are the organs of ſenſe and motion: we ſhall therefore proceed firſt to explain that motion before we deſcribe the organs of ſenſe; becauſe it is more ſimple, uniform, and perpetually exerciſed, even in the fetus, before any of the ſenſes.

CHAP. XII.

Of Muscular Motion.

391. THE organ of motion in the human body is not ſingle. And firſt, in every animal and vegetable fibre, alſo in hair, feathers, in membranes, the cellular texture, and in the humid muſcular fibre; again, in animal and vegetable gluten; there is a contractile power, which both reſiſts the lengthening out of its ſubſtance, and, when the extending power is taken away, reſtores the fibre to its former ſize; nor does this power ever ceaſe endeavouring to bring the elementary particles into the cloſeſt contact the mechaniſm of the part can admit. After death, even for many days, it does the ſame, ſo that the fibres of a divided muſcle contract towards each extremity, ſo as to leave

leave a wide gap in the middle. An artery, when cut, likewiſe contracts itſelf in length.

392. I call this force *dead*, becauſe it continues to be efficacious after death, and ſo is different from the powers of life. In the living animal indeed it is ſomewhat briſker: for, both from cold and fear, the ſkin is moved, ſo that it grows harder, and has its papillæ erected, and along with this hardneſs contracts itſelf in length. Again, the cellular fibres are animated with this perpetual niſus to ſhorten themſelves, and always tend to their own contraction. Hence, when the ſkin or any other membrane is extended, as ſoon as the cauſe of extenſion is taken off, it returns by a gentle effort to its former ſhortneſs. But it even ſomewhat reſiſts the attempt to perpetual diſtention; and by a gentle but continual acceſſion of its own elements, propels the contained fat or water, or other bodies accidentally introduced. The ſame power alſo ſeems to limit the excretion of vapour; for the fibres and plates of the cellular texture being preternaturally relaxed, an immenſe quantity either of fat or of watery humour is depoſited in that texture. And this debility ſeems to be the principal cauſe of a true dropſy. The ſame cauſe being always efficacious, and at work in the heart, joints, and every where throughout the body of the embryo, brings into nearer contact the arteries, auricles, and ventricles; produces flexures; and contracts the heart, when in a manner diſſolved, into a cone. The ſame, by an unknown or hidden power, ſeems to form the ſhape of moſt parts of the human body; and while it expels the gluten received into the cells, brings the terreſtrial particles nearer to one another, and gives the proper ſolidity, curvature, and ſituation, to the different parts.

393. It is the nature of this power to act continually by a gentle but uninterrupted effort. It is common for it alſo to be excited by poiſons, in every membrane, fibre, and cellular texture; but never by cutting or puncturing with an iron inſtrument. Theſe are the

known

known properties of the red muſcular fibre. The ſtructure of this fibre, then, it is now neceſſary for us to conſider.

394. By the name of *muſcular fibres* in the human body, we call bundles of reddiſh-coloured threads, which perform all the motions of which we are ſenſible. When many of theſe fibres are collected together, and appear more evidently red, they are called *a muſcle*. The extreme ſimplicity of the fabric in theſe parts has been the cauſe of the obſcurity that prevails in underſtanding how a ſmall, ſoft, fleſhy portion can produce ſuch ſtrong and ample motions as we ſee in man, but more eſpecially in the cruſtaceous inſects.

395. In every muſcle we meet with long ſoft threads or *fibres*, ſomewhat elaſtic or extenſible, and almoſt conſtantly diſpoſed parallel with each other; and theſe, being ſurrounded with a good deal of cellular ſubſtance, are by that faſtened together into little bundles. Thoſe bundles, called *lacertuli*, are again tied together into larger bundles, by a more looſe cellular net-work, which contains ſome fat; and betwixt theſe we conſtantly perceive membranous partitions and ſtripes of the cellular ſubſtance, removing them farther from each other, till at laſt a number of them, combined together in a poſture either parallel or inclined, are ſurrounded with a more thin and denſe cellular membrane, continuous with that of their partitions; and this being again ſurrounded by a thicker plate of the cellular ſubſtance, externally parts the whole from the adjacent fleſh, and gives it the denomination of a *ſingle* or *entire muſcle*. In every one of theſe threads there appears a leſſer ſeries of filaments, which, by oblique extremities, are cemented to others of the ſame kind, forming together a larger fibre.

396. The generality of the muſcles, but more eſpecially thoſe which are inſerted into the bones, and ſuch as are preſſed ſtrongly by other fleſhy incumbent parts, do not conſiſt of fibres altogether of one kind. For the fleſhy fibres (395.), being collected together, cauſe the

the muſcle to be thicker in the middle, which is called its *belly:* and the ſame fibres, degenerating by degrees obliquely at each end of the muſcle into a more ſlender, hard, and ſhining ſubſtance of a ſilver colour, in which, meeting cloſer together, the cellular ſubſtance interpoſed is thinner, ſhorter, and painted with fewer veſſels; they then become indolent and difficultly irritable, and receive the denomination of a *tendon*, by being collected together into a round ſlender bundle; or elſe, if it expands into a broad flat ſurface, it is called an *aponeuroſis*. The cellular texture which covers the whole tendon is called its *vagina* or ſheath, and reſembles the coat of a muſcle. For that the fleſhy fibres truly change into ſuch as are tendinous, is evident from comparing a fetus (in which there are very few tendons) with a child of ſome years growth, in which there are many more; and both with an adult or old perſon, in which are the greateſt number. Muſcles, which are not inſerted into any of the bones, have commonly no tendons, as the ſphincters and muſcular membranes of the viſcera and veſſels. But thoſe commonly end in long tendons, which are required to paſs round the joints and heads of the bones, to be inſerted in thoſe extremities which are more moveable. In a fetus the muſcles are evidently inſerted into the perioſteum only; but in adults, where the perioſteum is more cloſely joined with the bone itſelf, the tendons, being confuſed with the perioſteum, paſs together with that even into the foveoli of the bone.

397. The tendinous fibres indeed often lie in a ſtraight line with the fleſhy ones, and are as it were a continuation of them. But it is not at all rare for the fleſhy fibres to be obliquely inclined to the tendon, and to adhere to it, as the tendon itſelf grows thicker in its progreſs by continually receiving new fibres. This is called *a tendinous muſcle*. Other tendons lie in the middle betwixt two plates of fibres, forming an obtuſe angle with one another, at irregular diſtances, in their deſcent. There are inſtances of numerous tendons

pennated in different places formed into one muſcle. There are alſo other methods by which the tendinous fibres are joined with the fleſhy ones.

398. Within the cellular tunic that ſurrounds the fibres, the arteries and veins are ſubdivided into net-works, which commonly form right angles, run in company, and moſtly contiguous with each other; and from the ſmaller of theſe veſſels a vapour is exhaled into the thinner cellular ſubſtance, as the fat is alſo transfuſed into the thicker cellular ſubſtance; from whence again they are both abſorbed. The lymphatic veſſels, which run betwixt the muſcles of the tongue, with thoſe of the neck, face, and limbs, are difficultly demonſtrated. But there are alſo nerves more numerous than in other parts, diſtributed together with the blood-veſſels throughout the cellular fabric of the muſcle; which nerves, however, depoſite their harder covering, and become ſoft, and diſappear before they can be traced to their ultimate extremities. Thoſe enter the muſcle in many parts, without keeping to the ſame place or ſituation. In the tendons they cannot be demonſtrated. Nor are there any nervous fibres inveſting the muſcular bundles or portions ſo as to conſtringe them; for they, who have given ſuch a deſcription, have ſeen nothing but the cellular ſubſtance.

399. The fabric of the leaſt, which are as the elements of a muſcle, being inveſtigated by the microſcope in man and other animals, has always appeared ſimilar to the fabric of the larger fibres; nor do they yield any other appearance, upon which we can rely, than that of the leaſt threads joined one to the other by the intermediate cellular ſubſtance. There is, therefore, no foundation here for a ſeries of veſicles, nor for a chain of rhombs. It may be aſked, whether theſe fibres are hollow, whether they are continued with the arteries, or whether the difference betwixt muſcular and tendinous fibres lies in the latter being rendered more denſe and beat cloſer together by an expulſion of the fluids? That theſe are not probable, appears from the minute-

 neſs

nefs of the fibres, which are found lefs than the red-blood globules, and from the whitenefs of a mufcle after the blood is wafhed out of it; to which add the phyfiological reafons following, (411.) And, in general, more ftrength may be expected from a folid fibre.

400. A mufcle therefore is endowed at leaft with a threefold force. Firft, the dead one, in common to it with other animal fibres. Another, which we have called the *vis infita*, and which has different phenomena from the former. For it is more proper to life, and the firft hours after death, and difappears much fooner than the dead one. Again, in moft cafes, it acts by alternate ofcillations; fo that, being driven hither and thither, it fometimes contracts the mufcle towards the middle: fometimes again it extends the mufcle from the middle towards the extremities, and fometimes alfo it has a reiterated motion. Moreover, it is manifeftly quicker, and performs the greateft motions; the dead force, only fuch as are fmall and not eafily obferved. It is excited both by the pricking of an iron inftrument, and in the hollow mufcles by inflated air, by water, and every kind of acrimony, but moft powerfully of all by a torrent of electrical matter. Laftly, it is proper to the mufcular fibre, and is found in no other part of the human body with the qualities abovementioned. But we muft give a more particular explication of its phenomena.

401. It is natural to every mufcle to fhorten itfelf, by drawing the extremities towards its belly or middle. But to difcover the moving power of a mufcle from the fabric which we have defcribed, it will be of ufe to confider the appearances obfervable in the mufcular contraction. Every mufcle then becomes fhorter and broader in its action. But this contraction of its length is various; in fome more, in others lefs; and is very confiderable, for example, in fome of the fphincters, infomuch that they appear to be contracted more than one third of their extent, though this computation be taken from an erroneous hypothefis.

402. The

402. The inteſtines are exceedingly tenacious of their vis inſita, as they continue to contract themſelves long after they are taken out of the body, and even after they are cold. The heart is even more tenacious than theſe, if you conſider all things; as is moſt evident in a young chicken, and in cold animals. Different muſcles are beſt excited into action by different ſtimuli; as the bladder by urine, the heart by the blood, and the inteſtines by air. Though the nerves are removed, or the connection made by them between the muſcles and the brain cut off, the muſcles loſe but little of their irritable nature. It appears alſo from the example of polypi and other inſects, that the ſame irritable diſpoſition extends very widely through the animal fibres. Theſe creatures have neither brain nor nerves, yet are exceedingly impatient of ſtimulus. Laſtly, we may gather this from the affinity of plants; of which very many flowers and leaves open or contract according to the various degrees of heat and cold, ſome even very quickly, ſo that they are nothing inferior in this reſpect to animals. Neither does this depend upon weight, attraction, or elaſticity, ſeeing it is ſeated in a ſoft fibre, and vaniſhes when the ſame grows hard.

403. But that the cauſe of motion is conveyed thro' the nerves into the muſcles, is certain from the experiments before-mentioned (367. et ſeq.) For the nerve alone has any feeling; this alone carries the commands of the ſoul; and of theſe commands there is neither intimation nor perception in that part whoſe nerve is either tied or cut, or which has no nerve. Moreover, on irritating the nerve or ſpinal marrow, even in a dead animal, the muſcle or muſcles which have nervous branches from thoſe parts are moſt vehemently convulſed. When the nerve of any muſcle is cut or tied, or the baſis of the ſpinal marrow compreſſed, or that part of the brain from whence the nerve has its origin, the muſcle becomes paralytic, and languiſhes, and cannot by any force be recalled into action ſimilar to the vital one. But if the ligature be taken off from the nerve, the force

by which the muſcle is put into action is again recovered by it. The nerve being irritated below the place where it is cut, the muſcle to which that nerve goes is contracted. This appears from numerous experiments, eſpecially thoſe made on the phrenic and recurrent nerves.

404. This force is not the ſame with the vis inſita. The former comes to the muſcle from without; whereas the other reſides conſtantly in the muſcle itſelf. The nervous power ceaſes when life is deſtroyed; after which the other, from certain experiments, appears to remain a long time: it is alſo ſuppreſſed by tying a ligature upon the nerve, by hurting the brain, or by drinking opium. The *vis inſita* ſuffers nothing from all theſe; it remains after the nerve is tied; and continues in the inteſtines though taken out of the body, and cut in pieces: it appears with great ſtrength in ſuch animals as are deſtitute of brain: that part of the body is moved which has no feeling; and the parts of the body feel which are without motion. The will excites and removes the nervous power, but has no power over the *vis inſita*.

405. In the motion of the muſcles, whether owing to the *vis inſita* or the nervous power, the fibres are contracted towards the middle of its belly, and recede from one another outwards: they are alſo diverſified with various tranſverſe wrinkles: the whole muſcle alſo becomes ſhorter, and draws its extremities towards the middle; hence it draws towards each other thoſe parts with which it was connected, in the reciprocal ratio of their ſtrength: the muſcle alſo ſwells by its contraction, becoming hard at the ſame time, and as it were increaſes its circumference on every ſide. I have never obſerved it to turn pale. Whether on the whole it is increaſed in bulk, or acquires more in breadth than it loſes in length, is difficult to be known. It draws after it the tendons, which are obſequious to its motions, though of themſelves neither moveable nor irritable. The whole muſcle is alſo capable of being moved at once, or only a part of it: if one extremity is fixed to an

an immoveable part, that only is moved which is capable of yielding.

406. If it be demanded, Whether the arteries conduce any thing to mufcular motion? and whether the palfy, which falls upon the lower limbs after a ligature upon the aorta, be not an argument thereof? we anfwer, Not at all, further than as they conduce to the integrity of a mufcle, or to the confervation of the mutual ftructure and habit of the parts, which they fupply with vapour, fat, &c: for the irritation of an artery does not affect or convulfe the mufcle to which it belongs; nor does a ligature thereof caufe a palfy, unlefs after a confiderable time, when the mufcles begin to be deftroyed by a gangrene. Moreover, it is impracticable to explain the motion of peculiar mufcles from a caufe derived with an equal force from the heart to all parts of the body. Laftly, the influence of the will is confined to the nerves, without refiding in the arteries or other folid parts of the body.

407. But the direct manner by which the nerves excite motion in the mufcles, is fo obfcure, that we may almoft for ever defpair of its difcovery. And firft, concerning the vis infita, we do not indeed inquire; as this feems to be a more brifk attraction of the elementary parts of the fibre by which they mutually approach each other, and produce as it were little knots in the middle of the fibre. A ftimulus excites and augments this attractive force, which is placed in the very nature of the moving fibre. The other explanations are hypothefes. As to nervous veficles fwelling by a quicker flux of the nervous fpirits, they are inconfiftent with anatomical truth, which demonftrates the leaft vifible fibres to be cylindrical, and in no part veficular; and likewife repugnant to the celerity with which mufcular motion is performed, and with the bulk of a mufcle being rather diminifhed than increafed during its action. Again, the inflation of rhomboidal chains in the fibres is equally repugnant to the celerity, to infpection, and to anatomy; they would alfo occafion an immenfe wafte

of

of ſtrength, and after all render the muſcle but little ſhorter. The nerves want that irritable nature which is obſerved in the muſcular fibre. Finally, it is by no means demonſtrable, that the fibres, from ſo few nerves, can be ſo numerous, or diſtributed in ſo many different tranſverſe directions, with reſpect to the muſcular threads, as thoſe hypotheſes require to be allowed. A complication of the nerves round the extremities or fibres, ſo as to contract them by their elaſticity, is founded upon a falſe ſtructure of the muſcular fibre, ſuppoſing the nerves to be diſtributed, where filaments of the cellular ſubſtance only can be demonſtrated. Moreover, the phenomena of animals which, having neither brain or nerves, are yet very apt for motion, apparently demonſtrate the intrinſic fabric of the muſcles to be ſufficient for their motion, without other aſſiſtance from the nerves. Other explanations, derived from ſpherules full of air in the blood, ſuppoſe a falſe nature of that fluid; namely, a repletion of it with elaſtic air, of which it has none, (281.) The animal ſpirits are not of the nature of an electric torrent.

408. If we may add any thing to theſe phenomena, you may ſuppoſe the nervous liquor to be of a ſtimulating nature, by which means it forces the elementary particles of the muſcular fibre to approach nearer to each other. The motive cauſe which occaſions the influx of the animal ſpirits into the muſcle ſo as to excite it into action, ſeems not to be the ſoul, but a law derived immediately from God. For animals newly born, or newly transformed, without any attempt, or exerciſe, know how to execute compound motions very difficultly to be defined by calculation. But the ſoul learns thoſe things which it does, very ſlowly, imperfectly, and by making experiments. That muſcle then is contracted which in a given time receives more of the nervous fluid, whether that be occaſioned by the will, or by ſome irritating cauſe ariſing in the brain, or applied to the nerve.

409. But, tho' you may conjecture the ſoul to be the cauſe

cauſe of the nervous motion, you cannot do the ſame with regard to that ariſing from the vis inſita. The heart and inteſtines, alſo the organs of generation, are governed by a vis inſita, and by ſtimuli. Theſe powers do not ariſe from the will; nor are they leſſened, or excited, or ſuppreſſed, or changed by the ſame. No cuſtom nor art can make theſe organs ſubject to the will, which have their motions from a vis inſita: nor can it be brought about, that they ſhould obey the commands of the ſoul, like attendants on voluntary motion. It is ſo certain that motion is produced by the body alone, that we cannot even ſuſpect any motion to ariſe from a ſpiritual cauſe, beſides that which we ſee is occaſioned by the will; and, even in that motion which is occaſioned by the will, a ſtimulus will occaſion the greateſt exertions when the mind is very unwilling.

410. There ſeems to be this difference between the muſcles obeying the will, and thoſe which are governed by a vis inſita; namely, that the latter, being more irritable, are very eaſily excited into motion by a gentle ſtimulus; as for inſtance, the heart and inteſtines; which organs are moſt manifeſtly, and greatly, and conſtantly, irritable. On the other hand, the muſcles which obey the will, are neither endowed with ſo great nor ſo durable a power of this kind. Hence, they either ſtand in need of the power of the will, or a ſtronger ſtimulus; by which, indeed, when they are excited, even theſe are animated to motion againſt the will. Thus it happens, that, in apoplexies, the muſcles which obey the will, languiſh, and become paralytic, as being deſtitute of all influx from the brain; while the vital muſcles, having no occaſion for the operation of the brain, continue to be excited into contraction by their ſtimuli; the heart by the blood, and the inteſtines by the air and aliments.

411. The ſtrength of this action in the muſcles is very conſiderable in all perſons, but more eſpecially in thoſe who are phrenetic, and ſome who are called ſtrong men; ſince frequently, with the uſe of a few muſcles only,

only, they will eafily raife a weight equal to, or much greater than, that of the whole human body itfelf. For even in one who is in his fenfes, very flender mufcles fuffice to elevate 200 or 300 pounds. The mufcles of the back will even fuftain 3000. Notwithftanding this, we fee, that much the greater part of the force or power exerted by a mufcle is always loft without producing any vifible effect. For all the mufcles are inferted nearer the point or centre of motion, than the weights they are applied to; and therefore their action is weaker, in the fame proportion as they move a fhorter part of the lever, than that to which the weight is applied. Moreover, in moft of the bones, efpecially thofe of the limbs, the mufcles are inferted at very acute angles; whence again the effect which a mufcle exerts in action, is proportionably lefs as the fine of the angle intercepted betwixt the bone and the mufcle is lefs than the whole fine. Again, the middle part of all mufcular force is loft, becaufe it may be reckoned as a cord extended, and drawing an oppofite weight to its fixed point. Again, many of the mufcles are feated in the angle of two bones, from one of which arifing they move the other; and therefore, that bone being moved, they are bent, and of courfe, like an inflectsd cord, require a new force to extend them. Many of them pafs over certain joints, each of which they bend in fome degree, whereby a lefs part of their remaining force goes to bend the joint to which they are particularly deftined. The flefhy fibres themfelves of the mufcles frequently intercept angles with the tendon in which they terminate; from whence a great part of their force is loft, as much as is equal to the difference or deviation betwixt the fine of the angle of their infertion and the whole fine. Finally, the mufcles move their oppofed weights with the greateft velocity and expedition, fo as not only to overcome the equilibrium, but likewife to add a confiderable celerity to the weight.

412. All thefe loffes of power being computed, make it evident, that the force exerted by mufcles in their con-

contraction, is exceeding great beyond any mechanical ratio or proportion whatever; since the effect is scarce $\frac{1}{60}$ of the whole force exerted by the muscle, and yet only a small number of these muscles, weighing but a few pounds, are able not only to raise some thousands of pounds, but also with a considerable celerity. Nor is this to be reputed any defect of wisdom in the Creator. For all those losses of power were necessary towards a just symmetry or proportion of the parts, with the various motions and celerities required by the muscles to act in different directions; all which have no share in the composition of engines mechanically. But we may, however, conclude from hence, that the action of the nervous or animal fluid is very powerful, since, in an engine so small, it can exert a force equal to some thousand pounds for a considerable time, or even for many days together; nor does this seem to be otherwise explainable, than by the incredible celerity by which the influx of this fluid obeys the command of the will. But how, or from whence, it acquires such a velocity, is not in our power to say; it is sufficient, that we know the laws of its motion are such, that a given action of the will produces a new and determinate celerity in the nervous fluid or juice.

413. The easy and sudden relaxations of muscles in their motion are assisted by the actions of their *antagonist* muscles. Namely, in all parts of the body every muscle is counterpoised by some weight, elasticity, an opposite muscle, or a humour acting against the cavity of a muscle, by which it is expelled. This cause, which is a vis insita, continually operates as long as the muscle acts; and so soon as the additional celerity derived from the brain abates, it restores the limb or other part immediately to its former easy state, in which there is an equilibrium betwixt the muscle and its opposing cause. Whenever the antagonist power is removed from the muscle, there are none of them but must contract, extending their opposites, by which the distended nerves excite an uneasy sense, and cause a stronger endeavour

towards recovering the equilibrium. Hence one of the flexor muſcles being cut in two, the extenſor operates even in a dead body; and the reverſe.

414. But there are other means, by which the motions of the muſcles are rendered more ſafe, certain, and eaſy. The large long muſcles, by which the greater motions of flexure are performed, being included in tendinous capſules or caſes, drawn and tightened by other muſcles, are thus ſecured and ſtrengthened; for ſo the muſcle remains preſſed againſt the bone, in a ſtate of contraction, all the time that the limb is bent, and avoids a conſiderable loſs of its power. But the long tendons, which are incurvated or extended over joints in their motion, are received and confined by peculiar bands, which retain them within their ſlippery channels, and keep them from ſlipping out under the ſkin; which diſlocation of the tendon, whenever it happens, is attended with a cramp of the muſcle, ſevere pain, and loſs of motion. The ſame kind of guidance or direction is received by ſome of the muſcles, which perforate others in their courſe. In other parts, the tendons are either carried round certain eminences of the bone, in order that they may be inſerted at greater angles into the bone which they move; or elſe they are inſerted into another bone, from whence a different tendon deſcends under a larger angle into the bone to be moved. In other parts, the muſcles which are derived from convenient ſituations, have their tendons carried round in a contrary direction by nature, ſo that they paſs into the part to be moved as it were round a pully. Nature has likewiſe ſurrounded the muſcles on all ſides with fat, which is ſpread alſo betwixt their bundles of fibres and the ſmall fibres themſelves which lie contiguous together; which fat, being preſſed out by the turgeſcence of the muſcles and fibres, renders them ſoft, flexible, ſlippery, and fit for motion.

416. Moreover, the power and action of one muſcle is determined by the co-operations or oppoſitions of others, which ſerve either to hold firm ſome part from whence

whence the muſcle ariſes, or to bend it together with the muſcle, or elſe to change its action from the perpendicular to the diagonal, by concurring to aſſiſt its force at the ſame time. The muſcles alſo aſſiſt one another, even thoſe which are ſeparated at a conſiderable diſtance, the firſt keeping the bone firm which is not to be moved, and out of which the ſecond ariſe. Therefore, the action of no one muſcle can be underſtood from conſidering it alone; but all the others muſt likewiſe be brought into the conſideration, which are either inſerted into the muſcle itſelf, or into any of the parts to which the ſaid muſcle adheres.

417. By theſe muſcles, variouſly conſpiring and oppoſing each other, are performed walking, ſtanding, flexion, extenſion, deglutition, and all the other geſtures and offices of the ſeveral parts in the living body. But the muſcles have likewiſe ſome common or public actions, by which they are of uſe to the whole animal. They haſten the return of the venous blood, by preſſing it out from the veins both of the muſcles themſelves as well as of the veins which lie betwixt them; for the blood in theſe veſſels, diſtributed betwixt the turgid bundles of a contracted muſcle, is, by the valves, determined towards the heart only: they likewiſe return the fat to the blood; and ſhake, grind, or denſify the arterial blood, and return it quicker to the lungs. Again, in the liver, meſentery, womb, &c. they promote the courſe of the contained blood, bile, and other juices, ſo as to leſſen the danger of their ſtagnation: they ſerve alſo to increaſe the ſtrength of the ſtomach, by adding their own ſtrength to it, whereby digeſtion is promoted; inſomuch that all ſedentary and inactive courſes of life are contrary to nature, and pave the way to diſeaſes from a ſtagnation of the humours, or from a corruption or crudity of the aliments. The large muſcles, which are generally placed round any of the cavities of the body, propel the blood contained in that cavity, and preſs it towards the heart. But by too much exerciſe or action, the muſcles

themfelves grow hard and tendinous on all fides; render the parts upon which they are incumbent cartilaginous, or elfe change thofe which are membranous into a bony nature; increafe the roughnefs, protuberances, and proceffes, of the bones which lie next to them, and excavate their flat parts; dilate the cells feated in the diplöe; and bend the bones towards thefe parts.

418. The mufcle which the ftimulus has ceafed to irritate, or for the action of which the mind has no occafion, is relaxed, and grows foft; its wrinkles are filled up, and grow plain; its fibres are rendered longer, receding from the middle towards the fixed extremities; and its fwelling falls. Whatever is the caufe of additional contraction is then taken away; but that remains without which the mufcle never is as long as it is alive. Nor is this the work of an antagonift mufcle, although it may be affifted by it. It may be afked, What becomes of the fpirit that is fent forth from the brain? A part of it perhaps exhales; I fufpect a part to adhere to the fibre; and that thus it happens that the mufcles grow ftrong with exercife, and their brawny parts become thicker.

CHAP. XIII.

Of the Senfe of TOUCH.

419. THE other office of the brain and nerves is to *perceive;* that is, to fuffer a change from the actions or impreffions of external bodies, and thereby excite other correfponding changes or reprefentations in the mind. We fhall, therefore, firft lead our examination to each of the fenfes in particular; and then confider what is common to all of them, with the changes which follow from thence in the common fenfory and in the mind.

420. The fenfe of touch is underftood in a twofold manner. For, by this term, in general, we call all changes

changes of the nerves, arifing from heat, cold, roughnefs, fmoothnefs, weight, moifture, drynefs, or other affections of external bodies, in whatever part or organ they are applied to caufe a change. In this fenfe, the touch is afcribed to almoft all parts of the human body, to fome more, to others lefs; as in different places of the body the nerves are more numerous and bare, or covered with more tender membranes; and thus even pain, pleafure, hunger, thirft, anguifh, itching, and the other fenfations, belong to the fenfe of feeling.

421. But, in a fomewhat different and more proper acceptation, the fenfe of touch is faid to be the change arifing in the mind from external bodies applied to the fkin, more efpecially at the ends of the fingers. For, by the fingers, we more accurately diftinguifh the tangible qualities of things than by other parts of our body.

422. Indeed, this fenfe does not eafily diftinguifh any particles by the fkin, which it does not touch. But fince the touch is more peculiarly afcribed to the cutaneous papillæ, therefore the ftructure of the fkin is to be firft defcribed. That part, then, which is called the *true fkin*, is compofed of a thick cellular net-work, whofe fibres and plates are clofely compacted and interwove together in an intricate manner, which renders it porous, and capable of contracting or dilating to a furprifing degree. Its ftrata, when expofed to the air by turning up the epidermis, become more clofely compacted together; the fame is infenfibly relaxed towards fat, and is refolved into a fofter cellular texture. It is more tender in fome places, and in others more hard. Within this fubftance run many fmall arteries, which come from the fubcutaneous ones, which, tho' neither large nor of a very great length, are yet numerous in fome parts of the fkin, which look red, as in the cheeks; but in other parts they are fewer in number. The veins arife in great numbers from the fubcutaneous net-work, and the nerves likewife in the fkin are very numerous; but they vanifh fo fuddenly, that it is very difficult to trace the ultimate extremities

of

of them. Betwixt the ſkin and muſcles is placed the cellular fabric, into which the ſkin is inſenſibly reſolved, in moſt parts repleniſhed with fat, the little eminences of which preſs upon the ſmall hollows of the ſkin; but in ſome, as the penis, red part of the lips, &c. it is deſtitute of fat. There are very few parts in the body of man where the ſkin is immediately joined to the muſcular fibres without any ſeparation by fat or cellular ſubſtance; for, though the dartos of the teſticle has no muſcular fibres, it is not without the cellular ſubſtance. There are ſome places, indeed, where tendinous fibres are inſerted into the ſkin; as in the neck, in the palms of the hands, and ſoles of the feet.

423. Throughout the whole ſurface of the ſkin in moſt parts of the body, but with ſome difficulty, you will find it to have a rough appearance after the cuticle is taken off; but in the human body theſe are ſo obtuſe, that, unleſs you underſtand them to be very minute granulations, they are raiſed hardly any viſible height above the ſkin. But in the ends of the fingers there are larger round *papillæ* ſeated in cavities of the cuticle, and receiving nerves very difficultly ſeen; namely, a little mount or protuberance formed of ſmall veſſels, with one or more ſmall nerves wrapped up together in the cellular ſubſtance. Theſe, in the lips and glans penis, after long maceration, appear villous or down-like; and are ſeen moſt evidently of all in the tongue, from the fabric of which we conclude, by analogy, with reſpect to the other cutaneous papillæ.

424. Over the ſurface of the ſkin is placed another covering, which is not ſo liable to be injured by the air, and which coheres with the ſubjacent ſkin by an infinite number of ſmall bloodleſs veſſels, and by hairs which paſs through its ſubſtance. The outer ſurface of this covering, as it were of an horny fabric, is dry, inſenſible, and not ſubject to putrefaction; but, being deſtitute of veſſels and nerves, it appears in a particular manner wrinkled and ſcaly, and is joined to the ſkin by a kind of net-work. This is called the *epidermis* or *cuticle*,

cuticle, which is perforated by an infinite number of pores, ſome larger for the ſweat, and others ſmaller for the perſpirable vapours, out of whoſe ducts, expanded and cemented by the interpoſition of a condenſed glue, the ſubſtance of the cuticle is probably compoſed. By preſſure or burning, the cuticle grows thicker, by the addition of new plates or ſcales, formed betwixt the ſkin and thoſe which lie outermoſt; and this is called *a callus*. But even naturally, in Blacks, the cuticle has two diſtinct plates.

425. The inner ſurface of the cuticle is more ſoft and like a pulp, ſomewhat like an half fluid or a concreted mucus; whence, by macerating ſome time in water, it ſeparates from the former, difficultly in Europeans, but eaſily in the Blacks, where it is truly membranaceous, ſolid, and ſeparable, as in the palate of brutes. This ſurface of the cuticle lies incumbent on the ſkin itſelf, whoſe papillæ, in thoſe parts where they are to be found, are received into the ſoft cuticular alveoli or ſockets. This is commonly called *rete Malpighianum*, although it be certain there are no perforations viſible through it, like thoſe of a ſieve.

426. That this reticular body is compoſed of a humour, tranſuding from the ſurface of the true ſkin, ſeems very probable. As to the fabric of the cuticle itſelf, it is obſcure; for ſince it is both caſt off, or regenerated, inſenſible, and deſtitute of veſſels, it does not ſeem to belong to the organical parts of the body. Whether is it the outer part of the Malpighian mucus (425.), coagulated and condenſed by the air and by preſſure; after being perforated with a number of exhaling and inhaling ducts, the mouths of which are cemented together by the interpoſed condenſed glue? and whether or not are we perſuaded to this opinion by the mucous expanſion upon the membrane of the tympanum? to which add, the diſſolution of it in water, obſerved by the more eminent anatomiſts; which experiment is by others denied in the cuticle of Blacks.

427. More-

427. Moreover, to the hiſtory of the ſkin belong the ſimple glandules, which are ſeated in very many places under the ſkin in the cellular fabric; from whence perforating the ſkin by their excretory duct, they pour out a ſoft half fluid liniment. Other ſebaceous glandules, partly ſimple and partly compound, generate a dry white liniment, of an harder conſiſtence in the face, but more oily in the groins and arm-pits, with which the ſkin being anointed, ſhines, and is defended both from the air and outward attrition. They are found ſeated in all parts of the body that are under a neceſſity of being more immediately expoſed to the air, as in the face, where there are a great number of the compound ſort; or wherever the ſkin is liable to any great attrition, as in the arm-pits, nipples, groins, glans penis, nymphæ, anus, and hams. They frequently ſend out hairs. If it be aſked, Whether theſe follicles are ſeated in all parts of the ſkin? we anſwer, That, although anatomy does not every where demonſtrate them, yet it ſeems probable that they are in no part abſent, as may appear from the ſordes collected about the whole ſurface of the body, ſeemingly of the ſebaceous kind. But there is another ſort of liniment or oily ointment poured out upon the ſkin from the fat itſelf, by its particular pores, without the intervention of glands (209.); and this more eſpecially where the ſkin is clothed with hair, as in the ſcalp.

428. Again, both the *hair* and nails are appendages to the ſkin. The former are ſcattered over almoſt the whole ſurface of the body, the palms of the hands and ſoles of the feet excepted; in moſt parts ſhort and ſoft; but longer upon the head, mouth, cheeks, and chin, with the breaſt in men; alſo, upon the forepart of the limbs, in the arm-pits, groins, and pubes. They ariſe from the cellular texture lying under the ſkin, originating from a little bulb which is membranous, ſtrong, vaſcular, and of an oval ſhape, and more lax towards the cellular texture, (and from this baſis the hairs are augmented by veſſels); in which little bulb another bulb lies

lies hid, at firſt roundiſh, but afterwards cylindrical, and ſurrounded with blood. In that ſecond bulb lies the hair, laid over with a fat humour. The hair, with both its cylindrical ſheaths, comes to the cutaneous hole, goes out through the ſame paſſage, and forces the epidermis into a ſimilar ſheath; from whence the incorruptibility of the hair: and then the cover cannot be ſeparated farther from the cortex; but the filaments, and ſpongy and cellular matter, are continued throughout the whole length of the hair. The hairs grow naturally in the cellular ſubſtance under the ſkin; but, by diſeaſe, they are ſometimes formed within the fat of other parts. They grow continually; and are renewed again, after being cut, by a protruſion of their medullary ſubſtance from the ſkin outward, under a production of the cuticle. When the hairs are deſtitute of this medulla in old people, they dry up, ſplit, and fall off. Their colour is from the juice, which fills the internal cellular texture. They ſeem to perſpire through their extremities, and poſſibly throughout their whole ſurface; as we may conclude from the conſtant force of protruſion in their medulla, which, in the plica Polonica, wants a boundary to terminate it. To which add, the luminous ſtreaks or rays that come out from the hairs of an animal electrified. The ſubcutaneous fat, or oil, ſeems to follow, and tranſude through the medullary tract and pores of the hairs.

429. The *nails* are of the nature and fabric of the cuticle; like which they are alſo inſenſible, and renewable after being cut or fallen off. They are found placed upon the backs of the ends of the fingers and toes, which they ſupport, to make a due reſiſtance in the apprehenſion of objects, having the nervous papillary bodies, that ſerve the organ of touch, placed under their lower ſurface. They ariſe with a ſquare root, intermixed with the perioſteum, a little before the laſt joints, from betwixt the outer and inner ſtratum of the ſkin; and paſſing on ſoft, go out by a lunar cleft in the external plate of the ſkin, where the cuticle returns

 back,

back, and is partly laid over the outſide of the nail, together with which it is extended forward as an outer covering. The nail itſelf is of a ſoft tender fabric where it firſt ariſes, partly covered by the ſkin; but, by age and contact with the air, it in time hardens into a ſolid, horny, and elaſtic body, compoſed of long hair-like threads, cemented together by interpoſed glue, and diſtinguiſhable from each other by intervening ſulci or furrows, by which one may be able to ſplit them into a number of leſſer orders. The nail thus formed, extends itſelf to the extremity of the finger; and is, in this tract, lined all along internally within its concave ſurface, by an expanſion of the true ſkin, and ſubjacent perioſteum intermixed; the filaments of which ariſe firſt ſhort, and are afterwards continued of a greater length, till they become longeſt of all at the extremity of the nail to which they cohere. Theſe are moſt intimately connected into the root of the nail. Over the outer ſurface of the nail, ſome part of the ſkin is again at liberty, and lies under the nail, and diſtinct from it, and has its own epidermis. A furrowed net-work is interpoſed betwixt the ſkin and nail, which is alſo eaſily ſeparable and ſoft, for the protection of the papillæ; from thence the furrows grow gradually harder, ſo that at laſt they can ſcarce be diſtinguiſhed from the nail. The tendons do not reach quite ſo far as the nail.

430. The cellular ſubſtance is without fat, except in a few places to allow a neceſſary motion to the ſkin. Where it is repleniſhed with the fat, it ſerves to defend the warmth of internal parts from the cold air; to render the ſkin moveable upon the muſcles; to fill up the cavities betwixt the muſcles themſelves; and to render the whole body white and uniform. The ſkin, cuticle, and its Malpighian mucus, ſerve not only to limit the external bounds of the body every where; but likewiſe, where they ſeem to be perforated, paſſing inward, they degenerate by degrees. For the cuticle is manifeſtly extended into the anus, urethra, vagina, cornea of the eye, auditory paſſage, mouth, and tongue; nor is it wanting

wanting even in the ſtomach itſelf and inteſtines; although, by the perpetual warmth and moiſture, its fabric be altered, and extended or relaxed into their villous covering. Thus the true ſkin is continued into the internal fabric of the palate, tongue, pharynx, noſtrils, vagina, &c. where it degenerates always into a white, thick, pulpy, commonly called nervous, coat of thoſe parts.

431. What has been hitherto advanced, is ſufficient to enable us to underſtand the nature of touch. The papillæ, ſeated in the larger winding ridges at the ends of the fingers, regularly diſpoſed in ſpiral folds, are, by the attention of the mind, a little raiſed or erected; as appears from frights or ſhiverings; as we ſee in the nipples of women, in the handling of tangible objects, and by light friction; whereby, receiving the impreſſion of the object into their nervous fabric, it is thence conveyed, by the trunks of the nerves, to the brain. This is what we call the *touch*, whereby we become ſenſible chiefly of the roughneſs of objects; in which ſome perſons have ſo ſharp a ſenſation, that they have been known to diſtinguiſh colours by touching the ſurface only. By this ſenſation we perceive heat, when it exceeds in bodies the heat of our fingers; and weight likewiſe, when it preſſes more than is uſual. Humidity we judge of by the preſence of water; ſoftneſs, by a yielding of the object; hardneſs, from a yielding of the finger; figure, from the limits or rough circumſcribed ſurface; diſtance, from a rude calculation or eſtimate made by experience, to which the length of the arm ſerves as a meaſure: ſo the touch ſerves to correct the miſtakes of our other ſenſes; but yet it ſometimes errs itſelf, and then the other ſenſes ſhew themſelves to be true guides to the animal without that of touch.

432. The mucous body of Malpighius moderates the action of the tactile object, and preſerves the ſoftneſs and ſound ſtate of the papillæ. The cuticle excludes the air from withering and deſtroying the ſkin; qualifies the impreſſions of bodies, ſo that they may be only

ſufficient to affect the touch, without cauſing pain: and, therefore, when it is become too thick by uſe, the ſenſe of feeling is either loſt or leſſened; but if it be too thin and ſoft, the touch becomes painful. The hairs ſerve to defend the cuticle from abraſion; to preſerve and increaſe the heat; to cover and conceal ſome parts, and render the membranes of others irritable, which nature required to be guarded from the entrance of inſects; and perhaps they may ſerve to exhale ſome uſeleſs vapours, or afford a paſſage to the exhaling oil. The nails ſerve to guard the touch, that the papillæ and ends of the fingers may not be bent back by the reſiſtance of tangible objects: at the ſame time they increaſe the power of apprehenſion, and aſſiſt in the handling minute objects. In brute animals, they generally ſerve as weapons of offence; and might be of the ſame uſe to man, if they were not cut off.

433. But theſe are not all the uſes of the ſkin. For one moſt important office of that covering is to exhale from the body a large quantity of humours and other matters to be carried off by the air. Accordingly, the whole ſurface of the ſkin ſweats out a vapour by an infinite number of ſmall arteries, either coiled up into papillæ, or ſpread on the ſkin itſelf, which paſs out, and exhale through correſponding pores of the cuticle; although the courſe or direction of the veſſels which pour out this vapour be changed in paſſing from the ſkin to the cuticle. Theſe exhaling veſſels or arteries are eaſily demonſtrated by an injection of water or fiſh-glue into the arteries; for then they ſweat out from all parts of the ſkin an infinite number of ſmall drops, which being transfuſed under the cuticle, rendered impervious by death, raiſe it up into a bliſter.

434. In a living perſon, this exhalation is many ways demonſtrable. A clean looking-glaſs, placed againſt the warm and naked ſkin, is quickly obſcured by the moiſt vapour. In ſubterraneous caverns, where the air is more denſe, it more plainly goes off into the air, from

from the whole ſurface of the body, in the form of a viſible and thick cloud.

435. Whenever the motion of the blood is increaſed, while at the ſame time the ſkin is hot and relaxed, the ſmall cutaneous pores, inſtead of an inviſible vapour, diſcharge *ſweat*, conſiſting of minute, but viſible drops, which run together into larger drops by joining with others of the ſame kind. But thoſe parts chiefly are ſubject to ſweat which are hotteſt; that is to ſay, where the ſubcutaneous arteries are largeſt, and have a greater action from their reſiſtance, as in the head, breaſt, and foldings of the ſkin. The experiment before mentioned (433.), together with the ſimplicity of nature herſelf, joining with the viſible thickneſs or cloudineſs of the cutaneous and pulmonary exhalation (434.), ſufficiently perſuades us, that the perſpirable matter and ſweat are diſcharged through one and the ſame kind of veſſels, and differ only by the quantity and celerity of the matter. But together with the ſweat is intermixed the humour of the ſebaceous glands (427.) and the ſubcutaneous oil, which being more plentifully ſecreted, and diluted with the arterial juice, flows out of an oily and yellow conſiſtence, and chiefly gives that ſmell and colour to the ſweat for which it is remarkable. Hence we find it more fetid in the arm-pits, groins, and other parts, where thoſe glandules are moſt numerous or abundant. Both blood and ſmall ſand have been known to proceed from the ſkin along with the ſweat.

436. Concerning the nature of *perſpiration*, we are to inquire by experiments, and by analogy with the pulmonary exhalation, which more frequently and abundantly perſpires a vaporous cloud of the ſame kind, more eſpecially viſible in a cold air. That what flies off from the body in this exhalation is chiefly water, appears from experiments, by which the breath, being condenſed in large veſſels, forms into watery drops. Agreeable with this, we find the obſcuring vapour condenſed by a looking-glaſs to be extremely ſubtle, ſo

as wholly to fly off again from it ; and the ſame is confirmed by the obſtructed matter of perſpiration paſſing off by urine, or frequently changing into a diarrhœa ; and from the eaſy paſſage of warm liquors in the form of perſpiration by a hot air, or elſe by the urinary paſſages in a cold air. The water of theſe vapours is chiefly from what we drink, but is in part ſupplied from the inhalation of the ſkin. Frequently, even the particular ſmell of the aliments may be plainly perceived in the perſpiration ; and there is alſo an admixture of the electrical matter in every perſon, but in ſome it is more evidently lucid.

437. But that there are, beſides water, ſome volatile particles intermixed of an alkaline nature, is evident, as well from the nature of our blood, as the conſiderable miſchiefs which follow from a retained perſpiration. This volatile alkaline matter ariſes from the finer particles of the blood, attenuated by perpetual heat and triture, and changed into an acrimonious nature. Theſe afford the ſcent which is cloſely followed by dogs, who would not know their maſters unleſs ſomething of a particular nature perſpired from each perſon.

438. The quantity of our perſpiring moiſture is very large, whether we conſider the extent of the organ by which it is ſeparated, the abundance of vapours derived from the lungs only ; or barely take a review of the experiments made by Sanctorius, in which five pounds out of eight, but by other experiments in a colder country from fifty-ſix to thirty ounces, of the food and drink taken into the body in a natural day, were found to fly off by perſpiration only, excluſive of any of the viſible diſcharges, and without making any addition to the weight of the body ; but from this weight you muſt deduce that of the ſaliva, mucus of the noſe, and ſweat. But the cutaneous exhalation is even much larger than this ; ſince it is not only throws off ſuch a quantity of the indigeſted food and drink, but likewiſe what is added to the blood by the way of inhalation (442.), which entering, often in a very conſiderable quantity, is thus again expelled.

expelled. But different difpofitions of the air, and of the human body, caufe great variations in thofe matters. In warm countries, in the fummer-months, and in young exercifed perfons, more goes off by tranfpiration from the body, and lefs by the urine. But in cold climates, during the temperate or winter feafons, in aged or inactive perfons, more goes off by the urine than by the infenfible difcharge. But in temperate countries, making a computation throughout the whole year, fomething more is perfpired than what paffes off by urine; and joining together all the experiments made in different countries, both excretions are almoft alike. The difference of time after feeding does alfo in fome meafure vary the quantity tranfpired; but in general it is moft copious at that time when the greater part of the digefted nourifhment is conveyed into the blood, and therewith attenuated fo as to be fit for exhalation. It is naturally diminifhed in fleep, even in the warmer climates; but it is increafed by the heat of bed-cloaths.

439. In general, a plentiful and uniform perfpiration, with ftrength of body, are good figns of health; for whenever it abounds from too great weaknefs, it is obferved to do more mifchief than none at all, if the writings on that head are fufficiently to be depended on. It is thus a fign of health, becaufe it denotes a free pervious difpofition of the veffels difperfed throughout the whole body, together with a complete digeftion of the nourifhment, the greater part of which is perfectly attenuated into a vapour. When it is diminifhed, it indicates either a conftriction of the fkin, a weaknefs of the heart, or an imperfect digeftion of the aliments. Perhaps in too great a perfpiration the nervous fpirits themfelves are evaporated. This difcharge is, by moderate exercife, increafed to fix times that of an idle perfon, even to an half or whole pound in an hour, aided by ftrong and open veffels, by warm, watery, and vinous drinks, with animal food of an eafy digeftion, and a heavy, temperate, or moderately warm air,

air, aſſiſted with joyful affections of the mind. The contrary of theſe either leſſen or ſuppreſs the perſpiration; as thick ſkin, a moiſt air, or a cold and dry one, with reſt, more frequent bathing than uſual, or from a diarrhœa ſuddenly ariſing, and laſtly from a nervous concuſſion from a diſagreeable affection of the mind. However, the continuance of life does not depend on a ſcrupulous exactneſs in the quantity of this diſcharge, which is ſo eaſily increaſed or diminiſhed by ſlight cauſes; which is ſhut up by paints in many Indian nations, and is inconſiderable in many animals without any ſenſible injury. When it is ſuppreſſed, it does a prodigious deal of miſchief in fevers of a bad kind; it hurts chiefly by its putreſcent qualities, which are retained by ſuppreſſed perſpiration.

440. The ſweat is evidently of a ſaline nature; as appears both from the taſte, and from the minute cryſtals which ſhoot upon the cloaths of ſuch as work in glaſs-houſes; as well as by diſtillation, which ſhows the ſweat to be of an alkaline nature. Hence it is, that by this diſcharge the moſt malignant matter of many diſeaſes is thrown off from the body. But, in reality, ſweat is always a preternatural or morbid diſcharge, from which a perſon ought always to be free; unleſs by violent exerciſe, or other accidents, his conſtitution is for a ſhort time thrown into a diſeaſed ſtate. Nor is it unfrequent for ſweats to do conſiderable miſchief in acute diſeaſes; by waſting the watery parts, and thickening the reſt of the blood, at the ſame time that it renders the ſalts more acrimonious. By a too violent motion of the blood, the ſweat is rendered extremely fetid; and is ſometimes even red, or mixed with blood itſelf: being electrized, it ſometimes is lucid.

441. The uſes of perſpiration are, to free the blood from its redundant water, and throw out thoſe particles which, by repeated circulations, have become alkaline or otherwiſe acrimonious; and poſſibly to exhale therewith an extremely volatile oil, prepared from the ſame blood. The ſame perſpiration likewiſe quali-

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fies and ſoftens the cuticle, which is a neceſſary medium extended before the tender ſenſible papillæ.

442. But the ſame ſkin that makes this exhalation into the air, is likewiſe full of ſmall veſſels, which inhale or abſorb thin vapours from the air, either perpetually, or at leaſt when it is not very cold; more eſpecially when the air is damp, the body unexerciſed, the mind oppreſſed with grief, or both under conditions contrary to thoſe which increaſe perſpiration beforementioned (438.) Theſe veins are demonſtrated by anatomical injections, which, if thin or watery, ſweat through them in the ſame manner as through the arteries, if it was watery and thin: moreover, the manifeſt operation of medicines in the blood, which were exhaled into the air, or applied to the ſkin, prove the ſame; ſuch as the vapours of mercury, turpentine, ſaffron, Bath-waters, mercurial plaſters, tobacco, coloquintida, opium, cantharides, arſenic, with the fatal effects of contagious or other poiſons entering through the ſkin; as in the venereal infection: to which add, the living of animals almoſt without drink in hot iſlands, which abound with moiſt vapours; from which, however, they ſweat and piſs plentifully enough. Laſtly, ſome extraordinary morbid caſes have demonſtrated this, in which a much greater quantity of urine has been diſcharged than the quantity of drink taken in; in which you may believe that the moſt open paſſages ſerved for inhalation; that new ones were generated, is not credible. The proportion of this inhalation is difficult to aſſign; but that it is very great in plants, more eſpecially in the night-time, appears evidently from certain experiments.

443. Theſe cutaneous veſſels, both exhaling and inhaling, are capable of contraction and relaxation by the power of the nerves. The truth of this appears from the effects of paſſions of the mind; which, if joyful, increaſe the circulation, and relax the exhaling veſſels, ſo as to yield eaſier to the impulſe of the blood; from whence, with a ſhortening of the nerves, there

follows a redneſs, moiſture, and turgeſcence of the ſkin. Thoſe paſſions, on the contrary, which are ſorrowful, and retard the circulation, contract the exhaling veſſels; as appears from the dryneſs and corrugation of the ſkin, like a *gooſe-ſkin*, after frights; and from a diarrhœa cauſed by fear. But the ſame affections ſeem to open and increaſe the power of the inhaling veſſels, whence the variolous or peſtilential contagions are eaſily contracted by fear.

CHAP. XIV.

Of the TASTE.

444. FROM the ſenſe of touch, and its organ, there is but a ſmall difference or tranſition to that of the *taſte;* which appears by certain experiments to be ſeated in the tongue chiefly; for even ſugar applied to any other part of the mouth, excites ſcarce the leaſt ſenſe of taſte in the mind: neither will any other ſapid body, unleſs it contains ſomething vehemently penetrating; in which caſe the palate, root of the tongue, uvula, and likewiſe the œſophagus, are affected with the taſte. That ſenſation which is ſometimes excited in the ſtomach, œſophagus, and fauces, by the regurgitation of the aliments, ſeems alſo to belong to the tongue, to which the ſapid vapours are ſent back, uncommonly acrid and penetrating: and even that ſenſe which is ſometimes occaſioned in the ſtomach, œſophagus, and fauces, from a riſing of the aliments, ſeems alſo to be owing to the tongue, to which the taſtable vapours are conveyed.

445. Only the upper and lateral edges of the *tongue* are fitted to exerciſe the ſenſe of taſte. But by the *tongue* we underſtand a muſcular body, broad and ſulcated in man, and lodged in the mouth, whoſe poſterior and lower parts are variouſly connected to the adjacent bones and cartilages, while it remains moveable in

in its anterior and upper part. In thoſe portions of the tongue, which make the organ of taſte, the ſkin grows to the adjacent muſcular fibres, being continued from the ſkin of the face and mouth; only here it is always ſoft and pulp-like, from the perpetual warmth and moiſture. From this ſkin ariſe innumerable nervous *papillæ*, of a more conſiderable bulk here than in other parts. Of theſe there are ſeveral kinds: the firſt of them are diſpoſed in a rank on the back part of the tongue, on each ſide of the foramen cæcum. Theſe, ſurrounding that opening like a circle, are for the moſt part like an inverted cone, having a deep ſinus in their middle; but are otherwiſe hard, and but indifferently diſpoſed for taſting, although you can eaſily trace the nerves to them. There are ſome other papillæ of the ſame kind found ſcattered before theſe upon the back of the tongue.

446. Theſe degenerate into a kind of papillæ like muſhrooms, leſs and ſlenderer than the former, of a very cylindric and ſomewhat oval figure, placed at ſome ſmall diſtance from each other, upon the upper ſurface of the tongue, where they grow ſharper pointed as they lie more forwards, and are moſt numerous on the ſides of the tongue. The third ſort of papillæ are of a conical figure, which abound moſt in number among the former, and are ſpread largely over the tongue. Theſe have their apices ſomewhat inclined and fluctuating before, towards the tip of the tongue; theſe are likewiſe moſt numerous in the ſides of the tongue, though there are ſome alſo behind the blind foramen. They are highly ſenſible, and make the true organ of taſte: other papillæ lie between, which are partly conical, and partly ſhaped like threads; and ſome of the conical ones are greater, and the others grow always leſs and leſs.

447. Theſe papillæ have doubtleſs ſmall nerves detached into them, beſides numerous veſſels, although they are difficult to trace; for we obſerve, that larger nerves go to the tongue, than almoſt in any inſtance

which we have in other parts. For besides the nerve of the eighth pair, which, being one of the principal of the three branches, deeply enters the basis of the tongue, covered by the cerato-glossus, near the os hyoides, there is also a considerable nerve that goes to the tongue and its muscles, from the ninth pair; which having inosculated with the first nerve of the neck, and with the large cervical ganglion, it sends a branch downward, and frequently joins the eighth pair; but constantly communicates with the second and third of the neck, from whence its branches ascend to the muscles arising from the sternum, and frequently communicate with the phrenic nerve; after which, the rest of its trunk goes to the tongue. This communicates, by many branches, with the fifth pair in the cerato-glossus, and is more especially spent in the genio-glossus. Lastly, the third branch of the fifth pair having sent up or received the cord of the tympanum, and given other branches to the internal pterygoides, with the maxillary and sublingual glands, passes with its principal trunk behind the cerato-glossus, where it joins the ninth pair, and enters the tongue deeply, in company with the artery; together with which it is extended to the tip of the tongue, where it becomes cutaneous. To this nerve, therefore, if there be any prerogative or preference, the sense of taste is to be more especially ascribed, which is confirmed from observations on some diseases. Lastly, the nipples or papillæ of the tongue are of a hard texture, each papilla having its pulpy fabric made up by a number of small nerves, arteries, and veins, conjoined or wound up together by a firm cellular substance into a button, or protuberance, of which many are required to make up one large papilla.

448. The arterial and venous down which runs between the papillæ are for the purposes of exhalation; and have nothing to do with the taste, farther than that they separate from the blood a liquor fit for dissolving salts, and keeping moist the papillæ proper for taste: this liquor they pour out on the back of the tongue.

On

On the upper and back part of the tongue are ſeated many ſimple, round, muciferous glands, having one or more open outlets, which are completed by an hemiſpherical membrane, and the fleſhy part of the tongue. Some of theſe open into the obſcure, blind, and uncertain figured hollow, which is placed in the middle between the largeſt papillæ (445.), and commonly contains ſome of them.

449. Over the papillæ of the human tongue is ſpread only a ſingle mucous and ſemipellucid covering, which ſtrictly adheres to them, and ſerves them as a cuticle. But, in brute animals, a perforated mucous network receives the papillæ, which are in a manner wrapped up in caſes or capſules of this mucous body covered with the cuticle.

450. Under thoſe papillæ are ſpread the muſcles which make the fleſhy body of the tongue; which are very numerous, and hardly extricable in the human tongue: in the lower part, it is in a great meaſure made up of the genio-gloſſus muſcle extended outwards from the meeting of the chin, and diſtributed like rays into the ſubſtance of the tongue. The upper and lateral parts are compoſed of the ſtylo-gloſſus, whoſe fibres run to the tip of the tongue; which in its middle part, betwixt the former muſcles, is compoſed of one proper to itſelf, called *lingualis;* which ariſing from before the pharynx and origin of the ſtylo-gloſſus, only lower, goes out forward, and, terminating betwixt the ſaid genio-gloſſus and ſtylo-gloſſus, makes up a very conſiderable part of the tongue. The back part of the tongue is made up of the fibres of the cerato-gloſſus, which aſcend upward and backward; which ends between the ſtylo-gloſſus and lingualis, being included between them: and to this is joined the chondro-gloſſus, a muſcle entirely different, which ariſes from the ſmall bones, and next adjacent baſis of the os hyoides; from whence paſſing outward, with its lateral portions, covered by the genio-gloſſus, it joins the ſtylo-gloſſus, and diſappears in the tongue. By the action of theſe muſcles,

muſcles, the whole tongue is moveable in all directions, and capable of figuring its own ſubſtance, ſo as to form a hollow, by the elevation of the ſtylo-gloſſi, which it again flattens by the cerato-gloſſi, but contracts itſelf into a narrow and almoſt cylindrical figure, by the tranſverſe fibres from one ſide to the other, together with which there are many other orders of fibres, intermixed with a thick fat; ſo that they cannot be traced in the human tongue.

451. The *arteries* of the tongue are numerous. One that is larger and deeper aſcends in a ſerpentine courſe from the outer carotid, and extends to the tip of the tongue; and a leſſer ſuperficial artery, incumbent on the ſublingual gland, either ariſes from, or inoſculates with, the preceding. Behind, there are various ſmall branches derived from the poſterior labials; and from the branches proper to the lips, or thoſe of the tonſils. The veins of the tongue are variouſly wove, and difficult to deſcribe; ſome of which, lying deep, accompany the nerve of the ninth pair; and others, that are ſuperficial, accompany the mental artery, and, inoſculating with the former, ſends out the ranular vein: but all of them meet together in a large vein, which is one branch of the internal jugular coming from the brain. Theſe veins variouſly communicate with the adjacent networks belonging to the tonſils, pharynx, thyroide gland, and ſkin; and in the back of the tongue, before the epiglottis, there is a communication betwixt the right and left ſide of the venal plexus. I find lymphatic veſſels rather in the neighbourhood of the tongue, than in the tongue itſelf.

452. The *papillæ* of the tongue, which are larger and ſofter than thoſe of the ſkin, perpetually moiſt, perform the office of touch more exquiſitely than thoſe of the ſmall and dry cutaneous papillæ; and from hence the tongue is liable to a ſharper degree of pain: moreover, naked ſalts are not otherwiſe perceived than under a ſenſe of moiſture, or of pain. But the papillæ of the tongue being raiſed a little protuberant, to perform the office

office of taſte, from ſalts diſſolved in' water, or ſaliva, and applied againſt their tips or ſummits, are affected in a particular manner; which being diſtinguiſhed by the mind, and referred to certain claſſes, are called *flavours* or *taſtes*, either ſour, ſweet, rough, bitter, ſaline, urinous, ſpirituous, aromatic, or pungent and acrid, of various kinds, inſipid, putrid, and others reſulting partly from pure ſalts, and in part from an intermixture of the ſubtile animal or vegetable oils, variouſly compounded and changing each other. If it be inquired, Whether the diverſity of flavours ariſes from the different figures which are natural to ſalts? and whether this does not appear from the cubical figure in which ſea-ſalt ſhoots, the priſmatical figure of nitre, or the particular configuration of vitriol, ſugar, &c.? we anſwer, That this does not ſeem probable, for even taſteleſs cryſtals have their particular configurations; and the taſte ariſing from very different ſalts, and differently qualified objects of this ſenſe, are too much alike each other, and at the ſame time too inconinconſtant or changeable, to allow ſuch a theory; as for example, in nitre. The mechanical reaſon, therefore, of the diverſity of flavours, ſeems to reſide in the intrinſic fabric or appoſition of their elements, which do not fall under the ſcrutiny of our ſenſes.

453. But the nature or diſpoſition of the covering with which the papillæ are clothed, together with that of the juices, and of the aliments lodged in the ſtomach, have a conſiderable ſhare in determining the ſenſe of taſte; inſomuch, that the ſame flavour does not equally pleaſe or affect the organ in all ages alike, nor in perſons of all temperatures; nor even in one and the ſame perſon at different times, who ſhall be differently accuſtomed in health or variouſly diſeaſed. In general, whatever contains leſs ſalt than the ſaliva itſelf, ſeems inſipid.

454. The ſpirituous parts, more eſpecially of vegetables, either penetrate into the papillæ themſelves, or elſe are abſorbed by the adjacent pile or villi of the tongue;

tongue; as may appear from the ſpeedy recruital of the ſtrength by vinous or aromatic liquors of this kind, even before they are received into the ſtomach.

455. Nature deſigned the difference of taſtes to be felt by the tongue, that we might know and diſtinguiſh ſuch foods as are moſt ſalutary: for in general, there is not any one kind of aliment healthy, that is of a diſagreeable taſte; nor are there any ill taſted that are fit for our nouriſhment. For it muſt be obſerved, that we here take no notice of exceſs, by which the moſt healthy food may be prejudicial. In this manner nature has invited us to take neceſſary food, as well by the pain called *hunger*, as by the pleaſure ariſing from the ſenſe of taſte. But brute animals, who have not like ourſelves the advantage of learning from each other by inſtruction, have the faculty of diſtinguiſhing flavours more accurately, by which they are admoniſhed to abſtain cautiouſly from poiſonous or unhealthy food; and therefore it is that herbivorous cattle, to which a great diverſity of noxious plants is offered amongſt their food, are furniſhed with ſuch large and long papillæ of ſo elegant a ſtructure in the tongue, of which we have leſs need.

CHAP. XV.

Of SMELLING.

456. TO the ſame uſe, likewiſe, of diſtinguiſhing prejudicial from ſalutary food, the ſenſe of ſmelling conduces; by which we even diſcern and are admoniſhed to avoid, before it comes to our taſte, what might be otherwiſe dangerous: and thus we are eſpecially enabled to avoid any thing of a putrid tendency in our victuals, which is to us of a moſt peſtilent nature, and likewiſe find out what are grateful and wholeſome aliments; although continual practice, even in this faculty, has alſo rendered it more uſeful and ac-

quitted

curate among brute animals than in ourſelves. For men who have been brought up wild by themſelves, without debauching the ſcent by a variety of ſmells, have been obſerved moſt certainly to retain that faculty. Finally, the powers and virtues of medicinal plants are hardly to be better known than by the ſimple teſtimony of taſting and ſmelling. From hence it is, that in all animals theſe organs are placed together; and from hence the ſmelling is ſtronger, and the organs larger, in thoſe animals which are to ſeek their prey at a conſiderable diſtance, or to reject malignant plants from among thoſe that are fit for food.

457. The ſenſe of ſmelling is performed by means of a ſoft pulpy membrane, full of pores and ſmall veſſels, which lines the whole internal cavity of the noſtrils, being thicker upon the ſeptum and principal convolutions, but thinner in the ſinuſes. Within this membrane are diſtributed abundance of ſoft nerves throughout the middle of its fabric, from the firſt pair (357.), which deſcend through the holes of the os cribroſum into the ſeptum narium; but in ſuch a manner, that it is very difficult to trace them to their extremities and into the ſeptum. Other lateral nerves come from the ſecond branch of the fifth pair and its branches, from that which lies tranſverſe in the pterygoide canal, and from another which deſcends through the canals of the palate; and ſome from the infra-orbital-branch in the maxillary ſinus, from the dental branch, and from the anterior nerve of the palate. Moreover, the fore-part of the ſeptum has a ſmall twig from the ophthalmic of the firſt branch belonging to the fifth pair.

458. The arteries which go to the noſe are many: from the internal maxillary branches; from the three naſal ones, to wit, the upper and both ethmoidal branches; alſo from the frontal, naſal, and ſide branches; from the leſſer ophthalmic branch of the internal carotid; from branches of the palatine artery; from the infra-orbital within the ſinuſes; and from the ſuperior dental one. It is proper to theſe arteries

very eafily and very plentifully to fweat out blood, without any confiderable injury to the veffels themfelves. The veins run together in company with arteries, and form a large plexus, by uniting upon the external pterygoide mufcle, and communicate with the finufes of the dura mater; from whence they open together into the outer branch of the internal jugular. The arteries fupply the nourifhment, warmth, and mucus, neceffary to thefe parts.

459. The neceffary reduction of the human head to that of a round figure, has in us given to the organ of fmelling but a fmall extent of furface; but to enlarge this the more, nature has made the internal parts of the nofe varioufly hollow and complicated, in a furprifing manner. Firft then, by the *nares* we underftand the multiform cavity which begins before from the noftrils, and, extending tranfverfely backward over the roof of the palate under the os cribrofum, terminates at the cavity of the fauces. This cavity is divided into two by a *feptum* or partition of bone, which defcends above from the plate of the cribrofum, but below is formed by the vomer, and in its fore-part is completed by a triangular cartilage, whofe furface is largely extended and very fenfible.

460. Moreover, the lateral furfaces of the nares are increafed by the fpiral volution of the *offa turbinata*; the uppermoft of which are fmall turns or folds of a fpiral figure from the upper part of the os cribrofum. The middle fold belongs to the fame, fomewhat oblong like a fhell, internally convex, externally concave, rifing into an edge on each fide; all over rough with little finuofities or excavations, and inwardly filled with fpungy cells or receffes; the whole being fufpended in a tranfverfe pofition, and fupported by particular eminences in the bones of the palate and upper jaw. The lowermoft turbina, fomewhat like the middle ones, do like them refemble the figure of a limpet fhell, but longer; for the moft part divided from the former, but fometimes conjoined by a bony plate, which

which is moſt frequently of a membranous nature. This bony appendix, being extended upwards in a ſquare form, ſerves to complete the maxillary ſinus.

461. From hence the cavity of the nares is enlarged or dilated by various ſinuſes, which are a ſort of receſſes or appendages to the whole. And firſt, the frontal or uppermoſt ſinuſes, which are not always preſent, are of an irregular figure, intercepted betwixt the anterior and poſterior plate of the frontal bone, where it forms the ſuperciliary protuberances; and theſe, being not found in a fetus, ſeem to ariſe from the action of the corrugator and other muſcles, which draw the anterior plate of this bone outward, ſo as to increaſe the diploë into large cells, in the ſame manner as we obſerve in the maſtoide proceſs. Theſe open in the upper part of the nares into the interior cell of the os papyraceum. There are inſtances of their being totally wanting, and growing after the birth.

462. In the ſecond place come the *ethmoidal ſinuſes;* which are four or more on each ſide, in the outer part of the os cribroſum, like the cells of an honey-comb; completed above by the cellular middle part of the os frontis, and before by the os unguis; behind by the bone of the palate and ſphenoid bone; from whence they open by many ſmall tubes, placed one above another in a tranſverſe poſition, into the upper part of the nares. With theſe are continuous the cells in the pavement or bottom of the *orbit*, and thoſe engraved in the os planum and maxillare are continued from them outward. In a third place, this ſinus is contiguous on each ſide with the cavity or *ſinus of the multiform bone*, extending largely on each ſide towards the os cribroſum and palatinum, which is itſelf formed in a dry preparation, by a cartilage of large extent in the fetus, and by a ſolid bone, which gradually widens under the ſella turcica, with an ample cell, either ſingle or divided; and opening forward, by its aperture or foramen, into the ſuperior part of the meatus narium.

463. The laſt, lowermoſt, and biggeſt ſinus, which

in a fetus is inconſiderable, but in an adult very large, is that formed in the bone of the *upper jaw* by ſeveral thin bony plates. The opening of this into the noſe is betwixt the os unguis, bone of the palate, and the proper lamella or plate which accedes to it from the bottom of the os turbinatum. Which opening is ſo much leſſened by the ſurrounding membranes, as to form only a moderate round aperture in the ſpace betwixt the middle and bottom of the os ſpongioſum. But it likewiſe ſends forth an hollow appendix, tending forwards, under the orbits which the os planum, unguis, and papyraceum complete, communicating likewiſe with the ethmoidal cells, and open behind the oſtium lachrymale.

464. The nerves of the noſe, being almoſt naked, required a defence from the air, which is continually drawn through the noſtrils and blown out again by the uſe of reſpiration. Nature has therefore ſupplied this part, which is the organ of ſmelling, with a thick inſipid mucus, very fluid in its firſt ſeparation, and not at all ſaline, but by the air condenſing into a thick dry cruſt, more conſiſtent here than in other parts of the body. By this mucus the nerves are defended from drying and from pain. It is poured out from many ſmall arteries of the noſtrils; and depoſited partly into numerous cylindrical ducts, and partly into round viſible cryptæ or cells ſcattered all over the noſtrils. The ſame flows out all over the ſurface of the olfactory membrane, which is therewith anointed on all ſides. In the ſeptum runs down forward a long ſinus to a conſiderable length, which is common to many muciferous pores: this mucus is accumulated in the night-time; but, in the day, expelled by blowing the noſe, or ſometimes more powerfully by ſneezing; and may offend by its exceſs or tenuity, or irritate by too great thickneſs the very ſenſible nerves, from whence a ſneezing is excited for its removal. But the ſinuſes of this part, which abound with mucus, are this way variouſly evacuated, agreeable to the different poſtures of the body; by

by which always ſome of them are at liberty to free themſelves, whether the head be erect, or inclined forward, or laterally; yet ſo, that generally the maxillary and ſphenoidal ſinuſes are more difficultly emptied than the reſt. Moreover, the tears deſcend, by a channel proper to themſelves, into the cavity of the noſe, by which they moiſten and dilute the mucus.

465. To the extreme parts of the nares or organs of ſmelling, is prefixed the noſe; lined inwardly with a membrane of the ſame nature; and compoſed of two bones, and uſually ſix cartilages, two of which are continued together into the middle ſeptum (459.) Theſe cartilages render the noſe moveable by its proper muſcles, ſo as to be raiſed and dilated by a muſcle common to the upper lip, and to be contracted together into a narrower compaſs by the proper depreſſor and compreſſor muſcle pulling down the ſeptum. Thus it forms an air-engine, which, for the reception of ſmells, can take air in a larger quantity by dilating; then contracting again by elaſticity, when the air is afterwards abundantly thrown out.

466. The air, therefore, filled with the ſubtle and inviſible effluvia of bodies, conſiſting of their volatile, oily, and ſaline particles, is, by the powers of reſpiration (265.), urged through the noſe, ſo as to apply the ſaid particles to the almoſt naked and conſtantly ſoft olfactory nerves, in which a kind of feeling is excited, which we call *ſmelling:* and by this ſenſe we diſtinguiſh the ſeveral kinds of oils, ſalts, and other matters, difficultly reducible to claſſes, which hereby we perceive indiſtinctly; whence they are difficultly recalled to memory, though the odours already eſtabliſhed are ſufficient enough for our purpoſes. This ſenſe ſerves to admoniſh us of any pernicious putrefaction; of any violent acrimony; or of a mild, ſoapy, and uſeful diſpoſition in bodies. And as ſalt, joined with an oil, is the object of taſte; ſo a volatile oil, aided with ſalts, ſerves to excite ſmells: whence the affinity of the two ſenſes, which conjunctly aſſiſt and move each other, may be

be eaſily underſtood. But volatile particles chiefly are diſtinguiſhed by ſmell, and fixed ones by the taſte; perhaps becauſe the thick mucous cuticle, ſpread over the tongue, intercepts the action of the more ſubtle ſaline effluvia from acting upon the taſte, which yet eaſily affect the ſofter and leſs covered nerves of the internal noſe. We are ignorant of the reaſon why ſome ſmells pleaſe, and others diſpleaſe; and perhaps cuſtom may have ſome effect in this caſe.

467. Smells have a very ſtrong action, but of ſhort continuance; becauſe they are applied immediately, by the moſt minute particles, to nerves which are very near to the brain itſelf, and almoſt naked; from thence too proceeds the force of poiſonous vapours, and the refreſhment from agreeable odours, by which ſome perſons are effectually recalled to themſelves out of a dead ſwoon, or even after drowning. From hence comes that violent ſneezing, which often ariſes from acrid particles; and a looſeneſs or purging of the bowels, from the ſmell of ſome medicines, with the power of particular antipathies. From hence is derived the pernicious effects of exceſſive ſneezing, more eſpecially blindneſs, from the near conſent or ſociety of the nerves. But amongſt the various parts of the noſe, the ſeptum, and more eſpecially the os turbinatum, have a conſiderable ſhare in the organ of ſmelling: ſince theſe are parts multiplied in quick-ſcented animals, ſo as to form beautiful ſpires in hounds and other quadrupeds; and in fiſh, who ſmell by water, they are formed like the teeth of a comb, in an elegant manner.

CHAP. XVI.

Of Hearing.

468. AS the ſenſe of ſmelling diſtinguiſhes the ſmall bodies which float in the air, ſo that of hearing perceives the elaſtic tremors or impulſions of the air itſelf.

itſelf. Therefore, we obſerve the ſenſitive organ of the ear to be compoſed in a different manner from that of any of the other ſenſes; as it is made up, for the moſt part, either of hard bones, or elaſtic cartilages and membranes, which are the moſt exquiſitely enabled to receive and communicate the neceſſary tremors.

469. The external part of this organ, called the *auricle* or outer ear, is a cartilaginous funnel, connected, but with a ſort of mobility, before and behind, to the bones of the temple, by means of a ſtrong cellular plate, and likewiſe by its own proper ligaments and muſcles; but the mobility of this part is diminiſhed by cuſtom. This cartilage is of a very compound figure; in general of a kind of oval figure, yet marked with ſpirals ſtanding up, and hollows interpoſed, to which other hollows and ridges correſpond in the oppoſite ſurface. The outer eminence, called *helix*, begins above by a looſe tape, is carried round at liberty about the edge of the upper part of the cartilage, upon the poſterior ſide of which it terminates in the ſame looſe manner. Within the body of the cartilage, ſurrounded by the former, ariſes a bifurcated eminence, meeting together in one, called the *anthelix*, which terminates in a ſmall and ſhort tongue called the *antitragus*. The remaining part of the ear, called the *concha* or ſhell, is, before, hollow; behind, convex; growing gradually deeper, with a crooked line or ridge running through its middle, under the denomination of the concha, which is immediately joined with the meatus auditorius; before which ſtands a round moveable appendix of the cartilage, as a defence, called the *tragus*.

470. This whole cartilaginous body of the outer ear is only ſurrounded by a thin ſkin, and an empty cellular ſubſtance; it is repleniſhed with many ſebaceous glandules, which ſupply an ointment. This part is governed or directed by certain muſcles, which generally loſe their uſe and action, from the cuſtom of binding the head in children, which we are otherwiſe to ſuppoſe they were deſigned by nature to perform. The uppermoſt of

of thefe mufcles arifes thin from the frontal and from the aponeurofis of the cranium; whence it is broadly fpread over the aponeurofis of the temporal mufcle, and is inferted into the anthelix, or neighbouring helix, at the fide of the anonymous cavity. The pofterior mufcles, which are two or three, more or lefs, are more robuft than the former in a tranfverfe pofition; and, arifing from the fame aponeurofis, are inferted into the convex part of the conch near the maftoidal bone; the cavity of which conch they, doubtlefs, are defigned to open or enlarge. The anterior mufcle is one of the leaft, which, being fpread upon the aponeurofis of the temporal, is inferted almoft tranfverfely into the origin of the helix and neighbouring concha. But the leffer mufcular portions, which, though fhort, and not very confpicuous, look of a red colour, are probably of ufe to make fome change in the figure of this part. The tranfverfe mufcle of the outer ear, which, for a long way, conjoins the helix with the anthelix, ferves to open the auricle. The antitragic mufcle, defcending from the root of the anthelix to the antitragus, ferves to widen the entrance of the conch. The tragicus, which lies upon the tragus, opens the entrance to the auditory paffage; and the fmall mufcle of the larger notch or incifure, that lies betwixt the two cartilages of the auditory paffage, forming the tragus and antitragus, ferves to bring them nearer together, and to render the meatus itfelf more tenfe and elaftic. The remaining mufcles, the longer or larger, and the leffer of the helix, have hardly any great ufe; unlefs it be to tighten or brace up the cartilages whenever we attend or liften to the hearing of weak founds; and, by drawing together the cartilages, they likewife render the auditory paffage more firm.

471. To the concha is connected the *meatus auditorius*, fomewhat of a round compreffed figure, leffening as it bends inward; for a confiderable part bony, and bent forward in its middle. But, in its anterior and outer part, it is, in fome meafure, made up by three imperfect

imperfect rings, arising from the concha and tragus, and united together, and to the bone itself, by intermediate flesh, membrane, and cartilage. Upward and backward, the meatus is completed by a mere membrane. This is the state of it in adult persons; for, in the fetus and new-born infants, the meatus is wholly cartilage, and becomes afterwards, in part, a bone by degrees.

472. Through the auditory passage are continued the cuticle and true skin, gradually extenuated and exactly stretched over the surface of the bone, by which it is rendered extremely sensible of any itching pleasure or pain; and, being replenished with irritable hairs, is by them admonished of any sordes or wax abounding, and guarding from the entrance of small insects. But, in the cellular substance under the skin, which is here more firm, and makes up the greater part of the membrane (471.), in a sort of reticular manner, are seated numberless round follicles or cells of a yellow colour, which pour out their contents by short ducts into the cavity of the auditory passage; at first of an oily consistence, but afterwards it becomes more thick, bitter, and inflammable like wax. This liniment defends the sensible skin and membrane of the tympanum from injuries of the air, and keeps out or catches any small insects; but, when accumulated in too great abundance in those who are slothful or uncleanly, it may be the cause of deafness, or a difficulty of hearing.

473. Into this funnel of the ear the sonorous waves of the air flow, which, from principles of mechanics, it must of course collect together. The elastic air only receives sonorous tremors or impulsions; and transfers them, either alone or principally, much after the same manner as we see water, without air, transfer any impulse that is given to it. From hence, the sound is increased in air that is condensed, and is lost in a vessel emptied of its air. But the medium receives these tremors, either from some body striking against it, or from the air itself colliding against another body, or lastly

from the collision of two bodies against each other in the air. But the body which produces found, ought to tremble or vibrate in all, even the least of its particles, so as to form alternate arches rising up from the former straight surface, and returning beyond the same; the curve line of the same exceeding that of the sounding body. From such a tremor, the contiguous air is beat into waves, whereby the parts of the air that lie outermost are compressed and fly back again so soon as their elasticity gets over the impulse; whence the air flies again towards the sonorous body, where it is now more loose and rarefied, to be there again compressed by impulsion; and in the same manner the anterior and outer portion of air, surrounding that which is impelled, is, by the action of the latter, compressed and removed farther from the trembling body, yet so as to return again in its proper time by the force of elasticity, driving its contents to the tremulous body for the exciting of a new wave. These oscillations or impulsions of the air are required to succeed each other with a certain velocity; and, in order to render them audible, they must not be fewer than 30 in a second of time.

474. Acute sounds are, in general, yielded from bodies that are hard, brittle, and violently shook or struck; but grave sounds are from the contrary. Those sounds in general are called *acute*, which are produced from more numerous tremors in an equal time; and those *obtuse*, which are produced from few tremors. As to any medium betwixt acute and grave sounds, there is none but what is arbitrary. Cords, or other bodies, that yield the same number of vibrations in a given time, are said to be *unison;* as those which make double the number of oscillations in that time, are said to yield a tone that is an octave or eight notes higher; and other proportions betwixt the numbers of the vibrations have different names assigned to them. The shorter cords produce sharper tones, and the reverse, in a proportion directly as their lengths; as those which are more stretched afford sharper sounds in a subduplicate proportion

portion to their tenuity, or to the weights or powers by which they are ſtretched. Experiments to this purpoſe are very eaſily made with a monochord, or a ſeries of chords ſtretched with weights.

475. The ſound, thus produced, whether acute or grave, ſtrong or weak, is carried through the air with a celerity equal to about 1038 Paris feet in a ſecond, and that with an uniform velocity, without abating in the larger diſtances. But a contrary wind, cauſing the vibrations to extend more ſlowly, retards the progreſſion of ſound about $\frac{1}{12}$ of its velocity. So likewiſe denſity and dryneſs of the air increaſe the ſound, as a rarefaction and moiſture of the air leſſen it. Hence, in ſummer time, ſounds move ſwifter; and in Guinea, it has been obſerved to paſs at the rate of 1098 Pariſian feet in one ſecond of time.

476. The ſound, thus every way extended, meets with certain particles in all adjacent bodies, even in water and mercury, to which it communicates ſimilar tremors or vibrations, not only ſuch as are in uniſon with the original tone, and which yield a ſound in a more particular manner ſenſible, but alſo it excites tremors leſs ſenſibly, even in the other parts of bodies, which vibrate in the various proportions of the ſcale. From hence it is, that every ſound, which we hear, is a mixture of the original tone, produced by the trembling body, in conjunction with ſecondary tones generated from the elaſtic tremors of the ſurrounding bodies. The ſtrength of ſound is increaſed, if one audible or primary tone follows the other ſo cloſely, that their ſucceſſion cannot be diſtinguiſhed by the ear; but if they follow each other ſo ſlowly as to be diſtinguiſhable by the ear, they produce an echo; but to produce this, requires an interval of ſix thirds of a ſecond of time, or the diſtance of 55 feet betwixt the reflecting or echoing body and the ear.

477. Sounds, being elaſtic, are reflected from hard bodies in angles equal to thoſe of their incidence. But the ſame ſound, uſhered into the open air, and dilating

through an immenſe ſphere, grows proportionably weaker: but if it be uſhered through a tube, in a cylindrical ſhape, the ſtrength of it is more confined together; or elſe, by being collected into the focus of a parabola or ellipſis, it becomes increaſed, as we obſerve in ſpeaking-trumpets, from which the voice goes out parallel to the focus of the parabola, without ſcattering the ſonorous rays.

478. Therefore the ſonorous waves of the elaſtic air, being driven into the cartilaginous funnel of our ear, which is naturally inclined forward and outward in an high ſituation, are repelled and collected together, by alternate reflections from its elaſtic ſides, into the cavity of the concha, from whence it proceeds through the auditory paſſage, with a force ſo much ſtronger as the ſurface of the outer ear is larger than the light or ſection of the auditory paſſage. Through this paſſage, however cylindrical, the ſame force is continued entire forward, and increaſed by new reſonances, excited from the percuſſion of the elaſtic cartilages and hard bones, ſo as to mix imperceptibly with the primitive ſound.

479. Moreover, the bottom or end of the ſaid auditory paſſage is terminated internally by a thin membrane, called the *membrana tympani;* which, in adults, is of a roundiſh figure, and placed with an obliquity; but ſo that from its upper appendix it projects inward like a ſhield, whilſt the part which lies above its middle projects into the cavity of the meatus like a ſhield. This membrane of the tympanum is compoſed of ſeveral plates, the firſt or outermoſt of which is white and mucous; the other is a true ſkin, continued from the membrane of the meatus, and of a vaſcular texture; the third is a dry, rattling, ſplendid, and pellucid membrane or plate, without blood-veſſels; and the innermoſt is the vaſcular perioſteum of the auditory paſſage and tympanum, with a tender cellular texture lying between. This membrane is not naturally perforated with any opening, ſo far as I have been able to diſ-

difcover, and the tranfmiffion of fmoke is fabulous. It is conftantly fo ftretched in the fulcus or groove of the bony ring, in which it is contained, proper to the fetus, and after the birth coalefcing with the reft of the os petrofum, that there is no part of the human body to be found more tenfe or more tremulous than this. Upon the furface of this membrane, and more efpecially upon its conical cavity pointing inward, the fonorous waves ftrike, after they have received their laft reflections from the auditory paffage, by which the elaftic fabric of this membrane is forced into ofcillation.

480. This membrane is ftretched over a cavity of the os petrofum, called the *tympanum;* which is, for the moft part, of a roundifh figure, but not regularly fo; being divided in its middle into two by a promontory, and in the adult is increafed backward by the cells of the maftoide bone, which are abfent in the fetus. But alfo, in its upper and anterior and pofterior part, the tympanum has hollow cells, and is lined with a vafcular membrane, receiving fmall branches from the internal carotid, and from a branch of the artery of the dura mater, which laft paffes through a fiffure in the aqueduct, and it has others from the external arteries of the tympanum and from the ftylo-maftoidea. It is commonly full of a mucus, poured into it from the Euftachian tube, and is divided by various membranes into a kind of cells, namely, by productions of the periofteum to the little bones.

481. Within this cavity, three of the larger *bones of hearing*, together with a fourth which is lefs, are fufpended moveably. And firft, the *malleus* or hammer lies with its upper round head refting upon the concavity of the tympanum, from whence the handle of it is extended down, along the membrane of the tympanum, betwixt the plates of it: having reached as low as the middle of the membrane, it terminates by a very clofe cohefion, with a broad extremity a little incurvated outwards. The fame bone is, moreover, connected and fuftained by a peculiar ligament of its own, joining

joining it to the longer leg of the incus; and another membrane ſerves as a ſecurity near the longer proceſs of the malleus. This bone drives outwards the membrane of the tympanum, which is ſpread over the ſhorter and conical proceſs of its handle. From the ſame place of this bone a broad, long, and flat proceſs, goes out forward into a ſulcus of the tube. It is articulated with the incus by two heads, having protuberant lines with a ſulcus in the middle, and all of them oblique.

482. In the malleus are commonly deſcribed three muſcles: the firſt and internal of which, called *tenſor tympani*, being the largeſt, is lodged in a particular groove within the tube, with which it proceeds parallel; and, riſing from the proceſs of the multiform bone between the paſſage of the cerebral carotid and the hole of the artery of the dura mater, bending round a pully, is inſerted by its tendon reflected outward and downward into the beginning of the handle. The *ſecond* muſcle ariſes from a ſulcus in the ſame tube, but externally ſhorter than the former, and carried back almoſt in the ſame manner, but without being reflected: it adheres by a conſiderable extent to the longer proceſs; and the ſame is ſuſpected to be but little different from the red pulpy membrane. The *third* muſcle of the malleus, which ariſes from the auditory paſſage, paſſes through a notch in the broken or interrupted ring of the tympanum, and is inſerted juſt by the ſhorter proceſs into the malleus; and this, which is by ſome ſaid to relax the membrane of the tympanum, has never been ſeen with ſufficient certainty neither by myſelf, nor by the moſt eminent anatomiſts. For the reſt, by means of the tenſor of the malleus, the membrane of the tympanum is diſpoſed for the hearing of weak ſounds; as the other muſcle ſerves to moderate in too violent ſounds, by drawing the malleus from the incus; by which therefore the propagation of the ſonorous tremors is interrupted. If the membrane of the tympanum be broke, or the bones of hearing diſlocated, the perſon

perſon becomes at firſt hard of hearing, and afterwards perfectly deaf; this part being the ſeat of that ſlight hearing which is propagated through the bones of the ſkull.

483. The malleus returns the tremors impreſſed upon the membrane of the tympanum to the incus, which is a ſhort thick little bone, articulated with the former behind by a broad ſurface, with two ſulci and a middle eminence. The ſhorter leg of this bone, whoſe little body is bifurcated, being ſuſpended by a ligament, is held firm into a ſulcus proper to the bone. Another longer one deſcends parallel to the malleus; and, by a ſomewhat crooked extremity, is adapted to to the fourth orbicular bone which it receives, convex on one ſide, flatter on the other, and reſting upon the ſtapes, to which its protuberances are imparted.

484. The *ſtapes*, aptly enough ſo called from its figure, lies inclined, but more backward than forward, with a hollow head that receives the incus, from whence proceed two little crooked legs, the poſterior one of which is largeſt: but below, its oval baſis is occupied by an aperture of a correſponding figure, commonly called the *feneſtra ovalis*. Here the legs, which are ſulcated inwardly, are conjoined by a tenſe membrane affixed to the hollow baſis. This bone of the ſtapes is covered by its own muſcle, which being included in a bony papilla or caſe, ſends out a ſmall tendon, which is inſerted under the incus into the head of the ſtapes. Hence it ſeems to draw the ſtapes, that it may lie higher up, under the back part of the feneſtra ovalis, and paſs out of it before. Thus the nervous pulp of the veſtibulum is preſſed by the baſis of the ſtapes, and by the air of the tympanum. The whole courſe or ſeat of the ſtapes is ſeparated from the reſt of the tympanum, by a membrane proper to itſelf.

485. A ſmall roundiſh oval-ſhaped bone, here and there greatly excavated, is here fixed to the longer leg of the incus, and from thence goes to the ſmall head of the ſtapes.

486. There

486. There are various channels which paſs out from the cavity of the tympanum. Above the two larger bones behind the poſterior leg of the incus, is a ſmall cell, a kind of appendix to the tympanum, of the figure of a gnomon. Behind that, the ſmall cells begin in the os petroſum, above the mamillary proceſs. Below theſe, that proceſs is excavated in an adult by various ſmall caverns.

487. From thence the proper canal, going out forwards from the anterior extremity of the tympanum, emerges from the bones lying between the os multiforme and the oſſa temporum; and is joined into a correſponding elliptical and diverging cone, partly membranous, and in part made up of cartilages of a variable ſtructure: it opens by a very ample elliptical aperture, turning inward and forward behind the nares, into the cavity of the fauces: it is lined with a porous membrane, full of cryptæ and mucous cells, continued from and like unto the membrane of the nares. This is the *tube* which, by the action of the circumjacent muſcles, may be compreſſed and cloſed, and probably a little relaxed and opened again, by the circumflex muſcle of the moveable palate. By this canal the inſpired air enters into the tympanum to be changed or renewed, and the ſurrounding mucus of the little bones and other parts are this way depoſited: nor is it at all improbable, that the air enters by this tube, to ſupport the tympanum, when it is preſſed inward by the more violent ſounds; for ſounds themſelves, received into the mouth, are this way conveyed to the organ of hearing. In inſpiration, the air preſſes the membrane of the tympanum outward: and from thence proceeds that claſhing or whiſpering noiſe, by which the hearing is obſcured, when the mouth is held wide open in yawning; for then the air entering more abundantly through the cavity of the tube, to the tympanum, reſiſts the tremors of the external air.

488. Two other paſſages lead from the tympanum to the *labyrinth*, or innermoſt chamber of the ear. And,

And, again, the feneſtra ovalis (484.) not covered by any membrane, leads into the *veſtibulum;* which is a round cavity, formed in a very hard part of the os petroſum, that lies near the inner part of the tympanum. In that cavity are three receſſes; of which the upper one is elliptical, the lower one circular, and the third like a furrow. There is a nervous pulp in the veſtibulum, diſtinguiſhed from the parietal bone by the vapour ſurrounding it. Into this open the five mouths of the three ſemicircular canals, the foramen ovale, and the paſſages of the nerves and arteries.

489. In the fetus, theſe are formed of a diſtinct hard ſhell, which, being ſurrounded with a ſpungy bone, are lodged in a cavity of the os petroſum; which, in adults, is extremely hard, extended into ſegments ſomething larger than ſemicircles, which have an ample opening betwixt them. The larger poſterior and lower of theſe circles, is perpendicular; alſo the middle and upper one is placed towards the perpendicular: but the outermoſt and leaſt is horizontal. The inner mouth or aperture of the uppermoſt of theſe meets with the upper opening of the poſterior ring, and both join into one.

490. But the cochlea is a part ſtill more wonderful, ſeated in an inclined poſture within the anterior portion of the os petroſum. Into one part of this cavity opens the veſtibulum; and into the other the *feneſtra rotunda* of the tympanum, which is concealed behind a protuberance in the bottom of the tympanum. The cochlea itſelf is made up of a nucleus of bone, of a conical figure, with its apex inclined inward; divided by a middle ſulcus, both through its baſis, and through its whole length; and perforated with innumerable ſmall foramina into the tubes, which are called *ſcalæ*, terminating in the middle of the ſecond ſpiral. About this nucleus are wrapt two turns and a half of a canal; which, in the fetus, is made up of a diſtinct ſhell-like ſubſtance, peculiar to itſelf; and, in the adult, is united into one, with the adjacent bone: and this winding canal diminiſhes gradually in a conical figure, from the two forementioned

mentioned openings towards the tip of the nucleus. It is bilocular, or made up of two apartments, divided by a partition called *lamella ſpiralis*. This, at its larger end, is bony, and extended out of the nucleus, at right angles, into a cavity; is ſtriated, and every way wrapt up by the internal perioſteum as in a capſule. Another external part hereto belonging, is a membrane, which likewiſe divides the canal: thus there are formed two diſtinct ſemicanals, called *ſcalæ*. The interior and poſterior of theſe canals begins from the feneſtra rotunda, where it is ſhut by a membrane, and is called the *ſcala tympani;* the other begins before, from the veſtibulum, from which it has its name. In the tip of the cochlea is formed a third cavity, ſhaped like a funnel. Into this the ſpiral lamina terminates by a membranaceous extremity, but ſo that the funnel communicates with them by a ſmall hole on each ſide; but, in many bodies, it alſo communicates with the cavity of the bucket that is filled with the nerve.

491. The blood-veſſels of the outer ear come from the temporal, or proper auricular branches; thoſe to the membrane of the tympanum are either from the temporal, from the ſtylo-maſtoideal, or from both; thoſe of the meatus auditorius come from the former; thoſe to the tympanum were deſcribed (480.); and the veſſels belonging to the veſtibulum, cochlea, and ſemicircular canals, are from the vertebrals and ſtylo-maſtoideals. The induſtry of late anatomiſts has diſcovered veſſels of a particular kind, proper for carrying back liquids from the veſtibulum into the tranſverſe ſinus, from the cochlea into the cavity of the ſkull.

492. It now remains that we deſcribe the nerves deſtined to the ſenſe of hearing, of which the principal is that called the *ſeventh* (357.) This nerve enters into the internal auditory ſinus of the os petroſum, in the blind end of which it divides. The ſmaller part of the nerve is ſent upward, through the opening of a canal in the ſinus; whence paſſing tranſverſely, it is afterwards bent behind the tympanum. In this part deſcend-

ing, it gives off a branch through a peculiar channel to the tympanum, which aſcends betwixt the malleus and incus, and goes out of the tympanum, through a fiſſure behind the articulation of the lower jaw, afterwards inſerting itſelf into the nerve of the tongue (457.); the reaſon of which ſecret communication is obſcure, but ſerves to explain the conſent of the teeth ſet on an edge by ſharp ſounds, a removal of their pain by burning the ear, &c. The reſt of the nerve, eſcaping by the ſides of the ſtyloide proceſs, is diſtributed through the external ear, the parotid gland, a large part of the face, and upper part of the neck, both cutaneous and muſcular; and in the face forms numberleſs inoſculations, both betwixt its own branches, as well as with thoſe of the firſt, ſecond, third, and fifth pair; and it likewiſe communicates with the eighth pair, and the third cervical pair. But to the immediate organ of hearing it ſends either no branches, or at leaſt very ſmall ones. The outer ear again receives other nerves in its fore part from the third branch of the fifth pair, and in its back part to the ſecond and third of the cervicals.

493. But the *ſoft portion* of the auditory nerves ariſes larger, but more obſcure, from the fourth ventricle of the brain itſelf (357.) and enters by very minute threads through exceeding ſmall holes of the inner auditory ſinus, which go in part to the veſtibulum, and in part to the furrow of the cochlea. The branches in the veſtibulum form a pulp-like tender membrane, which is every way extended thro' the ſemicircular canals. The other part entering the furrow of the cochlea, has an obſcure termination.

494. With reſpect to the nerve which is diſtributed through the veſtibulum and ſemicircular canals, there is no doubt but it is ſtruck by the tremors of the external air, propagated to the ſtapes; from whence the tremors immediately paſs through the oval feneſtra, to preſs upon the naked pulp of the nerve. That part of the nerve which enters the cochlea, is altogether obſcure in its termination. It is probable, that ſmall

branches from thence paſs through the little foramina (490.) to the perioſteum of the cochlea, and to the membranous part of the ſpiral partition. Do the tranſverſe nervous filaments paſs out from the nucleus of the cochlea, all the way ſucceſſively ſhorter through the ſpiral plates? Is it the organ of hearing? Theſe are queſtions, which we are yet hardly able to reſolve from anatomy; though this ſeems repugnant to the courſe which we obſerve nature takes in brute animals, in birds, and in fiſhes, who all hear very exquiſitely without any cochlea. However this may be in the human body, it is there probable, that the ſpiral plate, ſpread full of nerves, is agitated with tremors from the oſcillations of the membrane of the tympanum, by which the air in the cavity of the tympanum is agitated, ſo as to preſs the membrane of the round feneſtra, which again agitates the air contained in the cochlea.

495. The preceding conjecture is indeed elegant; ſince the ſpiral plates make up a triangle, ending in a ſhort point towards the tip, by which it may be conceived to contain an infinite number of nervous cords, continually ſhortening in their length; and by that means adapted to an harmonical uniſon or conſonance (474.) according to the variety of acute and grave ſounds, ſo as to tremble together at the ſame time with moſt of them; namely, the longeſt cords in the baſis of the cochlea, with grave ſounds; and the ſhorteſt cords nearer the tip or apex, with the ſharper ſounds. Whether are ſounds perceived in the middle ſemicircular canals, when theſe alone are found in all claſſes of animals? Are they detained in theſe canals, in the cochlea, and by the membrane ſuſpended through the veſtibulum? This ſeems probably the caſe.

496. From what has been ſaid, it appears, that the elaſtic waves or tremors of the air arrive through the outer ear and auditory paſſage, to the membrane of the tympanum; which being injured, and not repaired, the hearing is totally deſtroyed. This ſeems to be ſtretched, for hearing weak ſounds, by the muſcles of the malleus.

From

From this membrane the ſound is conveyed through the ſmall bones to the veſtibulum; for theſe bones being deſtroyed, the hearing is again aboliſhed. The bony ſides of the veſtibulum, by their tremulation, agitate the ſmall quantity of aqueous fluid ſurrounding the nervous pulp. It ſeems to be ſtruck by the nervous pulp ſuſpended in the veſtibulum, and that tremor to be continued through the continuous pulp of the cochlea and ſemicircular canals. Of more than this we are not certain: but, by undoubted experiments, tremors, and even elaſtic ſounds, communicate themſelves by the internal Euſtachian tube, and through all the bones of the ſkull, ſo as to impreſs their force upon the auditory nerve.

497. The diſtinction of ſounds, doubtleſs, proceeds from the celerity of the tremors excited in the hearing nerve, according as they ſucceed each other more ſwiftly or ſlowly, in a ſhort time; in order to which, it is not neceſſary the mind ſhould number them; it is ſufficient that ſhe perceive their numbers to be different, and that this difference excites a variation in her thoughts and ideas thence ariſing. Whether the harmony or agreeableneſs of ſounds ariſes from the number of parts ſounding together in uniſon? and whether the mind, ignorant of herſelf, numbers the degrees of conſonance, ſo as to pleaſe herſelf in a majority of them? theſe are queſtions denied by the moſt expert muſicians, who make it appear, that there is an agreeableneſs, and that very conſiderable, in ſounds approaching the leaſt to a conſonance, and which lies in a proportion very difficult to determine. Why do ſounds often become too ſharp for the ear? Our auditory nerves ſeem to be ſtrained upon the ſpiral plates, in ſuch degrees as to be in danger of breaking, after the manner drinking-glaſſes may be broke by ſharp ſounds, and as the hearing is ſometimes almoſt loſt for a while by the violently ſhrill whiſtlings of the inhabitants of the Canary iſlands.

CHAP. XVII.

Of the SIGHT.

498. AS the organ of hearing perceives the tremors of the air, fo the fight perceives thofe of light: and as the firft confifted chiefly of bony organs capable of making a refonance; here, on the contrary, the greater part of the eye is compofed of pellucid humours capable of refracting the more fubtle medium of light: but the complexity of this organ was neceffary for the defence of its tender parts, and from the diverfity of the feveral humours, to be contained each in their proper integuments.

499. Outwardly, a defence is afforded to this organ by the eye-brow or *fupercilium*, which is a protuberance of the fkin, fuftained by mufcles, at the bottom of the forehead, full of thick hairs, lying over one another like the tiles of a houfe; and capable of being pulled down by the action of the frontal, corrugator, and orbicular mufcles, fo as to afford a fhade to the eye in too ftrong a light. After this office is finifhed, the eye-brow is raifed again, by the infertion of the frontal mufcle, thin and flefhy, immediately under the continuous fkin, faftened to the cellular membrane of the fkull, which is of a fhining fubftance, and not far different from the nature of an aponeurofis, which, being of a long quadrangular figure, is drawn backward by the occipital mufcle. A depreffion of the eye-brow ferves alfo to exprefs concern of the mind; as an elevation of it denotes the mind to be in a ferene quiet ftate. This guard alfo conduces to throw off the fweat and retained duft, or the infects which might fall into the eye.

500. The *eye-lids*, or palpebræ, are placed ftill nearer guards before the eye. Here the folds of the fkin, which are thinly extended, from that of the face, run

out in a confiderable length, and are reflected back with the cellular fubftance interpofed betwixt the outer and inner plate; the latter of which becomes then a thin vafcular membrane, and therefore of a red colour, extended before the globe of the eye, and fpread in its foremoft part upon the fclerotica, under the denomination of *conjunctiva tunica*. This production of the fkin is every where covered by another of the cuticle, even where it is clofely conjoined with the cornea. The upper eye-lid is larger and more moveable: the lower is fmaller; and rather obfequious to the motion of the other parts, than moved by any particular forces of its own. The *nerves*, which give fenfibility to the eye-lids, are numerous, from the firft branch of the fifth pair, and likewife from the fecond, and from the hard branch of the feventh pair; they abound with *arteries* from the ophthalmics, and from the branches of the temporals, internal maxillaries, infra-orbitals, and others of the face.

501. That the eye-lids might fhut together more exactly, they have each of them a cartilaginous arch, called *tarfus*, upon their margins, which meet together. It is flender, of a lunar figure, extenuated outward, and ferves to hinder the eye-lid from falling into wrinkles while it is elevated or depreffed. The elevation of the upper eye-lid is performed by a mufcle arifing from the involucrum of the optic nerve gradually fpreading, and extended by its expanfion to the tarfus. This elevator is confiderably affifted in its action by the frontalis, and by various connections with the orbicularis drawn up or dilated by the former. The upper eye-lid is depreffed by the *orbicularis* mufcle; which is broad and thinly fpread round the orbit, under the fkin of the eye-lids, to each angle of the eye, which ferve as fixed points to this mufcle; and it adheres to the os frontis, where that bone joins the upper jaw, and then its fibres are inferted into the os frontis and neareft parts of the upper jaw. The fame mufcle ferves to elevate the lower eye-lid, and covers the eye in fuch

a manner that no duſt or light can enter it in ſleep. The lower eye-lid is depreſſed by a double portion of fibres, inſerted into the upper lip.

502. Finally, that the protuberant margins of the eye-lids might not injuriouſly beat againſt each other, the *cilia* or rails of hair are placed ſpreading outwards, in a row, from the edges of the eye-lids, of different lengths, which by croſſing each other make a blind or ſhade. Theſe are of uſe in more diſtinct viſion, by excluding the extraneous rays, when we require a diſtinct repreſentation of any object.

503. That the eye-lids rubbing againſt each other might not grow together, they are ſupplied with a row of *ſebaceous glandules*, firſt noticed by Meibomius; namely, about thirty little gut-like cells or more in each eye-lid; placed in general according to the length of the lid, without ever branching, but compoſed of peculiar blind ſinuſes, which end at laſt in one larger ſerpentine duct, opening by a mouth in the margin of the eye-lid itſelf. Theſe diſcharge a ſoft liniment, which mixes and waſhes off with the tears.

504. But the perpetual attrition of the eye-lids aſcending and deſcending againſt the globe of the eye, is prevented by the diſtilling humour called *tears;* which preſerve alſo the tenderneſs of the membranes and of the cornea, and ſerve to waſh out any inſects or other ſharp corpuſcles. Theſe form a ſaline pellucid liquor, that may be evaporated, and never ceaſes to be poured over the anterior ſurface of the eye; but never runs over the cheeks, unleſs collected together in a larger quantity from ſome cauſe. This liquor is exhaled partly from the arteries of the conjunctiva, as we ſee from an imitation of nature by injecting water: and it is in part believed to proceed from a gland ſeated in a receſs of the orbit of the os frontis, ſomewhat hard, and of the conglomerate kind; intermixed with fat, and painted with many blood-veſſels from the ophthalmics and internal maxillaries; and interſperſed with many ſmall nerves

nerves arising from a peculiar branch of the first trunk of the fifth pair.

505. From this lachrymal glandule in horned cattle descend three, four, or more visible ducts, which open on the inner side of the conjunctiva, upon the eye-lid. In man these ducts are lately found out, according to credible authors. The separation of the tears is increased by the more frequent contraction of the orbicular muscle, either from irritation, or some sorrowful passion, by which means the tears are urged over the whole surface of the eye and conjunctiva, which they wash.

506. After the tears have performed their office, some part of them flying off into the air, the rest, that they might not offend by their quantity, are propelled by the orbicular muscle, towards its origination next the nose, to a part which is the lowest of the palpebral margins; which not being surrounded by the tarsus, does therefore not meet exactly together. Here a *caruncle* full of sebaceous hairy follicles, of an oblong figure, interposes and separates the meeting of the eye-lids, at the same time furnishing a liniment to those parts which have none of the Meibomian ducts. Before this part is extended a small portion, like a little eye-lid; which, descending perpendicularly, joins the true eye-lids, and is larger in beasts than in men: but at the beginning of this space, betwixt the eye-lids, in which the tears are collected, both in the upper and lower margin, a little papilla stands out, having each of them one opening, surrounded by callous flesh, which are perpetually open, unless when convulsively closed. This opening, which is called the *punctum lachrymale*, drinks up the tears from the sinus in which they are collected; and this partly by tubular attraction, and partly by impulse from the orbicular muscle. If these points or openings are obstructed, the tears run over and excoriate the cheek.

507. From both points proceeds a small duct, both from the upper and the lower eye-lid, much wider than

the opening itſelf, but thin, and included in the ſkin; one of which goes downward above the caruncle, and the other goes more tranſverſely inward and under it: theſe both join together, and are inſerted by two mouths near the uppermoſt part of the *lachrymal ſack:* thus it is called a cavity, formed in the os unguis and upper jaw, lined with a membrane, which is at firſt cellular, but harder, and as it were of the nature of an aponeuroſis; then by another red and pulpy one, continued from the membrane of the nares, pervious to the exhaling dew, and ſomewhat of an oval figure. From the ſame ſacculus is continued a duct, which deſcends a little backward into the nares, opening there by an oblique oblong aperture at the bottom of the meatus, covered by the lower os ſpongeoſum. Through this paſſage the ſuperfluous tears deſcend into the noſe, which they in part moiſten (464.) A muſcle is by ſome aſcribed to this ſack; but it is not yet ſufficiently confirmed.

508. The globe of the *eye*, compreſſed before, but longer than it is broad, is ſeated in the cavity of a bony orbit, which is almoſt of a conical figure, made up by ſeven bones which are in the back part; and on the inner-ſide perforated or interrupted by larger fiſſures, from whence the bones, widening forward, defend the cavity on all ſides. But as this is larger than the eye itſelf, the exceſs is on all ſides occupied by a very ſoft fat, ſurrounding the globe of the eye, that it may both fill and have a free motion within the orbit.

509. The eye begins from a conſiderable nerve, by the expanſion of whoſe coats thoſe of the eye itſelf are compoſed. The origin of this optical nerve we have already deſcribed (357.) Its progreſs is acroſs the crus of the brain, where it joins with its fellow nerve from the other ſide, and coheres therewith for a conſiderable length by a large portion of medullary ſubſtance; ſo that the right goes to the right eye, and the left to the left eye, yet not without ſome conjunction of of both medullary ſubſtances. The nerve, therefore,

thus

thus enters the orbit a little inflected, of a figure somewhat round, but compressed; and is inserted into the globe of the eye, not in the middle, but a little nearer to the nose.

510. The nerve having reached the eye, deposits the inner plate of its dura mater, which it received in the opening of the sphenoidal bone: and this being expanded and rendered thicker, makes up the first coat of the eye, called *sclerotica*. The other outer plate of the dura mater, receding from the former, makes up the periosteum of the orbit: but the pia mater, which is in this nerve very distinct and full of vessels, expands itself as before, so as to form a thin dark-coloured lining to the sclerotica. The remaining inner medullary part of the nerve, continued from the brain, but divided into filaments by the cellular substance, is contracted into a depressed white conical papilla; after which it is again expanded upon the inner membrane of the eye, so as to form the *retina*.

511. The *scelerotica* is in general white, tough, and furnished with few vessels, resembling the nature of the cutis or skin, of a figure completely enough globular, but compressed or flattened before, and of a greater thickness backward. To the fore-part of this globe, cut off circularly, is prefixed obliquely a portion of a more convex but less sphere; pellucid, and made up of many scales or plates, replenished with a clear water and pellucid vessels, very difficult to demonstrate; insensible, and almost circular, yet broader at the nose than towards the temples: it is termed the *cornea*, thro' which the light passes into the inmost part of the eye. This greedily imbibes water, and sweats it out again. Before the anterior and flatter part of the sclerotica, and also before the cornea, the conjunctiva is detached from each of the eye-lids, and closely conjoined to the sclerotica by a proper cellular substance, that may be inflated (500.); which is replenished with vessels, partly red, and partly pellucid continuations of red ones.

512. The origination of the *choroides* is from the cir-

cumference of a white circle, terminating the ſubſtance of the optic nerve, in that part where the retina and the central artery are expanded from it, and perforate it by many ſmall foramina. From hence it ſpreads within the ſclerotica, concentrically adhering thereto by a cellular ſubſtance and many veſſels, which enter from the choroides into the ſclerotica. This membrane is outwardly of a brown colour, but inwardly of a more ruſſet brown or almoſt black, both which colour and ſurface are ſeparable by maceration: the innermoſt may be diſtinguiſhed by the name of *Ruyſch;* but grows white through age. When this has extended itſelf as far as the beginning of the pellucid cornea, it there joins itſelf more accurately to the ſclerotica, by a cellular ſubſtance; from whence going off almoſt circularly in a different courſe, it forms a kind of rim, called *orbiculus ciliaris:* namely, the coat, which was before ſpherically expanded, now ſubtends circularly from the arch of the cornea, a little convex outwardly, and with a deficiency in its middle; from whence a circular parallel portion is taken out, ſo as to form a foramen or hole, called the *pupil*, which is ſeated nearer toward the noſe, and is larger toward the temple. The anterior part of this round rim, is called the *iris;* and the back-part, ſeparable from the former by maceration, is, from the black colour with which it is painted, called *uvea*. On the anterior ſurface of the iris appear numerous ſtripes, extended like rays, of various colours in different people, the whole covered as it were with little locks of wool. Theſe go off beyond the pupil into a ſerrated circle, from which tend other ſimilar ſtreaks, even to the edge of the iris. They are ſerpentine in a broad pupil, but ſtraight in a narrow one. On the poſterior face of the uvea is much black pigment; which being waſhed off, ſtraight radiated ſtreaks appear, produced into the pupil, but not woolly. Orbicular fibres, concentrical with the pupil, I have not been able to obſerve, neither with the naked eye, nor with a microſcope, even in an ox; but only in the uvea, an internal circle diſtinguiſhed by obſcurer rays, but

leſs

lefs woolly. In the human fetus, the pupil and the iris being produced, makes a complete circle. That part of it which is drawn over the pupil is of a vafcular texture.

513. Though the iris has little fenfation, and is not endowed with any mechanical irritability; yet in a living man, quadruped, or bird, it is conftricted on every greater degree of light, and is dilated on every fmaller one; hence it is rendered broader for viewing diftant objects, and narrower for viewing fuch as are near. The caufe of this dilatation feems to be a remiffion of the powers refifting the aqueous humour; an argument of which, is the dilatation of the pupil, occafioned by debility, and which fucceeds fyncope and death. The contraction is more obfcure, and perhaps only depends on the ftronger afflux of humours into the colourlefs veffels of the iris, into which thefe veffels are extended; and, along with thefe, the iris is rendered longer, and fhuts the greater part of the pupil: fo that this motion has fomething in common with a beginning inflammation. The pupil is more evidently moved and contracted; as the eye gradually grows callous in old people, it is rendered almoft immoveable. In an animal twenty or thirty hours dead, I have feen the iris extend by heat, and fhut the pupil.

514. Behind the uvea, from the fame circle by which the choroides and fclerotica join together, and outwardly adhere to the cornea, arife thick ftripes, extended from the choroides, elegantly wrinkled with parallel veffels, fpread under them, which are conjoined by feather-like loofe and thin footftalks, into the retina, every way fpread with a good deal of black paint; and departing, after the manner of a perforated ring, inward from the tunica choroidea, they fpread upon the vitreous humour; and, laftly, are laid on the capfule of the cryftalline lens, but do not adhere to it, and are called by the name of the *ciliary ligaments*. The origin of the black pigment we are as yet unacquainted with; nor can any glandules be found, which fome have affigned

for

for its separation. Among its other uses, one seems to be to keep firm the crystalline lens. In infants, this same mucus has the image of a radiated flower, behind the ciliary process.

515. But the *retina*, which is truly a continuation of the medulla from the optic nerve, is next expanded into a sphere concentric with the choroides, extremely tender, and almost of a mucous consistence, dissolvable by a blast; and this immediately embraces the vitreous body. But when the retina has extended itself as far as the ciliary processes, it follows their course, making their stripes and small arteries its foundation or support in its course to the crystalline lens, to the capsule of which it adheres; and, if we may believe the observations of some anatomists, as well as our own, spreads upon its surface.

516. These coats of the eye, which invest and support each other, after the manner of an onion or other bulbous root, give a spherical figure to the eye, and include its *humours*: by which name are understood commonly three substances; the one a solid, the other a soft body, and the third truly a liquor. First, then, the common surface of the retina is, on all sides, filled by the principal or *vitreous* humour, which is contained in a thin pellucid membrane of its own, of a cellular fabric, in the intervals of which is confined a most clear liquor, a little denser than water, which entirely evaporates by heat, like the aqueous humour; from which nature it does not easily degenerate, even in old people. Its vessels, which are most manifest in fish, lie in the back part; are most beautifully radiated from the central trunk of the retina, embracing the convexity of the vitreous humour; and are inserted into a circle formed by other arteries coming from the choroides, not far from the lens, and which I have seen in a sheep. The vitreous membrane, which is tender considering its body, is yet grown to the lens in two places, before and behind; so that the middle hollow ring is intercepted between both insertions, round the crystalline

cryſtalline lens. Afterwards it is divided by ſome little ropes. The ſtreaks of the ciliary body imprint their marks on the anterior face of it.

517. But, in the fore-part of the vitreous body, behind the uvea, there is an orbicular depreſſion or ſinus conſiderably deep, into the cavity of which the *cryſtalline lens* is received, though that be leſs properly ranked in the claſs of humours. The figure of this lens is made up of two elliptical convex portions or ſides, the foremoſt of which is flatter, and the poſterior more gibbous. The ſtructure of it is that of concentric plates or ſcales, ſucceeding each other, and compoſed by the fibres themſelves, elegantly figured and contorted, and connected together by cellular fibres, ſo as to form a tender cellular texture. Betwixt the cryſtalline leaves is alſo contained a pellucid liquor, which, in old age, turns of its own accord to a yellow colour. The innermoſt ſcales lie cloſer together; and form at laſt a ſort of continued nucleus, harder than the reſt of the lens: it does not ſo adhere to the capſule, but, when that is broke, it very readily leaps out; and ſome ſay that a little water is effuſed around it. Its artery is from the retina, which perforates the middle of the vitreous humour; that is, the poſterior one; for the veſſels in the fore-part are not yet known. This whole lens is contained in a ſtrong, thick, elaſtic capſule of a pellucid membrane, more firm in the fore-part, which is lined backward by the vitreous tunic.

518. Laſtly, the *aqueous humour*, which is extremely clear and fluid, and renewed again if it be let out, is ſeated in a ſmall ſpace of a curve-lined triangular figure betwixt the uvea and cryſtalline lens, and in a larger chamber that is before betwixt the iris and the cornea. This humour ſeems to exhale from the ſmall arteries of the iris, uvea, and ciliary proceſſes; being again abſorbed into ſmall veins of the ſame parts, while ſome portion of it is drunk up and exhaled through the cornea. This humour alſo waters the uvea and capſule of the lens. About the beginning of the preſent century, the

the ſpaces filled with this liquor were called the *cameræ* of the eye; the fore one between the cornea and iris; the poſterior one, which is ſmall, between the circumference of the cryſtalline lens and the uvea.

519. The eye, thus framed, is outwardly ſurrounded with muſcles, for its government and direction. Namely, into the circle of the ſclerotica, which is next to the cornea, are inſerted four ſtraight muſcles, ariſing from the dura mater of the optic nerve at the bottom of the orbit; where, departing from the nerve, they cohere with the perioſteum, forming, as it were, one circle; from whence, going forward, their bellies lie round the bulb of the eye, and terminate again by their aponeuroſes, meeting together in another circle into the ſclerotica. Of theſe, the elevator is the leaſt, and the abductor the longeſt. The office of theſe muſcles appears very plainly in each of them apart; ſince, being bent round the convex bulb of the eye, as about a pulley, they muſt, of courſe, elevate, depreſs, or turn the globe of the eye either to the noſe or to the temple. Moreover, two of them acting together may turn the eye in a diagonal betwixt the former directions; as upwards and outwards, upwards and inwards, &c. Laſtly, when all the four ſtraight muſcles are contracted together, there is no doubt but they draw the whole eye towards its origin within the orbit, by which means the cryſtalline lens is moved nearer to the retina.

520. But the two *oblique muſcles* of the eye are of a more compound fabric. The upper of theſe, ariſing together with the recti, is long and ſlender, aſcending forward to a notch in the os frontis, which is completed by a double ligament, cartilaginous on each ſide, and hollow in the middle, almoſt quadrangular, for ſuſtaining the tendon of the muſcle. Through this canal paſſes the tendon of the obliquus ſuperior; which being again reflected backward and downward, included in a capſule of its own, is inſerted into the globe of the eye behind the ſtraight muſcles. This draws the globe forward and upward, in a manner out of the orbit, that the

eye may take in a larger field of viſion; it alſo turns the pupil inward and downward. The other *leſſer oblique* muſcle, ariſing from a ſinus of the lachrymal foramen in the upper jaw, aſcends immediately outwards from the os unguis round the globe of the eye, and is inſerted by its tendon into the ſclerotica behind the external rectus: whence it appears, on its part, to turn the eye downward and outward; and of courſe, contrary to the former, to direct the pupil upward and inward.

521. But there are other more minute muſcular motions performed in the eye, which preſuppoſe a knowledge of the nerves belonging to this organ. And, firſt, we have already ſpoken of the optic nerve (509, 510.) The fourth pair goes only to the larger oblique muſcle, and the ſixth pair belongs to the external rectus. The third and fifth pair produce the principal nerves in the eye; and of theſe, the firſt branch of the fifth produces the ophthalmic nerve, and ſends off a ſmall nerve from its entrance into the orbit, to the eyelid and lachrymal glandule; it then conjoins with the ſecond branch of the fifth pair, and with the temporal branch of the third and fifth pair. After having entered into the orbit, its trunk divides into two. The upper and larger ſubdivides into two, which are ſpent upon the forehead and eye-lids: but the lower, going inwards above the optic nerve, ſends out long ſlender filaments to the outer part of that nerve, which, joining with another filament of the third pair, makes up the ophthalmic ganglion, and ſends off one or two ciliary nerves. Finally, having given off a nerve, running to that of the noſe (457.), it is then ſpent upon the different parts of the internal angle of the eye.

522. But the principal dignity of the *third pair* lies in giving off a branch upwards to the ſtraight muſcles of the eye, and to the eye-lids; and then, going forward with its trunk under the optic nerve, it ſends out three branches together to the lower and leſs oblique, and to the internal muſcle; after this, or often before, (from its trunk, and ſometimes from a branch of the

lower obliquus), aſcends out another ſhort and much thicker nerve, which ſometimes joins the root of the fifth (521.), or is ſometimes ſolitary; which, under the abductor muſcle, conſtantly forms the oval *ophthalmic ganglion.* From that ganglion, and ſometimes from the trunk of the third or fifth, go out four or five ciliary nerves in a crooked courſe, playing round the optic nerve in their courſe to the globe of the eye, where they enter the ſclerotica almoſt in its middle, in company with its longer ſmall arteries or veins; and running thence ſtraight forward through the choroides, they paſs viſibly to the iris, and ſeemingly to the ciliary proceſſes. Other very ſmall nerves, originating from the ſame ganglion, remain in the tunica ſclerotica.

523. Another more obſcure and leſs eaſily demonſtrable motion in the eye, is that of the ciliary proceſſes (514.); which, lying incumbent upon the furrows of the vitreous membrane, ſeem, by their action, to preſs back that body, ſo as to bring the lens forward, and ſeparate or remove it farther from the retina. But I have never ſeen, in all the animals I have diſſected, any thing like a muſcle in this ciliary body; but a membrane which ſupports the ſmall veſſels. As for any ſphincter of the pupil, or a conſtrictor of the cornea, mentioned by ſome writers of note, or even moving fibres, which others have imagined proper to the cryſtalline lens, they are in nowiſe ſupported by anatomy, nor are they conſiſtent with the perpetual hardneſs of texture obſervable in the lens and cornea of moſt animals.

524. Moreover, to the hiſtory of the eye belongs a deſcription of the veſſels, which, in this part, have a beautiful fabric. But all of thoſe which belong properly to the ſeveral parts of the eye itſelf come from the *ophthalmic artery*, a branch of the internal carotid (316.) This, creeping along under the optic nerve, ſends out, as principal branches, the upper and lower ciliaries, one or more; the lachrymalis, from whence the poſterior running to the noſe, and internal part of that belonging to the arch of the tarſus; afterwards the

muſcularis

mufcularis inferior, the anterior recurrent to the nofe, the uppermoft mufcularis, and the palpebralis; from whence, with the former branch, fprings the arch of the tarfus. Laftly, it goes out forward to the face, and adjacent parts of the nofe. But the ophthalmic branches, belonging to the inner fabric of the eye, are the pofterior and middle ciliaries; which, arifing from the trunks before-mentioned, and playing round the optic nerve, in four or more branches, in a ferpentine courfe, go partly in with the optic nerve at its firft entrance, and are partly extended further to near the middle of the fclerotica, where they fend in forty or more little arteries to the choroides, which make firft beautiful ramifications upon the external furface of that membrane, round, and like the branches of trees; from whence they proceed inwardly in a more direct courfe, and at laft go to the *circle* of the uvea.

525. But feveral of the fmall arteries of the tunica choroides gradually decline towards the interior parts of the eye; and, being covered with a kind of cellular woolly matter, go to the ciliary proceffes, through each of which run out two fmall arteries, fcattering vafcular woolly-like locks, united by an handle at their apex.

526. Other fmall arteries alfo, likewife arifing from the ciliary ones, but few in number, moft commonly two, come to the fame bafis from which the membrane of the uvea originates. There, fpreading in various directions, they furround the root of the uvea with their branches, and are joined into a circle, into which the anterior ciliaries mix themfelves; which are fmall arteries arifing from the mufcular branches of the ophthalmic, near the origin of the pellucid cornea; perforate the fclerotica by twelve or more branches, and together make up the circle of the pupil. From that circle, and likewife from the fore-mentioned anterior ciliary arteries, independent of the middle circle, are diftributed veffels, both on the anterior face, which makes the iris, and on the pofterior face of the uvea, together with the ciliary proceffes; the veffels are dif-

tributed, both ſtraight and ramified; the iris is full of a liquor of a bluiſh colour, otherwiſe brown; and the uvea is ſpread with a good deal of a black paint, without which it is naturally white. In the uvea, at ſome diſtance from the pupil, they frequently form an imperfect circle.

527. But from the ſame ophthalmic and its trunk, or from the lachrymal branch, or from one of the ciliaries, one or more branches enter into the optic nerve; the principal central artery of the retina penetrates through the medulla of the nerve, and, going out of the apex of the papilla (510.), divides in the centre of the retina; from thence ſpreading every way in company with the retina itſelf, by ſo many branches, when traced by a ſkilful anatomiſt, that that vaſcular net-work is taken for a proper membrane. Sometimes a leſſer branch goes along the centre of the nerve to the retina, and is in like manner ramified through it. It is certain, that from theſe branches the minute pellucid ones of the vitreous tunic are produced, as well as the poſterior artery of the lens. The centre of theſe arteries, entering the retina, is the celebrated *porus opticus* of the ancients.

528. The *veins* of the eye, in general, ariſe from the ophthalmic vein, which here comes from the vein of the face; and, going out of the bony orbit, is inſerted into the cavernous ſinus. The internal veins of the eye are fewer in the middle of the ſclerotica, which they perforate with larger trunks, and form buſhes or trees of a roundiſh figure, which commonly keep the middle of the baſis of the tunica choroides; ſome of them, which are long, reach even to the origin of the uvea: others, in the fore-part, are ſimilar to arteries: another central vein, like an artery, goes to the retina of the optic nerve. The pellucid or watery veſſels differ not in their courſe from thoſe which convey blood. There are alſo lymphatic veſſels ſaid to have been ſeen by ſome in the retina; but the obſervation has not been often enough repeated for us to depend on it.

529. So far with reſpect to the anatomy of the eye; but

but that the action of this organ lies wholly in the reception of light, excepting only a few doubts, appears very plainly from physical and mechanical experiments. *Light* then is a matter either the same with, or very nearly approaching to, that of fire; extremely fluid and subtile, penetrating through all even the hardest bodies, without receiving alteration from any length or distance in its course; moving with such a very great velocity, as to run through the distance between the sun and earth in the space of about eight minutes and thirteen seconds. The light we have in our atmosphere proceeds either from that of the sun, whose body seems to have the power of impelling to us, in right lines, the matter of light, which is confusedly spread around; or else it proceeds from some other ignited point or lucid body; from whence the rays spread every way, as from a centre to all points of a large sphere, so as to fall upon the surfaces of bodies; from whence again it is reflected into the eye, from the enlightened surfaces, in angles equal to that of their incidence, so as to render the bodies from whence it thus flows to the eye, both visible and of some colour.

530. It is now sufficiently evidenced from experiments, that light is composed of rays in right lines, almost without any physical breadth or thickness; and yet, that each of these rays is again separable into seven other permanent and immutable rays of a lesser kind. The known properties of these rays are, that all of them, conjoined together, constitute a white beam; which, being refracted by the minute surfaces of bodies, are subdivided into rays of a red colour, which are more constant or permanent, hard, and less refrangible; next to which follow those of an orange, of a yellow, green, blue, and indigo or violet colour; of which those are always weaker and more refrangible, which are farther distant in order from the red rays. A shadow arises from a deficiency in the reflected rays. Those primitive rays, variously compounded together with shade, make up all the variety of colours.

531. The

531. The colours, then, which ſeem proper to bodies, ariſe hence; that the minute ſurfaces of their conſtituent ſolid particles, by which their pores or vacuities are limited, do, according to the difference of their thickneſs, denſity, &c. reflect or ſeparate the rays of light, ſo as to ſend more of one kind or colour to the eye than another; whilſt moſt part of the remaining rays are loſt by repeated reflections within the pores of the ſubſtance: ſo that the ſtrongeſt and thickeſt particles reflect a white colour; thoſe next in denſity and ſize, a red colour; till at laſt the minuteſt ſurfaces reflect a violet colour. Thoſe bodies are opake, which retain the rays within their ſubſtance, without permitting any to paſs through them: which ſeems to follow from the largeneſs and the number of the pores, to the ſides of which the light is attracted; which pores are filled with ſome matter that has a power of refraction, different from that which the light ſuffers from the parts of the body itſelf. Theſe principles we embrace, till a new theory that places the diverſity of colours in vibrations of different celerities ſhall be better eſtabliſhed; neither is it our buſineſs to concern ourſelves with this matter.

532. Theſe rays, falling obliquely upon the ſurface of liquors of various denſities, paſs through them with a change in their direction, by variouſly receding from or approaching nearer to a perpendicular: and this is called their *refraction*. In general, the denſer the medium, the more are the rays bent towards the perpendicular; excepting only inflammable liquors, which, by a peculiar property, draw the rays more to a perpendicular than in proportion to the denſity of the liquor. The proportions of the angles of incidence to thoſe of refraction are obſerved to be conſtant enough; ſo that the ſine of the radius of refraction from air into water is to the ſine of the angle of incidence, as 3 to 4: and in the radius, paſſing from air into glaſs, the ſine of the incidence is to that of refraction, as 17 to 11; and from water into glaſs, as 51 to 44.

533. Rays,

533. Rays, which come through the air with but little divergency, (as do thofe of the fun on account of their immenfe diftance; or as, in general, do any rays that come from the diftance of above 100 feet), falling out of the air upon denfer bodies, fpherically convex, are reflected to greater angles, as of 48½ degrees; nor are they under that meafure. If the angles are fmaller, and they penetrate the refracting medium, they are there fo refracted, as to meet together in one point, which is called their *focus*. This point always falls within the axis or radius that is perpendicular to the furface; whence it becomes permanent and unchangeable. So that the focus of rays, paffing from air into a fphere of water, will be diftant from the axis one femidiameter of the fphere; and in a globular glafs, it will be diftant a fourth part of the diameter; but in a convex lens of glafs, that is part of a fphere not lefs than thirty degrees, and equally convex, the focus will be likewife diftant one femidiameter; yet fo that the rays will meet, not in a fingle point, but in a little circle.

524. Therefore the rays of light, whether direct or inflected, fall in fuch a manner upon the tunica cornea of the eye, as to form a moft fharp cone betwixt the lucid point and the membrane upon which they are fpread: the bafis of which cone will be the furface of the cornea, and the apex in the radiant point; yet fo that all rays in this cone may, without any fenfible error, be reckoned parallel with each other. Among thefe, there are fome rays reflected back from the cornea, without ever penetrating the furface; namely, all fuch as fall upon that membrane in a greater angle than that of forty degrees. Others, which enter the cornea at very large angles, but lefs than the former, and fall in betwixt the uvea and fides of the cryftalline lens, are fuffocated or loft in the black paint that lines the uvea (512.) and the ciliary proceffes (514.); but thofe rays only fall upon the furface of the lens, which enter the cornea at fmall angles, not much diftant

from

from the perpendicular, or at moſt not exceeding twenty-eight degrees. By this means, all thoſe rays are excluded which the refracting power of the humours in the eye could not be able to concentrate or bring together upon the retina; without which they would paint the object too large and confuſedly.

535. Thoſe ſlender rays, therefore, coming thus to the thick cornea, which is denſer than water, and forms the ſegment of a ſphere, ſuffer thus a greater power of refraction, and paſs through it in a more conſiderable degree towards the perpendicular; namely, about a fourth part: but theſe rays falling with but little convergency upon the aqueous humour, which is ſmall in quantity and almoſt like water, making there no focus becauſe of the nearneſs of the humour to the cornea, go on nearly parallel, or little converging, to the next adjacent ſurface of the very pellucid or cryſtalline lens; becauſe their divergency was conſiderably corrected by the refracting power of the cornea. Moreover, the cornea, being convex and part of a leſs ſphere than that of the ſclerotica, receives and collects a greater number of rays than if it was flatter with a leſs ſurface.

536. The refracting power of the cryſtalline lens, which exceeds that of water, may be underſtood from its greater hardneſs and weight; although we have no certain meaſure. In this lens therefore, and more eſpecially in its poſterior very convex ſide, the rays will converge much together, and paſs thence into the vitreous body.

538. This vitreous body is denſer than water, in which it ſinks to the bottom; but rarer than the cryſtalline lens; and continues to bend the rays a little more gently towards the perpendicular, till at length the rays, coming from the point of diſtinct viſion, are concentrated into a very ſmall part of the retina, where they paint an image of that object from whence they come; but in a poſition inverted, from the neceſſary decuſſation or croſſing of the rays. The manner in which

which the images of objects are thus painted, may be ſeen experimentally in an artificial eye, or by a natural eye when the back-part of the ſclerotica is cut off, and a piece of paper placed to receive the object. But the image we ſee is painted on the outer ſide from the optic nerve, within the bounds of the viſual axis; yet ſo that it is not a mere point, but has ſome degrees of breadth; ſince we ſee many objects at once, whoſe images muſt be in diſtinct points of the painted field. And there an object is ſeen moſt diſtinctly, becauſe the rays arrive thither nearly perpendicular. But frequently this point of viſion does not fall on the ſame place in both of the eyes. When the lens has been couched or diſplaced, the vitreous body, with a weaker refracting power, uſually ſuffices to bring the viſual rays together to a focus.

539. Is it altogether falſe that the object is painted on the retina? Or is this picture made on the choroides? Is this new opinion confirmed by an experiment, by which it is found that the place where the optic nerve enters is blind? and which is thus explained, that there is in that place no choroides but the bare retina, and that thence there is no viſion. But this is repugnant to a very well known obſervation, namely, that the retina is a moſt ſenſible nervous medulla; and that the choroides conſiſts almoſt entirely of a few ſmall nerves, and of veſſels moſt certainly blind. This is likewiſe contradicted by the very great variety of the choroides in animals; the equally great conſtancy of the retina; and the black ſpots, which, even in man, obſcure the exterior ſurface of the retina. But by this experiment we know the reaſon why the optic nerve is not inſerted into the axis of the eye, but into its ſide. For thus, except only in one ſingle caſe, where there is an impediment in the concourſe of lines drawn through the centre of the optic nerves, the one eye ſees and aſſiſts that whoſe blind ſide is turned towards the object.

540. But ſince the neceſſary offices of human life

require a diſtinct object to be painted upon the retina, not only by the rays which come from one certain diſtance, but likewiſe by rays which come from very different parts more or leſs diſtant; therefore, it is to be believed, that the neceſſary change is produced in the eye by its own proper cauſes. Other famous anatomiſts have ſuppoſed the lens moveable by the powers before mentioned (519. 523.) This art of ſeeing diſtinctly is ſaid to be learned by experience, it being unknown to an eye lately couched of a cataract. Alſo, in an artificial eye, the uſe and neceſſity of this motion, it is ſaid, may be plainly perceived. Therefore too great a divergency of the rays, as in thoſe which come from objects very cloſe to the eye, is corrected by a removal of the lens farther from the retina, ſo as to bring the focus of the diverging rays upon the retina itſelf, which would otherwiſe have fallen behind the eye; for the refracting power of the eye being determined, that which will unite the focus of rays coming from the diſtance of three feet, ſo as to make them fall perfectly upon the retina, will not be able to collect together into the ſame point thoſe rays which come from the diſtance of three inches; and rays ſtill more diverging will meet together yet farther behind the eye, if they are not collected together by a greater refracting power.

541. But thoſe rays, which come from parts very remote, and which may be therefore counted parallel, will meet together before the retina, in the vitreous body; and again ſeparate according to the nature of rays from the point of concourſe, as if it was a lucid point: to remedy which, therefore, it is probable that thoſe powers (523.) remove the cryſtalline lens back from the cornea, nearer to the retina; that the rays, which come together from a certain diſtance to the lens, may be alſo united together at a certain proportionable diſtance on the retina. For an eye, that will collect the rays coming from ſeven inches, ſo as to unite them on the retina, will collect thoſe together before the retina

tina which come from a diſtance of three feet. It was therefore perfectly neceſſary for the eye to be made thus changeable, that we might be able to ſee diſtinctly at various diſtances. But the point of diſtinct viſion is in that part of the retina where the given object is painted in the leaſt compaſs poſſible. The powers cauſing the viſual rays to unite or converge together on the retina, are often very different in the two eyes of one and the ſame perſon, ſo as to render one eye nearly preſbyoptical or long-ſighted, and the other myoptical or ſhort-ſighted.

542. Theſe and other things ſimilar are commonly received and taught, more eſpecially by the mathematicians, who more readily perceive the neceſſity of theſe changes. But yet there is no power in the human eye which can either move the cryſtalline humour out of its place, or compreſs it. But we do not perceive this faculty in ourſelves: for we move a book nearer to our eyes when it is too far off, ſo as to appear confuſed; which we would have no occaſion to do, if by changing the internal figure of the eye we could correct the fault of the diſtance: and, through a ſmall hole, we perceive an object only ſingle in the point of diſtinct viſion, but double in every other. Perhaps the contraction of the pupil may do ſomething, by which we can perceive more diſtinctly ſuch objects as are near.

543. But this artifice of the eye is not ſufficient in all perſons: for there are now a greater number of people than formerly employed in a ſtudious or ſedentary life, and taken up with the obſervation of more minute objects; by which the cornea is rendered more convex and denſe, and the cryſtalline lens more ſolid and of leſs ſegments; while the eye itſelf, by the weight of the humours, is more elongated, and the reſt of the humours themſelves are probably more denſified: many or all of which circumſtances attend the eyes of one perſon. In ſuch, the iris is ſenſible in a ſmall light; whence, by winking or ſtraining the eye-

 lids,

lid, they are denominated *myopes*, ſhort or near ſighted. In theſe, the point of diſtinct viſion is very near to the eye, from one to ſeven inches from before the cornea; but they ſee remoter objects more obſcurely, without being able to diſtinguiſh their parts. The reaſon of this is evident; ſince, from the forementioned cauſes, there is a greater refracting power of the humours, by which the diſtant and conſequently parallel rays are obliged to meet in their focus before the retina; from whence, ſpreading again, they fall upon the retina in many points. Thus alſo to a good eye, the ſenſe of objects which are too near the cornea is confuſed; becauſe the rays coming from thence are ſpread all over the retina, without being collected towards the centre.

544. The remedy for this fault in the ſight is to correct it in its beginning, by viewing diſtant places, by keeping the eyes from minute or near objects, and by the uſe of concave glaſſes; or by viewing things through a ſmall hole, by which the light is weakened. When the diſorder is confirmed, the remedy is a concave lens, which takes off a degree of the refracting power in the humours, cornea, and cryſtalline lens, in proportion as it is more concave; by which means the focus of rays from remote objects is removed farther behind the cornea, ſo as to fall upon the retina. This glaſs ought to be a portion of a ſphere, whoſe diameter is equal to the diſtance of diſtinct viſion from the naked eye, ſquared by the diſtance of diſtinct viſion in the armed eye, and divided by the difference betwixt them. Age itſelf advancing, gives ſome relief to the ſhort-ſighted; for children are in a manner naturally myoptical: but, as the eye grows older, it becomes flatter, in proportion as the ſolids grow ſtronger; and, contracting to a ſhorter axis, the converging powers of the lens and cornea are diminiſhed.

545. Another diſorder of the ſight, contrary to the former, troubles people who are often looking upon very diſtant objects, and is more eſpecially familiar and

incurable

incurable in old people. In ſuch, the cornea and cryſtalline lens are flatter, and the humours of the eye have a leſs refracting power. Hence near objects, whoſe rays fall very diverging upon the cornea, appear confuſedly; becauſe the converging or refracting powers of the eye are not ſufficient to bring the rays together in a focus upon the retina, but the rays go on ſcattered through the retina, and through the point of their pencil behind the eye; from whence viſion is confuſed. The point of diſtinct viſion among preſbyopi, or old or long-ſighted people, is from the diſtance of fifteen inches to three feet.

546. Such perſons are, in ſome meaſure, relieved by looking through a black tube held before the eye, by the uſe of which the retina grows tenderer, and the rays come to the eye in a parallel direction. The remedy here is a convex lens of glaſs, which may cauſe the rays to converge and unite together ſooner in a focus, that it may not fall behind the eye, but upon the retina. The diameter of the ſphere, of which ſuch a lens ought to be a portion, is determined as before (544.) There is no hope from age, which increaſes the malady.

547. The medium betwixt ſhort and long ſighted is the beſt, by which a perſon can ſee diſtinctly enough objects that are both near and remote; and of this kind we reckon an eye that is able to read diſtinctly at the diſtance of one foot. But to this are to be added other neceſſary conditions; ſuch as a perfect clearneſs of the humours; a due mobility of the eye itſelf, and its parts; a ſenſibility of the pupil and retina, neither too tender nor too tough.

548. But the mind not only receives a repreſentation of the image of the object by the eye, impreſſed on the retina, and transferred to the common ſenſory or ſeat of the ſoul; but ſhe learns or adds many things from mere experience, which the eye itſelf does not really ſee, and other things the mind conſiders or interprets to be different from what they appear to her by the

the eye. And, firſt, the *magnitude* of an object is judged of by an optical angle intercepted; as the baſis of a triangle betwixt the cornea, and as the point of a cone betwixt the radiant object. From hence, things very near ſeem large, and remote objects ſeem ſmall. Hitherto may be referred the power of microſcopes, by which objects are made to appear to us ſo much larger, as the diſtance of the focus of the lens or magnifier is leſs than the diſtance of diſtinct viſion; when, in reality, they do not appear larger, only more diſtinct and lucid; whence the mind judges them to be nearer.

549. The ſtrength of viſual light likewiſe is proportionable to the ſame angle, in the external day-light; and the multitude or number of the rays, joined with the ſmallneſs of the ſeat which they affect in the retina, occaſions near objects to appear brighter, and diſtant objects more obſcure; or if remote objects appear bright by their own light, the mind repreſents them as large, near at hand, or both.

550. The *place* of a diſtant object appearing to one eye, is reckoned to be in a line comprehended by two other ſtraight lines drawn to the extremities of the body. If the ſame body is looked upon with both eyes, it will then ſeem to be in the concourſe of two lines drawn through the axis of both eyes to that object.

551. Diſtance we cannot perceive; and if a blind man, who never ſaw, ſhould by any means be reſtored to ſight, he would imagine every thing he ſaw to touch his eyes. Even we who are accuſtomed to judge by ſight, make many fallacious conjectures concerning the diſtance of objects: but concerning this we judge as well from the known diminution of the bulk of the body, as from the leſſer ſtrength of the light, and faint image of the object whoſe parts we are leſs capable of diſtinguiſhing, and from the number of bodies interpoſed, whoſe diſtance is known.

552. The convexity or *protuberance* of a body is not ſeen; but is afterwards judged of by experience, after we have learned, that a body, which is convex to the feeling,

feeling, cauſes light and ſhadow to be diſpoſed in a certain manner. Hence it is, that microſcopes frequently pervert the judgment, by tranſpoſing or changing the ſhadows. The ſame alſo happens in that phenomenon which is not yet ſufficiently underſtood, by which the concave parts of a ſeal are made to ſeem convex, and the contrary.

553. The viſible *ſituation* of the parts of an object, are judged by the mind to be the ſame with that which they naturally have in the object, and not the inverted poſition in which they are painted upon the retina. But it is certainly a faculty innate or born with the eye, to repreſent objects upright to the mind, whenever they are painted inverted upon the retina: for new-born animals always ſee things upright. And men who have been born with cataracts, without ever being able to ſee, are obſerved, upon couching the cataracts, to ſee every thing in its natural ſituation, without the uſe of any feeling, or previous experiences.

554. One thing which impoſes upon the mind, is the continuance which external ſenſations make, during almoſt the ſpace of a ſecond of a minute, after they have been conveyed to the ſenſorium by the eyes; whence they are repreſented to the mind as objects really preſent. From hence proceeds the idea of a fiery circle from the circumrotation of a lucid body; and from hence proceeds the continuance of the ſhining image of the ſun, and ſometimes of other bodies, after they have been viewed by the eye.

555. Do we perceive only that object diſtinctly which is directly before that part of the retina which ſees moſt diſtinctly? And does the eye perſuade itſelf, that it ſees many objects at a time, partly from the duration of the ideas, and partly from the quickneſs of the motions of the eye? Concerning the moſt diſtinct viſion, this is moſt certain; but we cannot affirm it of that which is leſs diſtinct. Why do we ſee only one object with two eyes? Becauſe the ſenſation becomes one, and without difference, when we have ſimilar impreſſions of

two

two objects. For, even without the concourse of optic nerves, insects who have numerous eyes perceive objects single. Hence the images of two objects excite only one sensation, when they fall upon the same point of the retina; but two sensations arise from one object, when the images fall upon different parts of the retina. Whence proceed diurnal and nocturnal blindness? The former is common to many nations living in the warmest climates, under the brightest rays of the sun, and to old men. The other happens in inflamed eyes, and young men of a hot temperament, and hence endowed with eyes vastly sensible. Whence do animals see in the dark? From a large dilatable pupil, and tender retina; a shining choroides, and one which reflects the light very strongly. Why are we blind when brought out of a strong light into a weak one? Because the optic nerve, having suffered the action of stronger causes, is incapable of being moved by weaker ones. Whence have we a pain, by passing suddenly from a dark place into the light? Because the pupil, being widely dilated in the dark, suddenly admits too great a quantity of light before it can contract; whence the tender retina, which is easily affected by a small light, feels, for a time, an impression too sharp and strong. Whether see we with one eye, or with both? Most frequently with one, and more especially the right eye: but when both are employed together, we see more objects, and more plainly; and we also distinguish more points of the same object, and judge better of their distances.

CHAP. XVIII.

Of the Internal Senses.

556. HITHERTO we have considered the senses as they are, each of them apart. It is now common to them all, that the tender pulp of the nerve, being

being ſtruck or impreſſed by external objects, conveys a change by the nervous ſpirits, to that part of the brain where the impreſſed fibres of the nerve firſt ariſe from the arteries (372.) We know nothing more, than that new thougnts are thus excited in the mind: which we call *perceptions*, with reſpect to the thinking mind herſelf; and *ideas*, with reſpect to the objects from whence they ariſe. Perception is therefore excited whenever any of the forementioned changes, in ſome of the ſenſible organs, are transferred to their firſt origin; for the thought or ſenſe by which the perceiving nerve itſelf is affected, is no expreſs image or idea of the object. The idea of redneſs has nothing in common with rays but little refrangible, and ſeparated from the ſeven portions of which rays of light are compoſed; and much leſs is it conſiſtent with optical principles, for the image painted by rays, upon a ſoft white nerve, to be conveyed through a moſt opaque body, in a long courſe of perfect darkneſs, to the origin within the thalami. There is nothing in the pain of burning that can repreſent to the mind its ſwift and ſubtile matter violently moved, by the particles of which the continuity of the nervous threads is broken or deſtroyed. There is nothing in the idea of a ſharp ſound, from a chord of a certain length, that can inform the mind the ſaid chord trembles 5000 times in the ſpace of a ſecond. Neither does a ſalt taſte teach us that the cryſtals of ſea-ſalt are of a cubical figure. Again, though a motion is impreſſed on the brain, from the ſenſation perceived by the body, the mind neither perceives this motion, nor the tremors of ſounds, nor the percuſſions of the rays of light, but ſomething perfectly diſtinct from this motion. But it is eſtabliſhed as a perpetual law by the Creator, that certain changes, made firſt in the nerve, and then in the common ſenſory, ſhall produce certain new correſponding thoughts in the mind, which have an indiſſolvable connection with each other; ſo that, although what we perceive in the world be arbitrary, yet that it is real, and not falſe, appears plainly from the perpetual agreement of similar thoughts arising from similar affections of the sensitive nerves, in all persons at the same time, from one object, or in one person at different times.

557. During the time of our perceptions, therefore, five very different beings are joined together: the body which we perceive; the affection of the organ of the sensory by that body; the affection of the brain, arising from the percussion of that sensory; the change produced in the mind; and, lastly, the mind's consciousness and perception of the sensation.

558. It appears from certain experiments, that the first origin of every perceiving nerve is always distinct; and that the change which is first excited by the external object in the said nerve (556.) continues in the origin of that nerve for a considerable time; and also that those changes are so classed and laid up within the said part of the brain, that those are nearest together, which were either contemporary, or nearly so, or which have succeeded next in course; or lastly, which have a relation to the same subject, or were excited by similar objects: insomuch, that it is certain, new species or ideas are always conveyed again to the same part of the brain where others of the like kind are reserved: for otherwise the arbitrary signs of words and letters would never be able to renew the same old ideas again in the memory; nor could disagreeable ideas, returning into the mind, without the assistance of external objects, reproduce the same effects, as would the disagreeable objects themselves; nor, otherwise, could there be so constant and manifest a connection of analogous ideas, which most powerfully occur in dreams, according to the corporeal causes which then remarkably act in the brain. Whether or no do imagination and memory depend on this conservation of ideas? Finally, those changes in the sensorium, which many term past or reserved ideas, are, for distinction's sake, by us called the *footsteps* or *traces* of things, which are lodged or engraved not in the mind, but in the body itself, by certain notes or characters, incredible in their minuteness,

neſs, and infinite in their number, recorded after an inexpreſſible manner in the medulla of the brain. Amongſt theſe characters, ſuch are more eminently and diſtinctly preſerved as were received, firſt by the ſight, and next by the hearing; for thoſe of the other organs are more confuſed and irrevocable by the will. And both the traces and their ſigns are preſerved; the latter more eaſily; the former, however, ſo far, that a painter can eaſily expreſs with his pencil upon canvas, an image of a face ſimilar to one which he is accuſtomed with, and which is impreſſed on his mind.

559. *Imagination*, then, is whenever any ſpecies, preſerved in the common ſenſory, and in preſent perception, excites ſuch other thoughts in the mind as would ariſe if the perceiving nerve that gave the firſt birth to the ſaid ſpecies was itſelf affected or changed. This definition is confirmed by examples of the great ſtrength of fancy in certain perſons, and thoſe who are delirious; but in every body, in the inſtance of dreams, in which thoughts ariſe in the mind, occaſioned by the corporeal ſpecies reſerved in the brain, ſo as to be not at all weaker than thoſe which were firſt formed by the change in the ſentient nerve, from the external objects. Even more, the attention and reſt of the mind, with the abſence of all external objects, will often obtain a ſtronger aſſent from dreaming, towards the traces impreſſed in the brain, than that which is given from the mind by the perceptions which are excited from external objects: for the will is more powerfully determined in thoſe who dream, than in thoſe who are awake, ſo as often to perform certain actions by the voluntary muſcles, while they are aſleep, which they never can perform awake, even though the ſame nerves were more ſtrongly affected by the real objects. From hence we may underſtand, how it is poſſible the internal ſpecies, which are very ſtrong in a delirium, may ſo impoſe upon the mind, as to make her miſtake them for the perceptions of external objects; as, for example, in the fiery ſparks which are excited by preſſing the

eye and optic nerve; in the rednefs feen by the eye when it is fhut; in the vertigo or rotation that arifes from a motion of the retina, which we afcribe to the the external objects themfelves; in the duplicity of fight, &c.

560. But *memory* is, when any internal former thought of the mind, or the fpecies perceived and preferved in the brain, from external objects (372.), repeat or excite again other perceptions in the mind. And here the perceptions are commonly weaker than in the imagination, being almoft only certain arbitrary figns conjoined together, with the idea that was firft perceived in the mind: for the memory hardly reprefents the images and pictures of things to the mind; only the words or figns, and certain attributes, together with the general heads of ideas; for which reafon, they move the will with lefs force: but it appears from the obfervation of thofe changes which happen in the memory, that fuch as arife from the external fenfes, remain longeft in the brain; and fometimes, if they made a ftrong impreffion, they may for ever, and in all ages of life, be repeated to the mind; but they are weakened, and in a manner blotted out in time, by degrees, unlefs the reprefentation be renewed again to the mind, either from an external object, or from the mind itfelf recalling the fame change again into memory: fo that, without this repetition, at laft the change or impreffion will be in a manner erafed and quite loft; and will never be able to be drawn in again to the mind, whenever fhe repeats fuch other thoughts as had naturally any connection with the former. This deftruction of new and different fpecies, conveyed to the fenforium, is evident, not only from the effect of time, but likewife from cataleptic diforders; which fometimes, after a confiderable interval of time, go on with the fame train of thought which the difeafe had interrupted. But fometimes all of them will be fuddenly deftroyed by difeafe, in which the brain is any how compreffed, either from the blood or other caufes.

Such

Such a compreſſing cauſe, acting on ſome part of the common ſenſory, blots out a correſponding number of the ſpecies from the mind or memory, whether they be certain or all kinds of words, or even the characters by which we expreſs words; or, laſtly, the characters of our friends, and neceſſaries of life: yet all theſe ſpecies are often again renewable to the mind, whenever the compreſſing cauſe is removed. But the ſtrength and duration of an idea depends upon its being either unuſual, of a ſtrong action, or greatly conducing either to increaſe or leſſen our felicity; or, laſtly, from being joined with great attention from the mind, and often repeated: all which circumſtances being conjoined, may render the ſpecies ſo ſtrong to the mind, that ſhe will afterwards receive the perception of them, as if they came from external objects, in the manner we obſerve in mad people.

561. Moreover, if we review the hiſtory of human life, it will appear, that in the beginning of our infancy, we have hardly any memory; only ſimple perceptions, that ſoon vaniſh: which, nevertheleſs, do for the preſent excite ſtrong thoughts or impreſſions in the mind, as we learn from the clamours of infants. But, afterwards, the memory is perfected by degrees, and the ideas received from perſons moſt beloved and familiar to the infant remain impreſſed in the mind; while, at the ſame time, the imagination likewiſe increaſes in proportion, ſo as to be often very powerful in young children; as we ſee, for example, in frights, which in no age produce more violent or fatal effects. From thence forward, as the number of our ideas increaſes, the faculty of preſerving thoſe paſt, weakens; and, at the ſame time, the power of the imagination is more torpid or ſluggiſh: till at laſt the former almoſt periſhes, and the ideas, which are received but a ſhort time, eſcape from the brain; while, at the ſame time, the imagination, which is a kind of memory, languiſhes in proportion.

562. But ſince the perceptions thus formed in the mind,

produce

produce in her various changes, which are perfectly free, and diſtinct from any corporeal faculty, we ſhall briefly add ſomething concerning them, ſo far as may ſuffice to the purpoſes of phyſic. The office of *cogitation* in the ſoul, is to attend to the ſenſations which are either brought by the ſenſes, or recalled by the imagination; frequently alſo to the ſigns alone which recur into the mind. *Attention*, then, is ſaid to operate when the mind obſerves one and the ſame idea alone, and for a longer time together. The compariſon of two or more ideas brought to the mind, is called *reaſon;* as the ſimilitude, diverſity, or relation perceived by the compariſon, is called *judgment*. The principal cauſe of *wiſdom* and *invention* lies in a ſlow examination of the ideas, conſidered in the relation of all their parts one to another in the mind, while, neglecting all other objects, ſhe is employed with a ſtrong attention only upon that which is under examination. From hence proceeds that efficacy of ſolitude and darkneſs in making difficult calculation; with the more exquiſite attention of blind people to the nature of ſounds; and of thoſe who are deaf, to colours. The ſource of *error*, is ſome neglect in contemplating the whole idea, or the making an eſtimate of it from only a part of its note or character, or from a leſs congruous connection of ſome ideas with others that are diſtinct, but only related by accident, external cauſes, or affections.

563. The integrity or *ſoundneſs* of the judgment depends upon a perfect and healthy conſtitution of the brain. For the fabric of the encephalon being changed, either by compreſſure, irritation, or a deficiency of blood, confounds all the uſe of reaſon; occaſions the ſtrong internal ſpecies of the brain to be repreſented to the mind as if they came from external or real objects; breaks the connection of the ideas, ſo that the mind cannot compare them together; and is conſequently unable to judge of, or foreſee, their proportions, differences, or conſequences; ſtarting immediately from one idea to another that has no kind of

rela-

relation: or laſtly, the actions of the ſenſes being either weakened or aboliſhed, and the brain in a manner deprived of its corporeal ſpecies, the man is reduced to the ſtate of an ideot or a plant. But the powers of external bodies alſo have a conſiderable influence in changing the ſpecies of objects, which the mind acquires by the ſenſes; for the air, way of life, food, and cuſtoms, either help or diminiſh the ſoundneſs of the judgment, the force of the imagination, and the ſtrength of the memory.

564. Finally, as theſe ideas are either indifferent to us, or elſe conduce to the loſs or increaſe of our felicity, ſo they produce different determinations in the *will*. Some of theſe ideas, by which the felicity of our mind is either increaſed or diminiſhed, ariſe merely from the mechaniſm of the perfect body; and amongſt theſe corporal pain is a ſorrowful ſenſe or perception in the mind, to which every violence or over-ſtrong ſenſation in any nerve ſeems to ſerve as a foundation; while pleaſure conſiſts only in the nerve's being irritated beyond what is uſual, but in a moderate degree. Itching ſtands related to pleaſure, inaſmuch as both of them have an increaſed flux of blood into the parts in which either the pleaſure or the titillation is perceived; but, when increaſed, it tends towards pain, or to an over violent ſenſe of the nerve. Anguiſh or anxiety is from an over diſtenſion of the veſſels, becauſe the blood is hindered from paſſing freely through the lungs. The other ideas with which the mind is affected, are either wholly abſtracted from the properties of matter or body, or are at leaſt much leſs ſimple than the foregoing, which ariſe either from ſenſe or mechaniſm. The perception of good ideas excites joy; the deſire of poſſeſſing good excites love, as the expectation of it is the cauſe of hope: on the contrary, preſent evil cauſes ſorrowfulneſs, terror, or deſpair; the deſire of ſhunning evil excites hatred; and the expectation of a future evil excites fear. Hope, curioſity, and glory, ſeem to be affections of the human mind,

mind, which neither belong to the body, nor are to be found in beafts.

565. From thefe affections of the mind, the mere will appears not only to be determined to fome forefeen purpofe, to which it directs the actions of the body, in order to poffefs good and avoid evil; but alfo in the body itfelf, unconfulted, and making no great refiftance, it exercifes an equal dominion over the pulfe, refpiration, appetite, ftrength, affections of the heart, nerves, and ftomach; with the changes which arife in the other parts, ferving as figns of the paffions in the mind, from which they immediately follow. Thus anger excites a violent motion of the fpirits, caufes a a palpitation in the heart, a frequency of the pulfe, a greater ftrength of the mufcles; urges the blood into the fmaller pellucid and improper veffels; and, laftly, haftens the expulfion of the bile from its veffels; by which means it frequently removes obftructions, or eafes chronical difeafes. Grief, on the contrary, weakens the ftrength of the nerves, and the action of the heart; retards the motion of the pulfe; deftroys the appetite and digeftion; whence it produces a palenefs, cachexy, diarrhœas, jaundice, fcirrhofities of the glands, and other flow difeafes, arifing from a ftagnation of the humours. Thus, alfo, fear fo much diminifhes the force of the heart, as to occafion polypufes, palenefs, and weaknefs of the mufcular motions, a palfy or relaxation of the fphincters, an increafe of the inhalation of vapours, but a diminution of thofe difcharged by perfpiration. Terror from a prefent evil, will alfo increafe the ftrength to fo great a degree, as to caufe convulfions and a ftrong pulfe; whence it fometimes removes obftructions in palfies, or, by intercepting the courfe of the blood, it kills fuddenly. Love, hope, and joy, promote the perfpiration, quicken the pulfe, and give the blood a free circulation; whence they increafe the appetite, and render difeafes curable. But exceffive and fudden joy often kills, by increafing the motion of the blood, and exciting a true apoplexy.

Shame,

Shame, after a peculiar manner, retains the blood in the face, as if the veins were tied; it will alſo ſuppreſs the menſes or other ſecretions, and has been even known to kill.

566. But in what manner are theſe changes produced, from the commotion of thoſe paſſions in the mind? Do not the nerves cover the veſſels like ſphincter muſcles, ſo as, by contracting them ſuddenly, to increaſe the courſe of the blood, or, by relaxing and weakening their tone, retard and vitiate the circulating juices? That this is the caſe in the ſmaller veſſels, appears evidently from the near ſimilitude of effects in fear and cold upon the nerves of the ſkin. But in the genital parts, from a conſtriction of the veins, under particular circumſtances, we perceive that the blood is manifeſtly collected or accumulated in the parts: and it is no leſs probable, that, even in the larger veſſels, the nervous bridles with which many of them are ſurrounded produce the ſame effects: for thus, in ſeveral parts, they ſurround and include the meningal, temporal, vertebral, carotid, ſubclavian, cœliac, meſenteric, renal, and other arteries. But after it is ſhewn by our experiments, that the nerves are at reſt during the action of the muſcles, nor can be rendered ſhorter by any irritation, we muſt deſert this elegant theory. Nor does it ſeem far from the truth, that the arteries are rendered more or leſs irritable from the various ſenſibility of the nerves, and thus may be contracted more vehemently or languidly by the ſame quantity of blood: and thus the motion of the blood is either quickened or ſlackened, if it is at all certain that the ſmaller arteries have the ſame irritable nature which is common to the large ones. And thus it is that the appetite and periſtaltic motions of the alimentary tube are manifeſtly deſtroyed or depraved by the paſſions of the mind.

567. Nor is it to be denied, that the Creator has affixed certain characteriſtic marks or evident ſigns to the paſſions of the mind, that in mutual ſociety one

man might not impoſe upon another. For the reſpective muſcles, more eſpecially of the voice, face, and eyes, do naturally expreſs the ſeveral paſſions of the mind, ſo faithfully, that they may be even repreſented by a painter. To run through them all would indeed be an elegant theme, but too long for this Compendium. From the actions of theſe muſcles, often repeated by the affections, follows the features or phyſiognomy of a perſon's face, which is a perpetual index to the ſtate of the mind, and retains ſomething of the action of the prevailing muſcles; ſo that the appearance of anger often remains in the countenance, after the paſſion itſelf is gone off.

568. From whence proceeds the conſent of parts, which is ſo famous and often repeated by writers on the practice of phyſic? Some of them appear to depend upon the conjunction or inoſculation of the blood-veſſels; by which the blood, being driven out of one, is more ſtrongly urged into another veſſel, which has its branches from the ſame common trunk. Hitherto belong the revulſions made by blood-letting, the pains of the head, which enſue from a cold in the feet, &c. In other parts, the conſent ariſes from a ſimilitude in their fabric, by which they ſuffer like effects from the ſame cauſes in the body: hitherto we refer the conſent that is betwixt the womb and the breaſts. Another cauſe of this conſent is, a continuity of the membranes, extending from one part to another: from hence a ſtone in the bladder excites an itching in the glans of the penis, a diarrhœa cures a deafneſs ariſing from a defluction. Another cauſe of conſent lies in the nerves themſelves, and their anaſtomoſes or communications one with another, as appears plainly from the teeth being ſtupified or ſet on an edge by certain ſounds, becauſe the various communications which the hard portion of the auditory makes with the maxillary nerve transfer the diſagreeable ſenſe to the latter. Thus alſo, the ſympathy of the eyes, which is not obſervable in like manner in the ears, proceeds from the mutual conjunction of the optic

optic nerves within the ſkull; and thus a ſtone in the kidney excites vomiting. Laſtly, the conſent may proceed from ſome cauſe acting on the common ſenſory, and beginning of the nerves, whence the irritation of a ſingle nerve manifeſtly excites ample convulſions, ſpreading through the other parts; ſo an univerſal epilepſy will proceed from a local diſorder, &c. A conſent is obſerved, in ſome diſeaſes, from a tranſlation of the matter of a diſeaſe by filtration through the cellular ſubſtance of one part to another; and another kind proceeds from the incumbent weight or actions of the adjacent muſcles and arteries.

569. But there is ſtill another remarkable conſent to be explained betwixt the body and the mind. For that the nature of the mind is different from that of the body, appears from numberleſs obſervations; more eſpecially from thoſe abſtract ideas and affections of the mind which have no correſpondence with the organs of ſenſe? For what is the colour of pride? or what the magnitude of envy or curioſity? to which laſt there is nothing ſimilar in brute animals; neither can that happineſs which is deſired by it, *viz.* the glory of new ideas, be referred as an acquiſition to any corporeal pleaſure. For is it poſſible, that a body can acquire two kinds of forces, by the uniting of an infinite number of ſmaller parts into one maſs; each of which ſhall not only preſerve their own particular properties and affections, and repreſent themſelves, but alſo join together into one conſcious whole, differing from all the characteriſtics of its component parts, and yet be capable both of perceiving and comparing the attributes of thoſe parts? Is there any one inſtance of a body, which, without an external cauſe, can, like the mind, paſs of itſelf from reſt to motion; or is there any body that can change the direction of its motion, without the action of ſome other cauſe? Let thoſe conſider who have well obſerved the voluntary actions of the human body from the mind.

570. Yet the mind, however different from the na-

nature of the body, is closely tied to the same, under certain conditions: so that she is obliged to think upon those species which the body offers to her perception; and again, so that she cannot perceive, remember, nor judge, without the use or representation of those corporeal species, which are lodged in the brain; and again, by her will, is the cause of the greatest and swiftest motions in the body.

571. Those have behaved modestly who, confessing themselves ignorant as to the manner in which the body and mind are united, have contented themselves with proceeding no farther than the known laws which the Creator himself has prescribed, without inventing and supplying us with conjectures not supported by experience. We may be manifestly excused in this respect, from the observation (556.), which is here equally certain as in optics, that the affections of bodies cohere with the thoughts of the mind, by an arbitrary relation or connection; in such a manner, that they would produce other thoughts of a different kind, if the Creator was to alter the figure of the refracting power, or colours of the parts of the eye. Thus he has established a law, which obtains always, betwixt the least refrangible rays and the connection of a red colour or idea in the mind: thus there is a law betwixt the impression of those rays upon the retina, and the connection which he has appointed of the corresponding thought. Nor need we be more ashamed to confess our ignorance in the mechanism of this ultimate law in the effects of nature, than we are to own ourselves unacquainted with the first causes of our being.

572. But it will perhaps be demanded of us, Whether the mind does not govern the whole body? and whether or no all the motions and actions in the body do not arise from the mind, as the immediate spring and principle of motion? Whether even the motion of the heart, arteries, and respiration, does not arise from the mind, conscious and solicitous for the common

good of the whole ſyſtem? Whether this power of the mind does not appear in the ſtopping of hemorrhages from wounds, by grumous concretions; to which add, the force of paſſions of the mind, and the power of the mother's imagination, in the marking or other blemiſhes of infants? Whether the abſence of conſciouſneſs in the mind, with reſpect to theſe defects, be not excuſable, from the known obſcurity of attention which ſhe gives to the reſpiration, the motion of the eye-lids, and muſcles of the eye itſelf, the ear, or tongue; all which motions, we know, are effected by the will, although we know not the organs, nor take any notice of the action of the will, when we breathe, look, hear, or even walk, while we are taken up with other thoughts? Whether or no is it certain, that all bodily motions ariſe from the mind, on the account of our being unable to find out any other cauſe, conſtantly united to the body, to which we can manifeſtly refer them?

573. There are indeed many reaſons which will not permit us to conſent to this opinion. And, firſt, the conſtruction and government of the body itſelf appear greatly to exceed all the power and wiſdom of the mind. The mind is able to ſee but one point diſtinctly at a time (555.), and it can think only one thought or idea at once: for if it endeavours to ſee two objects at a time, to contemplate two different ideas together, or read two letters at once, the ſenſe of both is immediately confuſed, the mind ſtrays in her reaſoning, and makes no right judgment of either object; inſomuch, that being ſenſible of this her weakneſs, whenever ſhe endeavours to make a ſerious and diligent inquiry into any object or intended work, ſhe withdraws herſelf, and ſhuts up all the ports of ſenſe, without taking any impreſſions either by the ſight, hearing, ſmelling, &c. or without exerciſing any of the voluntary motions of the muſcles. But the mind ought to be capable, not only of infinite thoughts, but alſo diſtinct ones, for her to be able to perform and govern ſo many hundred muſcles,

organs,

organs, veſſels, and moving fibres, in ſuch a variety of ways, and with ſo great an exactneſs, as is difficult to, or even above all the ſolutions that can be given by the working of geometrical problems: and yet, by this hypotheſis, the mind, ignorant both of herſelf and of her works, ought not only to be equal to ſo immenſe a taſk; but likewiſe, at the ſame time, ſhe muſt, over and above thoſe works, be capable of contemplating the moſt difficult and abſtracted ideas, without either diſturbing her meditations by the cares which concern the body, or neglecting any of her neceſſary corporeal offices by the variety of her mental operations.

574. Moreover, if, without being conſcious of our will, we are nevertheleſs able, by that faculty, to influence the reſpiration, the winking of the eyes, &c. and even to be able not only to govern, but alſo to ſuſpend our breathing, ſhut or cloſe our eyes, and open them again; it follows from thence, that we never loſe either the conſciouſneſs or the uſe of thoſe actions, and conſequently neither the government of them. But we are able to perform nothing of this kind in the heart or inteſtines; we cannot reſtrain the motion of thoſe parts when they are too quick, nor excite them when they are too languid. In ſuch a number of perſons as inhabit the world, why do we not meet with ſome who can govern the motion of their guts? or why, in all the ages of the world, not one who could govern the contractions of the heart? If cuſtom only is the cauſe of this unknown power, why does not the mind receive a ſenſe of her action, in moving the heart, after it has ſtood ſtill for whole hours, or even days, in ſwoons, in hyſteric fits, and in perſons drowned?

575. But it is evidently a falſe poſition, that all the motions of the body ariſe from the mind, without which the body would be an immoveable unactive maſs: for the force of muſcular contraction, by any kind of ſtimulus, to which the motion of the heart, inteſtines, and perhaps all the other motions in the human body are obedient (491.), do not require the preſence of the mind;

mind; ſince that power continues a conſiderable time in a dead body, and may be recalled again into action by mechanical cauſes, as heat, inflation, &c. Nor does this power deſert the fibres ſo long as they continue unſtiffened by cold, although the mind may have been a long time ſeparated from the body by a deſtruction of the brain: and this action we ſee more evidently in the heart, after that muſcle has been taken out of the body for ſome time, ſo as to be ſeparated from any imaginable connection with the mind.

576. As to the blemiſhes of infants, we have declared in another place, how little that article is to be depended on. The adminiſtration of the vital motions, in diſeaſes, is not under the rule of any prudence, but governed almoſt entirely by the power of ſtimulus; as we are manifeſtly taught from the moſt ancient and only certain practice, by which we are directed to reſtrain the too great violence of theſe motions in acute and intermitting febrile diſeaſes, by the uſe of blood-letting, with the poppy, nitre, Peruvian bark, &c. The wiſeſt philoſopher in the world has no more privilege or advantage in the government of his body, than the mereſt ideot; and that even infants ſhould build up the fabric of their own body, before they know that they have any muſcular motions, is an aſſertion ſo far from being credible, or even moderately probable, that of itſelf alone it is ſufficient to refute the hypotheſis.

577. A ready diſpoſition to the exerciſe of ſenſe and voluntary motion, in healthy organs, is called *vigilance* or *wakefulneſs;* but an indiſpoſition to ſuch an exerciſe of them, with an inclination to reſt, in all the ſaid organs, while they remain healthy and entire, is called *ſleep.*

578. In ſleep, the mind either thinks not at all of what ſhe knows or retains in memory; or elſe ſhe only attends to the traces of paſt objects repoſited in the common ſenſory (558.), the vivid repreſentations of which excite altogether the ſame perceptions as are made by the impreſſion of external objects upon the

organs of ſenſe, by which they were firſt received. Theſe repreſentations of ſpecies to the mind are called *dreams*; and happen whenever a ſmall portion of the brain or common ſenſory is, by the refluent motion of the ſpirits, kept in a ſtate of vigilance, while all the reſt of the empire of ſenſe and voluntary motion is ſilent and at reſt. Sometimes there are certain voluntary motions, following of courſe from the perceptions thus perceived by the mind, ſuch as ſpeech, or motion of all or ſome of the limbs, conformable to the nature of what the mind perceives; and hitherto are to be referred thoſe who walk in their ſleep.

579. But, during the time of ſleep, the motion of the heart, with the diſtribution and circulation of all the other humours in the body, are regularly continued, together with the periſtaltic one of the ſtomach and inteſtines; and, finally, the action of the ſpincter muſcles, with the reſpiration, are continued in a like manner. This compoſition, in which a certain number of the organs are at reſt, while others continue their motions, renders a knowledge of the mechanical cauſe of ſleep ſomewhat difficult to attain.

580. Therefore, in order to make this diſcovery, with all its cauſes, we ſhall conſider all the appearances both of ſleep and vigilance, and trace them in all kinds of animals; for that condition which appears conſtantly to follow from all thoſe cauſes and appearances, will be the true and mechanical cauſe of ſleep. Sleep naturally follows after the vigilance and labour which are joined to human life. For when a perſon is awake, there is a continual motion or exerciſe of the voluntary muſcles, of the parts which guard the ſenſes, and of the affections of the mind; all which continually add a new ſtimulus to the nerves, blood-veſſels, and heart itſelf. Thus the blood, by continual motion and triture, changes its ſmooth albuminous nature, to a rough alkaline, and in ſome degree putrid, ſharpneſs; while, at the ſame time, its more fluid parts, eſpecially thoſe ſubtile ones which compoſe the nervous ſpirits, are diſſi-

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pated faster than they are secreted; whence gradually ensues both a weakness and a weariness of the body: and, if the vigilance be continued longer than usual, there is also a feverish heat, a greater acrimony of the humours, and a sensible loss of strength. As the night advances, a weight or heaviness seizes all the large muscles and their tendons, the mind becomes unfit for any accurate thought or study, and seeks after rest. Hereupon the powers which hold the body erect, shrink from their office, the eye-lids close, the lower jaw falls down, a necessity of yawning comes on, the head nods forward, and by degrees we take less notice of the external objects, which also affect us less, till at length all the thoughts and ideas are in confusion, and a sort of delirium ensues; from whence there is a transition to sleep not known to us, which however always precedes sleep. In this natural sleep, which is common to all animals, the cause seems to be a deficiency of the nervous spirits, which have been every where largely consumed by the exercises of the muscles and senses, in whose actions there is probably a great quantity of this fluid exhaled.

581. A perfect rest or composure of the mind and external senses, with the absence of all stimulus or irritation in the head and other parts of the body, joined with darkness, promote and hasten the forementioned steps of sleep, and render it more quiet or profound.

582. Again, it is observable, that a variety of causes, which weaken the powers, incline to and increase sleep; such as great losses of blood from any cause, bleeding from a vein, the use of cooling medicines or those prepared from the poppy, and cold of the external air; to which add, such as call off the quantity of blood flowing to the head, as warm-bathing of the feet, a plentiful ingestion of food into the stomach, which is found to produce sleep in all kinds of animals.

583. On the contrary, again, there are various hot medicines which induce sleep, by exciting a greater af-

flux of blood to the brain; ſuch as wine, alcohol, or vinous ſpirits of all ſorts, but more eſpecially when reſolved into vapour, opium, hyoſcyamus, the indigeſtible particles of our aliments; to which add, acute and malignant fevers of various kinds, or elſe ſuch things as retard the return of the venous blood, as fatneſs. All theſe cauſes ſeem to concur in this, that the blood being collected in the head, compreſſes the brain, ſo as, in a degree, to intercept the courſe of the ſpirits from thence into the nerves.

584. But likewiſe mechanical cauſes produce a ſleepineſs; namely, a compreſſure of the dura mater and brain, whether from extravaſated blood, a depreſſed part of ſome bone, or a collection of ſerous water within the ventricles of the brain itſelf.

585. Sleep, therefore, ariſes either from a ſimple deficiency of the quantity and mobility of the ſpirits, or a compreſſure of the nerves; but always from a more difficult motion of the ſpirits through the brain.

586. This theory is likewiſe confirmed by the cauſes of vigilance: for all thoſe things prevent ſleep which produce plenty of ſpirits; more eſpecially warm aromatic drinks, which ſend plenty of minute ſtimulating particles to the head, by which the motion or courſe of the blood is moderately quickened through the brain; and, being at the ſame time more dilated, makes a larger ſecretion of ſpirits in a given time.

587. Sleep, again, is hindered by cares of the mind, meditation, ſtudy, and paſſions of a ſtronger degree, with pains of the body and mind; all which hinder the ſpirits from reſting in the common ſenſory, or urge them ſo as to prevent the nerves from collapſing. Therefore, as the former increaſe the quantity of the ſpirits, theſe cauſes increaſe their motion. And therefore, again, the ſame concluſions are to be made from hence as before (585.); namely, that the nature of ſleep lies in a collapſing of the nerves which go out from the common ſenſory.

588. If it be inquired, Whether the ſeat of ſleep be not

not in the ventricles of the brain? we anſwer, that it is not conſiſtent with the ample bounds or dominions of ſleep, which extends itſelf even to ſuch animals as have no ventricles in the brain. Whether the vital actions continue to be carried on in ſleep, as it is only an affection of the brain independent of the cerebellum? and what may be the cauſe of this difference, by which the animal offices reſt in ſleep, while the vital operations are continued? We know not of any other reaſons, beſides thoſe before given, that the vital motions are perpetually ſtimulated into action, from the cauſes urging a neceſſity of keeping them from reſt (392.)

589. The effect of ſleep is a moderation or abatement of all the motions in the human body. For now the action of the heart only remains, by which all the humours are ſent through the veſſels, at the ſame time that all the muſcles and perceiving nerves, with the paſſions of the mind and voluntary motions, are removed; by which the courſe of the ſpirits was quickened not only to the heart, but to all the other organs, ſo as to cauſe wakefulneſs (565, 417.) Thus the heart is gradually reſtored from its quick and almoſt feveriſh pulſation, to the ſlow and calm condition in which we find it in the morning; the breathing in ſleep becomes ſlower and ſmaller, the periſtaltic motion of the ſtomach and inteſtines, the digeſtion of the aliments, the ſenſe of hunger, and the progreſſion of the fæces, are all diminiſhed; at the ſame time, the thinner juices move more ſlowly on, while the more groſs and ſluggiſh are collected together, and the fat being poured out is accumulated in the cellular ſubſtance; the viſcid albuminous humour, for the nouriſhment of parts, adheres more plentifully to all ſides of the fibres and ſmall veſſels; the conſumption of the ſpirits, the attrition of the blood, and the quantity of perſpiration, are all diminiſhed. Thus, while the quantity of the nervous ſpirits continues to be ſecreted, with a leſs conſumption, it is by degrees accumulated in the brain, ſo as to diſtend and fill

the collapſed nerves, which, both in the internal and external organs, return again to action by the approach of ſome ſmall ſtimulus, by which they are again reſtored to vigilance. Sleep, continued for too great a length of time, diſpoſes to all the diſorders that attend a ſlow circulation, to fatneſs, drowſineſs, weakneſs, and cachexies; and is, at the ſame time, highly detrimental to the memory.

590. From whence does yawning attend thoſe that are about to go to ſleep? We anſwer, To promote the paſſage of the blood through the lungs, which is now ſlower. Whence the ſtretching of the limbs? To increaſe the motion of the ſpirits, that they may over-balance the natural contraction of the muſcles, by which all the limbs are drawn into a moderate degree of contraction. If it be demanded, From whence came the unjuſt opinion, which has been ſo well received, that the motion of the heart becomes ſtronger in ſleep, and the perſpiration more plentiful? we anſwer, That the miſtake aroſe from the increaſed heat ariſing from the bed-cloaths, by which the perſpirable matter being confined, every where conduces to warm, ſoften, and relax the ſkin. But any one that ſleeps in his uſual garments, grows colder; and animals which ſleep for a long ſeaſon together grow cold externally to the higheſt degree, as field-mice and hedge-hogs. From whence is it that all animals grow ſleepy after taking food? Not from a compreſſure of the aorta, or from a repletion of the head with blood; for even animals which have ſcarce any brain, ſleep after food. Whether or not do the indigeſtible particles of our aliments, by paſſing leſs eaſily through the brain, and compreſſing its medulla, produce ſleep of a leſs benign kind? Whether or not there is a perpetual dreaming, ſo as to be inſeparable from ſleep? and whether this be natural, ſo that the mind never ceaſes to be without thought, as a conſequence following from ſenſation? We anſwer, This does not ſeem to be the true ſtate of nature; for dreams we judge to be rather referable to diſeaſe, or to ſome ſtimulating

mulating cauſe that interrupts the perfect reſt of the ſenſorium. Hence that ſleep refreſhes moſt where there are no dreams, or at leaſt that where we have no remembrance of any. Hence they are generally wanting in the firſt ſleep, at which time the ſpirits are moſt exhauſted, and return in the morning when theſe are in ſome meaſure repaired. Hence we ſee, that intenſe cares of the mind, or the ſtrong impreſſion of ſome violent idea received in the memory, hard indigeſtible food abounding in its quantity, with any uneaſy poſture of the body, are the moſt uſual cauſes that excite dreams; for they are uſually generated by ſome ſenſation which, by the law of aſſociation of ideas, joins with itſelf a whole collection of ſpecies having an affinity with that one.

CHAP. XIX.

Of MASTICATION, SALIVA, *and* DEGLUTITION.

591. SUCH hard and tough foods as conſiſt of long parallel fibres, or are covered with a bony ſhell or cartilaginous ſkin, generally require maſtication, to divide them into leſs cohering parts, that they may more eaſily yield their nouriſhment to the diſſolving powers of the ſtomach. The more diligently they are ſubdivided in the mouth, the more reliſhing and agreeable they become to the ſtomach; the nearer do they approach to the nature of a fluid, and the more eaſily are they digeſted or aſſimilated.

592. Therefore moſt animals are provided with *teeth*, extremely hard, but planted with a root that is indeed bony and hollow; ſince it receives, through a ſmall hole in the tip or point of each fang, little blood-veſſels, and a nerve, which go to form its internal perioſteum: and this whole root, being fixed into a ſocket of the jaw conformable to itſelf, is, in the upper part towards its crown, ſtrongly ſurrounded and tied down

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by the adhering gum. But the crown, or upper part of the tooth, placed above the gums, is not bony; but a peculiar ſort of enamel, of a harder, denſer ſubſtance, and almoſt of a glaſſy texture, compoſed of ſtraight fibres vertical with its root, and running together towards the middle. This laſt portion of the tooth, having neither perioſteum nor veſſels, perpetually grinds away, and is as often repaired again by a kind of petrifying juice, that aſcends or filters from the cells of the root, by which mechaniſm they are therefore ſupplied with a great degree of hardneſs, very fit to overcome that of other bodies, and to grind the food with their unequal ſurfaces.

593. As the materials of our food are various in their texture and firmneſs, nature has accordingly made our teeth variouſly figured. In us, the anterior or inciſive teeth are four in each jaw, weaker than the reſt, and fixed by a ſingle root, upon which ſtands a crown inwardly concave, outwardly convex, and terminated by a gradual extenuation, like a wedge or chiſel, with a rectilineal edge. The office of theſe is only, in the ſofter foods, to cut thoſe which are tougher than the reſt into ſmaller portions; ſuch as the fibres and membranes of animals and vegetables, with the brittle ſeeds and kernels of fruits.

594. The ſecond ſpecies is the *canine teeth*, which are two only in each jaw, fixed by a longer and ſtronger, but ſingle root; from whence their crown is extenuated into a cone. Theſe lacerate tough aliments, and hold faſt ſuch as require a longer triture by the grinders.

595. The third order of the teeth is that of the *molares*, which in general are compoſed of ſeveral roots, with a quadrangular crown, ſomewhat flat ſurfaced, but more or leſs divided by rocky aſperities. The two foremoſt of theſe are weaker than the reſt, inſerted by two, or often but one root, with the ſurface of their crown parted into two; but the three poſterior grinders are larger, fixed by three, four, and ſometimes

five

five roots, but terminated in their crown by only one surface, somewhat square and flat, but less in the lower than upper jaw, and is subdivided into a number of eminences corresponding to that of their roots. Betwixt these teeth, the most compact or bony foods are interposed and broke, as the more tough and hard are ground smaller, while the lower teeth are urged obliquely and laterally against the moveable upper ones; and these are the teeth which perform principally what we are to expect from mastication of food.

596. That the teeth might break or grind the food with due strength and firmness, the uppermost are fixed into the sockets of the immoveable upper jaw, as the lower ones are into the lower moveable jaw, which is a single bone, and so joined with the temporals, that it may be drawn down from the upper jaws, and pulled up against them with a great force; and may be moved laterally to the right or left, forward and backward. Those various motions of the lower jaw depend upon the articulation of its oval heads, in which the lateral parts of the jaw terminate, convex or highest in the middle, and received betwixt the oblique protuberances of the temporal bones, in a shallow excavation, at the root of the jugal process, deeper in its middle; and increased by a little excavation of the same kind before the auditory passage, from which it is separated by a peculiar fissure. This joint has the freer liberty in moving, and its incrusted cartilages have a longer duration, by the interposition of a small cartilaginous plate, betwixt the condyle of the jaw and tubercle of the temporal bone; concave in its middle above and below, with rising sides, which surround the tubercle of the temporal bone upward, the condyle of the jaw downward, and corresponds to the adjacent inequalities.

597. The muscles moving the lower jaw, which are weak in man, but very strong in brute animals, are the *temporalis* and elevator, arising from a large part of the side of the skull, and from the outward tendinous

nous expansion of it the stellated fibres run together into a tendon fixed to the sharp process of the jaw; the *masseter* elevator, having two or three distinct parts or less muscles, descends from the os jugalis and margin of the upper jaw backward into the angle of the lower jaw. Both these act in concert; but the temporal muscle brings the jaw more backwards, and the masseter forwards. The *pterygoideus internus* descends from the pterygoide fossa, and from the palate bone and root of the little pterygoidal hook, with the internal wing, into the angle of the lower jaw, which it elevates or draws to one side or the other alternately. The *pterygoideus externus* has a double origin; one transverse from the inner wing and adjacent bone of the palate, with the posterior convexity of the upper jaw: the other, descending, arises from the hollow temporal part of the great wing of the sphenoides; thence it proceeds backward and downward into the outer part of the condyle of the lower jaw, which it moves laterally, and draws forward before the upper jaw.

598. The lower jaw is depressed, so as to open the mouth by the digrastric or *biventer* muscle, arising from an hollow of the mamillary bone; from whence descending, its middle tendon is tied by a firm cellular substance of a tendinous nature to the os hyoides; and being likewise connected to the mylohyoideus, and then passing through the divided fibres of the stylohyoideus, it is increased by another fleshy belly, inserted at the symphysis of the two halves of the lower jaw, within the chin. Moreover, the mouth may be partly opened by all the other lower muscles of the jaw, os hyoides, and the larynx, as the geniohyoideus, genioglossus, sternohyoideus, sternothyroideus, coracohyoideus, and latissimus colli; although the latter rather draws the skin of the neck and face downward than the jaw itself. The geniohyoideus and digastric muscles have a power of drawing the jaw backwards.

599. The lower jaw is elevated with a great force, so as to divide the food by the pressure of the upper

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and lower teeth againſt each other, by the action of the temporal, maſſeter, and internal pterygoide muſcles; the contraction of which appears by experiments to be very powerful, and ſufficient to raiſe ſeveral hundred weight. The lateral and circular motions of the jaw upon one of its immoveable condyles are performed by the external and internal pterygoidei, acting either alone or together with the former. Thus the food is cut, lacerated, and ground to pieces; and if the maſtication be continued diligently, it is, together with the liquors of the mouth, reduced into a kind of pulp.

600. The fore-part of the teeth is covered with a cutaneous and fleſhy ſack, which is every where produced from the integuments of the face; and makes a hollow, in which both rows of teeth are ſhut up. The ſides are called the *cheeks*, the middle parts the *lips*. From this cavity there lies a paſſage, betwixt the teeth, into the mouth; which on the upper part is bounded by the bony and ſoft palate, underneath by the fleſhy parts lying under the tongue, and on the fore-part by the teeth. On the back part it opens between the ſoft palate and tongue into the fauces. The tongue divides the cavity of the mouth in the middle, and is eaſily moveable to every part of it.

601. During the trituration of the food in the mouth, there is continually poured to it a large quantity of a watery clear liquor, evaporable or inſipid, or at leaſt but very little ſaline, and containing but little earth; neither acid nor alkaline, although from thence may be obtained a very ſmall portion of lixivial ſalt; of which there are numerous ſprings in the neighbourhood. A large quantity of this *ſaliva* is ſeparated by numberleſs ſmall glandules of the lips and cheeks, of an oval figure, and ſome larger ones which are placed round the mouth of the duct of the parotid gland; and laſtly, the pores of the hard palate pour out this liquor, which they ſecrete, through a little ſhort duct and hole. The juice,

poured out from the exhaling veſſels of the tongue, mouth, and cheeks, is of the like kind, or rather more watery. As for the ductus inciſivus, we are now ſufficiently certain that it is blind, or diſcharges nothing into the mouth, only gives paſſage to an artery from that of the palate into the nares.

602. The ſaliva is a watery liquor, with a moderate quantity of ſalt, partly lixivial, and partly culinary; with ſome oil and earth, diſſipable by the fire; with ſcarce any taſte, unleſs given to it by diſeaſe or famine. The quantity produced is very conſiderable, as twelve ounces have been known to flow out from wounds in thoſe parts in the ſpace of an hour. By good-mannered people it is for the moſt part ſwallowed; and uſefully, as it cannot be thrown away without hurting the digeſtion.

603. But the ſalival glands eſpecially ſupply the watery humour called after their own name. Of theſe the principal is the parotid, filling up a large interval betwixt the auditory paſſage and the lower jaw, to which it is immediately contiguous in the part uncovered and to the maſſeter. It is a conglomerate gland, made up of round or grape-like cluſters, connected by the cellular ſubſtance; which laſt, being denſified and reticulated, forms an almoſt tendinous covering that ſurrounds and connects the whole gland. Its duct is white, vaſcular, and capacious, aſcending from the bottom of the gland to the os jugale, from whence it is tranſverſely inclined, and takes in by the way a ſmall duct of a ſolitary glandule on the top of the maſſeter, or elſe lodged diſtinct, or continued upon the parotid itſelf, and is rarely double; after this the duct, bending round the convex edge of the maſſeter, opens with an oblique or cut aperture, without a papilla, through the departing fibres of the buccinator muſcle, in the midſt of many little glandules of the cheek. The bulk of this gland, and the number of its arteries, make it the chief ſpring from whence the ſaliva flows.

604. Another ſmall gland, adjacent to the parotid, but

but twice as little, compofed of fofter and larger kernels, connected by the like cellular membrane, is, from its fituation at the lower angle of the jaw, called *maxillary;* being in part terminated only by the fkin, but in part fends off an appendix over the mylo-hyoide mufcle, which, following the long hollow fide of the lower jaw, of a granular fabric, is fpread under the membrane of the mouth, by the name of *fublingualis*. From the larger maxillary, together with this appendix, a duct paffes out, which, being a long way covered in its middle part by the fublingualis, receives one, two, or three branches; by whofe infertion being increafed, it opens into a projecting membranous cylinder under the bridle of the tongue. But other fmall and fhort ducts from the fublingual gland, from the number of three, four, or more, to twenty; with fhort little ducts and points in the line continued backwards from the fmall frenum, perforate the edge of the tongue, and fecrete faliva. There are fome inftances where the larger anterior branch of the duct of the appendix, which ufually joins itfelf to the maxillary gland, goes on fingle, parallel, and opens by itfelf. Other glands alfo, fimilar to thofe of the cheeks, which likewife may be reckoned among the fublingual ones, by their proper ducts perforate the membrane of the mouth where it departs from the tongue. Various other falival ducts have been publifhed by different profeffors, which are not confirmed by anatomy.

605. The Creator has wifely provided, that, by the motion of the jaw in maftication, the falival glands fhall be compreffed by mechanical neceffity, fo as to difcharge their juices then to the mouth in greater plenty. For, when the mouth is opened, the maxillary gland, being preffed by the digaftric and mylo-hyoideus, throws forth a fountain of faliva; the maffeter when fwelled preffes the parotid gland, as does alfo the cutaneous mufcle of the neck which lies over it:

and it is this muſcular preſſure that excites the appetite, and pours the ſaliva into the mouth.

606. The food therefore, being in this manner ground betwixt the teeth, and intermixed with the watery ſaliva and air, is broken down into a ſoft juicy pulp, pliable into any figure, and replete with elaſtic air, which by the action of the latter undergoes a farther diſſolution, by the warmth of the parts exciting the elaſticity of the air to expand and burſt aſunder the confining particles of the food, betwixt which it is included. In this act of maſtication, the oily, aqueous, and ſaline parts of the food are intermixed the one with the other; the ſmell and taſte of different ingredients are loſt in one, which by the dilution of the ſaline parts with ſaliva renders the food flavourable: but ſuch particles as are more volatile and penetrating, being directly abſorbed by the bibulous veſſels of the tongue and cheeks, enter ſtraight into the blood-veſſels and nerves, ſo as to cauſe an immediate recruit of the faculties.

607. But the motions which are neceſſary for turning round the food, applying it to the teeth, and conveying it through the different parts of the mouth in maſtication, are adminiſtered by the tongue, cheeks, and lips. And firſt, the tongue being expanded ſo as to form a ſmall concavity in its back or ſurface, takes up the food thus prepared, and conveys the charge by its moving powers (450.) to the parts for which it is deſigned. At one time the tongue, rendered narrow by lateral contraction, ſearches every part of the mouth with its tip, and turns out the latent food into a heap on its common concavity. At another time, applying its extremity to the fore-teeth, and raiſing itſelf up ſucceſſively, it draws from the cavity of the mouth the fluids or chewed aliments, and conveys them to the fauces or back part of the mouth behind the teeth.

608. But theſe motions of the tongue are likewiſe governed by the muſcles and membranes, largely in-

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ſerted into the os hyoides, the baſis of which is internally concave; from whence are extended horns laterally and outwards, terminated by more protuberant heads, and completed with little oval cornices; and this bone being drawn down by its reſpective muſcles, depreſſes the tongue at the ſame time, and the lower jaw likewiſe, if the muſcles of that be relaxed. Theſe powers are the *ſternohyoideus*, but ariſing alſo in part from the clavicle, extenuated upwards, and ſtriped with tendinous lines; the *ſternothyroideus*, ariſing as the former, and broader from the upper rib; which muſcle, depreſſing the cartilage to which it is inſerted, is under a neceſſity of pulling down the *os hyoides*, to which it is joined: this is partly intermixed with the hyothyroideus and thyreo-pharyngeus, and every where confuſed with the ſternohyoideus. Next the coracohyoideus, ariſing from the upper and ſhorter ſide of the ſcapula, near its notch, aſcends obliquely, and at the croſſing the jugular vein changes into a tendon; from whence the other belly of the muſcle aſcends direct to its inſertion into the os hyoides, which it depreſſes, being every where confounded with the ſternohyoideus. The *hyothyroideus* is determined by the former muſcles.

609. The other powers which elevate the os hyoides, together with the tongue, are its *ſtyloglоſſus* muſcle, ſuſtained by a peculiar ligament of the upper jaw. The *ſtylohyoideus*, a weak muſcle, often ſplit for the paſſage of the biventer, and again united into one portion, after adhering to the tendinous expanſion of the biventer, is inſerted, together with its fellow, into the angle of the baſis, and often into the horn of the os hyoides: the ſecond ſtylohyoideus, when it is preſent, reſembles the former, behind which it is placed; ariſing from the tip of the ſtyloide proceſs, it is inſerted into the ſmall oſſa triticea, and anſwers the purpoſe of a ligament to ſuſtain the os hyoides. All theſe muſcles draw the tongue back, but laterally they elevate it. The *mylohyoideus*, ariſing from the whole length of the jaw, running into one with its companion, elevates the tongue,

tongue, and fixes it in making various motions, or in like manner depreſſes the jaw. The *geniohyoideus*, being a companion of the genioglоſſus, pulls the tongue forward out of the mouth.

610. But, moreover, the muſcles of the cheeks variouſly move and preſs the food in the mouth. Others move it from the cavity of the cheeks into the inner cavity of the mouth behind the teeth, as we ſee in the buccinator when the mouth is ſhut. Others open the mouth for receiving the food; ſuch as the double-headed proper elevator of the upper lip, and the elevator which is partly common; to which add, the zygomaticus, upper and lower; the riſorius, triangularis menti, and the depreſſor proper to the angle of the mouth; which ariſing from an excavation on each ſide, near the ſocket of the canine tooth, are inſerted into the orbicularis of the lips. Others, again, cloſe the lips, that the food received may not return out of the mouth; ſuch as the orbicularis of each lip, the proper depreſſor of the upper lip, and the proper elevator of the lower lip, and that which ſerves in common for the elevation of both. Of theſe, more particular deſcriptions may be had from profeſſed ſyſtems of anatomy.

611. By theſe means the food, ground and mixed with the ſaliva into a ſoft pulp, collected from all parts of the mouth by the tongue into the arched ſpace betwixt the teeth, is afterward, by the expanſion and ſucceſſive preſſure of the tongue, conveyed backward behind the teeth; and, in this action, the tongue is expanded by the ceratogloſſi and geniogloſſi, and rendered a little concave by the ſtylogloſſus. And from thence it is next conveyed into the fauces.

612. For the tongue being raiſed by the ſtylogloſſi, and broadly applied to the palate, firſt by its apex, then alſo inſenſibly by its poſterior extremity, preſſes the food ſucceſſively towards the fauces, which at that time only afford an open paſſage. After this, the thick root and back part of the tongue itſelf, by the forementioned muſcles, and by the ſtylohyoidei and biventers carried

back-

backward, preſſes down the epiglottis, which ſtands up behind the tongue, connected therewith by numerous membranes, and perhaps by ſome muſcular fibres. At the ſame time, the muſcles elevating the pharynx all act together; ſuch as the biventer, geniohyoideus, genioglosſus, ſtylohyoideus, ſtyloglosſus, ſtylopharyngeus, and the other elevators, which now draw the larynx upward and forward, that the epiglottis, being brought nearer to the convex root of the tongue, may be better cloſed or depreſſed. Hence it is neceſſary towards deglutition for the jaws to be cloſed, that by this means the biventer may have a firm ſupport; and, together with the muſcles already deſcribed, elevate the os hyoides. Thus the epiglottis, being inverted, ſhuts up and covers the paſſage very exactly, into the larynx, over which it is extended like a bridge for the aliment to paſs over into the fauces.

613. By the pharynx we underſtand an ample ſhapeleſs cavity, extended from the occipital bone before the great opening of the ſkull downward, along the bodies of the cervical vertebræ, covered above by the middle cuneiform bone, the opening of the nares, and moveable velum of the palate, receiving the tongue and larynx before, and continued into the œſophagus below. Its ſides are formed by the lower jaw, the cheek, the velum of the palate, the pterygoid proceſs, the ſtiliform appendix, the tongue, os hyoides, and larger cartilages of the larynx. It forms one ſoft membranous bag, outwardly ſurrounded on all ſides by muſcular fibres. Internally it is lined with a membrane continuous to the cuticle, like which it is renewable, but more moiſt. Outwardly it is joined to the pharynx with a good deal of cellular ſubſtance, more eſpecially in its poſterior and lateral parts. By this ſtructure it becomes lax and dilatable, ſo as to receive all bodies that are preſſed by the tongue over the larynx.

614. It is dilated in its action (612.) by the powers ſerving to its elevation; ſuch as the *ſtylopharyngeus*, ſometimes double, from the proceſs of its name; whence deſcend-

defcending, it is inferted into the membrane of the larynx, under the os hyoides, and into the cartilaginous edge of the defcending thyroideus; after which, it is broadly fpread through the internal face of the pharynx, together with the following. The *thyreopalatinus*, being fpread in the form of an arch round the moveable palate, is from thence extended downwards in two columns, on each fide the pharynx, which form a confiderable part of that bag, being alfo connected by broad fibres to the thyreoid cartilage. That the *falpingopharyngeus* is a true or diftinct mufcle, I am ready to believe, rather from the obfervations of eminent anatomifts, than any of my own. As to the *cephalopharyngeus*, I almoft defpair of finding any, unlefs you will reckon the ftrong white plate of the cellular fubftance, which furrounds the upper part of the pharynx, for a mufcle. This bag clofely furrounds and follows the drink, on each fide the epiglottis, above the larynx, that it may from thence fall into the œfophagus.

615. That the aliments might not regurgitate into the noftrils at the time when they are preffed into the dilated pharynx (614.), a moveable velum or palate is interpofed: namely, from the bony palate anteriorly, and laterally from the pterygoide wings, is continued a moveable velum, compounded of the membranes from the mouth and nares, betwixt which membranes are fpread mufcles and glandules; being almoft of a fquare figure, and pendulous betwixt the cavity of the nares and fauces, in fuch a manner, that they naturally leave the former open, and form a concave arch towards the mouth: and from the middle of this is extended a fmall portion, pendulous, and of a conical fhape, before the epiglottis, replete with many fmall glands; which, from its appearance in a difeafed ftate, is called *uvula*. The elevator of this velum, which is ftrong, arifes from the afperities and plane face of the os petrofum, behind the fpinal foramen; and from a cartilage of the tube defcending inward, does, with its companion, form an arch, which is moveable with the palate itfelf, between the

the two plates of the thyreopalatinus muſcle, ſo as to be brought into a cloſe contact with the ſides of the nares and with the tubes, that none of the aliment may enter into either of them. But this elevator does not ſeem to have any conſiderable action in ſwallowing. At this time regurgitation into the noſtrils is prevented by a conſtriction of the muſcles of the pharynx, together with a depreſſure of the thyreopalatinus, which then manifeſtly draws the moveable velum downward and towards the tongue and pharynx. Add to theſe, the *circumflexus palati mollis*, which ariſes a little more forward from the ſame cuneiform bone, from the internal ſide of its wings, and from the inner wing, with the cartilaginous end of the tube, broad; and then, paſſing through a notch of the pterygoide hook, changes its direction, and aſcends with a radiated tendon through the upper membrane that covers the velum of the palate, joins with its fellow, ſpreads over the other muſcles, and adheres to the edge of the palate bone. This is able both to open the tube, and to preſs down the moveable velum of the palate. Thus the pharynx being contracted like a ſphincter, drives down the food, without permitting any part to return back into the cavity of the nares. Hence, when the velum of the palate is vitiated, the aliments regurgitate into the noſtrils, and a deafneſs enſues.

616. During this endeavour to depreſs the food by the pharynx (617.), the velum, drawn back and expanded over, is pulled down towards the tongue, by the action of the palatopharyngei, and by the circumflex muſcles of the ſoft palate. Theſe muſcles, together with the gloſſopalatinus, (which laſt is indeed weak, being received into the leſſer arch of the fauces, and here united with its companion into the arch by the velum of the palate, and from thence ſent to the tongue,) preſs the velum againſt the protuberant root of the tongue, and intercept any return to the mouth and noſtrils. After there is no further danger of any part falling into the windpipe, the epiglottis is raiſed up a-

 gain,

gain, as well by its own elasticity, as by the elevation of the tongue itself, by which it is drawn forward. Lastly, the depressed uvula is raised by the azygos, which arises from the tendons of the circumflexi muscles and levator of the soft palate.

617. A little after this follows an attempt to urge the food downward, which is exerted by the constrictor muscles of the pharynx which draw the fore parts towards the back, and the muscles which are partly transverse and partly ascend into the posterior surface of the pharynx. Of these the principal is the pterygopharyngeus, arising from the whole hook and internal edge of the wing, and from the tendon of the circumflex muscle; from whence forming an arch, it is extended upward and backward, and, largely surrounding the upper part of the pharynx, it joins into one with its companion, which has the same name. The mylopharyngeus, partly continuous with the fibres of the buccinator, in the middle betwixt its two adhesions to the bones, arises also in part from an origin of its own, above the last of the grinding teeth in the lower jaw. These having a course almost transverse, surrounding the pharynx, draw it back towards the fore part. Next to these follow the geniopharyngei, ascending in two strata of obscure and confused fibres which originate from the tongue; next the chondropharyngei, of a triangular figure, arising from the officula triticea; the ceratopharyngei, which ascend radiated from half of the horn; the syndesmopharyngei, arising from the horn of the thyreoide cartilage, and distinct from the former; to which add, the thyropharyngei of both kinds, increased by the fibres of the sternothyroideus and cricothyroideus, with the cricopharyngei, the transverse, the ascending, and the descending. These muscles acting successively from above downward, according to their situation, drive the aliment into the œsophagus. At the same time, the depressing muscles of the larynx, coracohyoideus, sternohyoideus, and sternothyreoideus, draw down the larynx forward, and lessening the capacity

city of the pharynx urge the food downward. But in this action, as the aliment paſſes by the poſterior rima of the glottis, the arytænoidei contract the larynx perpendicularly.

618. As various dry and rough bodies are frequently ſwallowed, it was neceſſary for the pharynx to be dilatable, and not very ſenſible of pain; to which end the great quantity of mucus, which is collected in all parts of the fauces, greatly conduces. Therefore, in general, betwixt the nervous and innermoſt coat of the pharynx, are placed a great number of ſimple mucous follicles or cells, of an oval figure, pouring out their mucus through ſhort mouths; of a ſoft, viſcid, and ſomewhat watery nature; but ropy, or drawing out into threads, not without oil, and abounding more with volatile ſalt and earth than the ſaliva itſelf. Theſe mucous receptacles are moſt plentiful in that part of the pharynx which is immediately extended under the occipital bone, where they are diſpoſed in a ſort of radiated right lines; and they are likewiſe numerous about the tonſil towards its tube, where commonly the ſecond tonſil on each ſide lies, adjacent to the large one, and in that portion of the pharynx which is called ſalpingopharyngeus. But there are likewiſe other flat and circular follicles, ſeated in great numbers about the back part of the tongue, as far as its foramen cæcum (448.) Other follicles and pores of the ſame kind are every where ſeated in the pulpy fleſh of the palate, where numerous ſmall glands diſcharge ſuch a viſcid mucus. Moreover, the whole ſurface of the moveable palate is of a glandular nature, like that of the pharynx; only the follicles and glandular corpuſcles are here more numerous and thickly ſet together. Nor, laſtly, are lacunæ wanting, into each of which are joined many ſimple glandules.

619. Where the pharynx deſcends laterally from the little pterygoidal hook betwixt the two arches of the fauces, namely, between the gloſſopalatinus and pharingopalatinus, are ſeated the tonſils, of an oval figure,

convex behind, and thick on the upper part, perforated inward with ten or more large ſinuſes, which open through the membranous covering of the velum extended over them, and by the preſſure of the adjacent muſcles diſcharge a great quantity of a moſt thick mucus from their ſinuſes. In like manner, the adjacent parts of the nares, and projecting ring of the tubes, and that ſide of the epiglottis which lies next to the larynx and the back of the arytænoide cartilages, are alſo repleniſhed with mucous organs. Laſtly, the œſophagus itſelf, on all ſides, abounds with ſimple follicles, from whence a mucus is poured out ſomewhat more fluid. But the larger glandulæ œſophagææ are of the conglobate kind, and conduce nothing to this mucus. The blood-veſſels of the tonſils are ſupplied from thoſe of the tongue, lips, and pharynx itſelf; as thoſe of the œſophagus are derived from the branches of the pharynx, upper and lower thyreoidals, from the bronchials and aorta. The veins of the palate and tonſils being numerous, run together into a net-work, ending in the ſuperficial branch of the internal jugular.

619. The *œſophagus*, then, is a double tube, of which the innermoſt is ſeparated from the outer by a good deal of cellular ſubſtance, that may be inflated. The innermoſt tube of the œſophagus is nervous and ſtrong, being continued from the membranes of the mouth and nares, on its inner ſide plaited and porous, having an epidermis which is not villous, but pulpy, and exhaling a thin humour; it is diſtinguiſhed by a thin cellular ſubſtance, in which the ſmall veſſels are reticulated with minute glands interſperſed, which are continuous, and ſimilar to thoſe of the pharynx. The outer tube is muſcular, and in itſelf conſiderably ſtrong, compoſed of fibres internally continued from the lower and back part of the cricoide cartilage, which, by degrees, change from annular to fibres that are externally longitudinal, and ſerve to draw up and dilate the œſophagus againſt the food, that the mouthful may be received. But the other internal circular fibres, which

are ſtronger than the former, ariſe in like manner from the top of the cricoide cartilage; and by their ſucceſſive contraction againſt the food, drive it down through the whole long tube of the œſophagus, which deſcends firſt in a direct courſe, a little to the left ſide of the windpipe; but having reached the cavity of the breaſt, it paſſes behind the heart, through the cellular interval that lies behind the bag of each pleura (77.); from whence, inclining by degrees a little to the right, it afterwards bends again forwards to its proper opening, by which its included food paſſes through the diaphragm (262.) in the interval of time that is betwixt exſpiration and inſpiration. Outwardly, the whole tube of the œſophagus is ſurrounded by the cellular ſubſtance, by which it is looſely tied to the neighbouring parts.

620. The aliments are moved through the œſophagus as through an inteſtine. The longitudinal fibres, aſcending to the cartilages of the larynx, dilate the gullet, oppoſite to the deſcending morſel. But when it is received, the longitudinal fibres equally dilate and elevate the gullet at that place which receives it. Then that part of the œſophagus where the morſel is ſeated, being irritated, contracts, and moves the food downwards. The muſcle is ſtrong, and very irritable.

621. This upper opening of the ſtomach is contracted or compreſſed in ſuch a manner, by the lower muſcle of the diaphragm, in every inſpiration, as to confine the food within the ſtomach, and direct it in every reſpiration, by preſſure, naturally towards the pylorus. By this means, the ſtomach is ſo cloſely ſhut, that in the moſt healthy man even wind or vapours are confined within the ſtomach; nor do they ever aſcend but by a morbid affection.

CHAP.

CHAP. XX.

Of the Action *of the* Stomach *on the* Food.

622. BY the *ſtomach* we underſtand a membranous bag, deſtined for the reception of the food; placed within the cavity of the abdomen, behind the lower diaphragm and left falſe ribs; in general of an oval figure, or like a caſk; of a larger diameter tranſverſely, and this more ſo as the perſon is more adult; but in the fetus it is altogether ſhort and round. But if we conſider more accurately every ſection of its figure, they will appear circular; although there be a blind or obtuſe concavity in its left extremity, from whence it grows wider towards the œſophagus, at whoſe inſertion its light or ſection is the largeſt of all; from thence it diminiſhes by degrees, till, bending in a contrary direction to itſelf, it ends in the pylorus. Its bulk depends on the quantity of food, by which the cavity of the ſtomach is augmented; and, on the contrary, it is diminiſhed by famine. Its ſituation in general is tranſverſe; yet ſo that the œſophagus enters its poſterior ſide, and the pylorus goes out from it forward to the right ſide. The middle of the human body, or enſiform cartilage, thus covers or anſwers nearly to the center of the ſtomach; but alſo to the right ſide, and laſtly to the pylorus; to the latter anſwers the umbilical fiſſure. Since its figure is round but incurvated, its lower convexity will form a larger pendulous arch when empty; but when full, it ſhows itſelf prominent before, and in contact with the peritonæum. On the other hand, the leſſer arch, intercepted betwixt the two orifices, will in this ſtate of the ſtomach lie perfectly backward towards the ſpine, ſo as to include the ſmall lobe of the liver. Thus the inſertion of the œſophagus into the full ſtomach will be in an obtuſe angle, in

in a manner parallel with the horizon; but in the empty ſtomach it will be almoſt perpendicular: and at the ſame time, the right extremity of the ſtomach forming the pylorus, which in an empty ſtate lies bent upward, will in the full ſtomach be bent more backward, ſo as to deſcend in perſons lying on their back. In a living man, that ſituation of the ſtomach which we have attributed to the full one is neareſt the truth.

623. In the neighbourhood of the ſtomach lie the viſcera: and particularly to its large imperforated extremity is connected the ſpleen, by a conſiderable portion of the omentum; the leſſer arch or curvature of the ſtomach receiving the little lobe of Spigelius, as likewiſe the left lobe of the liver, largely interpoſing betwixt the ſtomach and the diaphragm; which lobe compreſſes the forepart of the ſtomach; below the margin of which, a portion of the ſtomach lies immediately contiguous to the diaphragm itſelf; yet ſo as, by a moderate extenſion, to lie hid within the bounds of the falſe ribs. Under and behind the ſtomach, lies the pancreas, extended for a conſiderable length in an empty ſpace, upon the tranſverſe portion of the colon. Again, from the leſſer curvature ariſes the little omentum, to which is continued the ſtronger membrane that connects the œſophagus with the diaphragm: nor is the large omentum connected to the whole length of the ſtomach; but, leaving a deficiency to the right ſide near the pylorus, it is continued on beyond the left extremity, into a ligament which connects the ſtomach and ſpleen together. The ligaments, in theſe parts, are productions of the peritonæum; which, receding from the diaphragm, ſpreads itſelf over the ſtomach, ſo as to form its outermoſt coat. The pylorus lies between its mouths, on the forepart, more to the right ſide, and a little lower down.

624. The fabric of the ſtomach anſwers in general to that of the œſophagus; of which, indeed, it is an expanſion; and, in ſome animals, has in all its parts the ſame appearance. The outermoſt coat is from the peritonæum,

um, of conſiderable ſtrength, ſo as to limit the reſt, and afford a ſupport to the ſubjacent muſcular fibres: this is expanded into the little and great omentum, and in that place the ſtomach is without its outermoſt coat. Then follows the cellular coat, more abundant in the origin of the little omentum, where it contains little conglobate lymphatic glandules, which alſo holds true of the cellular ſubſtance in the great omentum; but it is thinner and much leſs conſiderable betwixt the coats of the ſtomach itſelf, whence the outer and muſcular tunic cloſely cohere together: in this ſubſtance the larger branches of the veſſels are diſtributed.

625. Next in order appears the muſcular coat, neither eaſy to deſcribe or prepare. Here, indeed, we ſee the longitudinal fibres of the œſophagus, coming to the ſtomach, are detached one from another, along all the ſides of the ſtomach. Some of them, of more conſiderable ſtrength, run on to the pylorus, along the leſſer curvature; which, by degrees declining from their longitudinal courſe, following the length of the ſtomach, deſcend into a plain of each ſide, and are in part ſtretched out through the pylorus into the duodenum itſelf, where they gradually diſappear. Other fibres deſcend to the blind ſack of the ſtomach, ſeated on the left ſide. And, finally, through every ſection of the ſtomach, from its blind or left extremity, to the the pylorus, are ſpread concentric circular fibres, which, by degrees increaſing in their thickneſs or number, are continued on with the reſt of the circular fibres belonging to the ſtomach: this laſt makes the moſt conſiderable order of the muſcular fibres. Laſtly, the ſphincter of the cardia and œſophagus is compoſed internally of fibres, ariſing from the left ſide of the œſophagus, and running to the right, paſs on each ſide the gula, which they thus cloſely embrace, and then degenerate longitudinally till they are loſt under the circular or ſecond ſtratum near the pylorus. But the ligaments of the pylorus ſo called, are two conſtrictions, betwixt the two incurvations into which the pylorus is bent, formed by the foreſaid longitudinal

gitudinal fibres, which run along from the ſtomach to the pylorus, and are very cloſely joined to the internal coat in their way.

626. Immediately under the muſcular fibres, follows another cellular ſtratum, larger than the outermoſt, ſofter, more eaſily inflatable, and conſiſting of larger cells or veſicles than what we uſually obſerve in the inteſtines. Within this cellular ſubſtance are ſpread the veſſels which, coming from the larger trunks, perforate the muſcular coat, and are divided into an angular net-work. Under this lies the nervous coat, which is thick, white, and firm, and properly makes up the true nature or ſubſtance of the ſtomach itſelf, after the manner of other nervous parts: and this is again lined internally with a third cellular ſtratum, evidently enough to be perceived, whoſe vaſcular net-work is much more minute than that of the former, from whence it is derived. Immediately within this lies the villous coat, that lines the cavity of the ſtomach itſelf, continuous with the external cuticle, like which it is renewable; but of a ſoft mucous texture, and extended into a very ſhort pile, and folded into large plates, which form a ſtar under the œſophagus; but in the middle of the ſtomach, theſe folds are almoſt parallel with the ſtomach itſelf. But, at the extremity of the pylorus, there is a more conſiderable fold, commonly called valvula pylori, which is formed by a production both of the tranſverſe muſcular fibres, and of the thicker nervous coat, extended together in the ſhape of an unequal looſe ring, produced towards the duodenum; this forms a ſlippery fleſhy protuberance, which ſurrounds the duodenum for a conſiderable length. The large wrinkles of the villous membrane are afterwards ſubdivided more minutely into others of a quadrangular or net-like figure; but very ſhallow, and eaſily diſappearing, being much more obſcure than thoſe in the biliary ducts. Within this villous coat of the ſtomach throughout, but more eſpecially towards the pylorus, I have truly obſerved ſome

pores, not always to be perceived, which terminate in ſimple follicles, ſeated in the next cellular ſtratum.

627. The *veſſels* of the ſtomach are both numerous and derived from many trunks or various quarters, that the courſe of the blood through them might not be intercepted by any kind of preſſure, as it might eaſily have been if the veſſels of the ſtomach had come from a ſingle trunk. The common mother of all theſe gaſtric arteries is the cœliac; from the threefold diviſion of which, or above the ſaid diviſion, ariſes the upper coronary, which is the firſt and largeſt artery that paſſes in a ſingle branch round the edge of the œſophagus into the ſtomach; to which, firſt, and afterwards to the diaphragm and to the liver, it ſends off ſome ramifications; and then running on the leſſer arch or curve of the ſtomach, it inoſculates by more than one branch with the leſſer coronary of the right ſide, ariſing from the right branch of the cœliac at the vena portarum, and is diſtributed along the leſſer curve of the ſtomach. But the ſame right branch of the cœliac, ariſing behind the duodenum, along which it deſcends, gives off a very conſiderable artery that runs contrary to the great arch or curve of the ſtomach, the *right gaſtro-epiploica*, which being ſuſpended in the omentum, it ſpreads itſelf both upon each ſide of the ſtomach, and upon the greater part of the omentum itſelf, being at laſt inſerted into the *left gaſtro-epiploica*. Namely, the left trunk of the cœliac, paſſing along in the direction of the pancreas and ſinuoſity of the ſpleen, there ſends off many branches to the ſtomach: of which the firſt are commonly nameleſs; and among the following, one branch, more conſiderable than the reſt, is called the *left gaſtro-epiploica*, which ſends off a conſiderable twig to the omentum, with ſome others that are ſmaller; from whence, deſcending round the ſtomach towards the right ſide, it inoſculates with the right artery, which is its companion. Other ſmaller ones, coming from thoſe of the ſpleen, are ſpread upon the greater curve of the ſtomach, even as far as the diaphragm, under the denomination

mination of the *vaſa brevia*. Frequently, alſo, one or two arteries come from the ſplenic one, to the poſterior plate of the ſtomach under the œſophagus, in another line from the gaſtro-epiploics. The other ſmaller arteries are the upper ones of the pylorus from the hepatics, and the lower ones from the gaſtro-epiploics: but thoſe of the lower part of the œſophagus, are from the phrenic arteries.

628. Thoſe arteries are diſtributed in ſuch a manner, that firſt they ſend off ſhort twigs to the external and to the muſcular membranes of the ſtomach; their trunks are ſet in order in the firſt cellular ſtratum; from whence, diminiſhing a little in ſize, they penetrate through the muſcular coat; and between that and the nervous membrane, they compoſe a larger and true net-work; in which all the ſmall arteries, coming from a great variety of trunks, join one with another, by an infinity of inoſculations. From this plexus, again, other ſhort, but numerous and very ſmall ramifications, paſs through the nervous coat to the third or inner cellular ſtratum, and are loſt in the villous lining of the ſtomach.

629. The *veins* have their branches diſtributed in company with the correſponding arteries. The greater coronary from the left ſide of the ſtomach, generally goes to the trunk of the porta, together with the brevia and left gaſtro-epiploic; while the right vein of the laſt denomination joins with the middle vena colica, and, together with a branch from the meſentery, pours its contents into the vena portarum. Finally, the right coronary vein belongs to the trunk of the vena portarum itſelf. All theſe veins are without valves; and, like the arteries, there are upper coronary veins, with others of the œſophagus from the thorax, all communicating together by inoſculations, in ſuch a manner, that there is a free paſſage for the blood thence into the vena azygos, with which they inoſculate.

630. The *nerves* of the ſtomach are both large and numerous, produced from the eighth pair, forming two complications about the œſophagus, of which the ante-

rior and leſs plexus deſcends through the upper or outer ſide of the ſtomach to its greater curve; and the poſterior plexus, which is larger, is diſtributed through the leſſer arch of the ſtomach; from whence it paſſes, together with the arteries, to the liver, pancreas, and diaphragm itſelf. Theſe nerves may be every where traced into the ſecond cellular ſtratum. The remainder, but eſpecially the papillæ, are more obſcure. From their number, the ſtomach is extremely ſenſible, inſomuch, that things which make no impreſſion upon the tongue, will nauſeate and pervert this organ, which is capable of much ſeverer pain than the inteſtines; as we know from infallible experience in diſeaſes: even the ſkin itſelf, when naked by a bliſter, is leſs ſenſible than the ſtomach. By making a ligature upon the nerves of the eighth pair, both the action of the ſtomach and the digeſtion of the food ceaſe.

631. *Lymphatic veſſels* I have obſerved, ſometimes very conſiderable, about the leſſer curve of the ſtomach, ariſing from the glandules of that part, and inſerted by a very large trunk into the thoracic duct. Others, no doubt, ariſe from ſmall glandules of the ſame kind in the greater curve; and ſome famous anatomiſts have obſerved lymphatic glands over the whole ſtomach. Other lacteal veſſels, I have neither ſeen, nor am ready to admit; ſuch as thoſe lately deſcribed, which are ſaid to paſs from the ſtomach through the omentum to the liver, filled with a true chyle.

632. All parts of the human ſtomach are perforated by inorganic pores, through which water injected both exhales through the ſtomach when ſhut, and, on the contrary, penetrates the cavity of the ſtomach when put under water. But we cannot for this reaſon conclude, that in a living perſon this paſſage lies open for moiſture.

633. Within the human ſtomach, we firſt meet with a great quantity of *mucus*, ſpread upon its villous lining, from the pores before deſcribed (626.); which mucus is not unfrequently tinged, by ſome of the bile return-

ing

ing into the ſtomach. Beſides this, in an empty ſtomach after faſting, upon bending the body, a great quantity of a *limpid humour* will ariſe into the mouth, altogether of the ſame nature with the ſaliva, but more mucous; which liquor is very rarely to be found pure or unmixed in the ſtomach. It is very far from poſſeſſing any acid acrimony, when it can be had pure from the food. Left to itſelf, it changes, both in man and brutes, rather to a lixivial or alkaline nature, when it is ſeparated from the acid illuvies of the aliments, more eſpecially in an hungry animal. This liquor diſtils from the arteries of the ſtomach, through its villous coat, after the manner we ſee by anatomical injections; by which water, fiſh-glue, and oil, may be eaſily urged into the veſſels of the ſtomach, ſo as to ſweat through its numberleſs pores.

634. The ſtomach then, contained within the abdomen, which is perfectly full, will from thence, as in a preſs, receive a force or compreſſure upon its ſides, which lie betwixt the diaphragm; the concavity of whoſe right wing is filled by the liver, under which, and within the left wing, lies the ſtomach, extended almoſt tranſverſely behind the reſiſting muſcles of the abdomen, *viz.* the recti and obliqui, but chiefly the tranſverſe. The more the ſtomach is filled, the more it is urged by this preſſure of the abdominal muſcles; becauſe, at the ſame time, it riſes upward in a right angle to the contact of the peritonæum.

635. Now we muſt ſpeak of what is received into the ſtomach, and why it is received. The Creator has given to man the two faithful guards of pleaſure and pain (564.) for his preſervation; the one to avert evil, the other to invite him to uſeful actions. But the taking of aliment is an action very neceſſary and uſeful to our ſupport. For ſince every day there is a great quantity waſted from the body, by a diſſolution of its true ſubſtance thrown off by perſpiration, a repairing of this loſs is every way neceſſary, as the body is manifeſtly waſted by faſting. But this neceſſity of taking food

food recurs the more quickly from the nature of the blood itſelf, which is ſtrongly inclined to a ſharp, ſaline, lixivial quality, and to a putrid acrimonious ſtate; to which laſt it is continually ſolicited, and approaches, from the putreſcent diſpoſition of all the more ſtagnant humours of the animal, promoted by the inceſſant and natural motion of the heart and arteries, and by the heat which very much promotes the putrefaction of all the animal humours. Moreover, the coagulable diſpoſition of the blood, continually loſing a great part of its diluting water by inſenſible perſpiration, calls ſtrenuouſly for a recruit of the watery element, in the way of drink, by which its coheſive globules are ſeparated from each other, and hindered from running together into a conſiſtent maſs.

636. Theſe truths are proved not only from their cauſes, but likewiſe by the appearances which they exhibit in men and other animals killed by hunger. For, in ſuch, we commonly obſerve a ſharp ſtinking breath, a looſeneſs of the teeth from the diſſolving acrimony of the juices, violent pains in the ſtomach, ſharp fevers, and even a true madneſs. All theſe diſorders ariſe ſooner and ſtronger, as the perſon is more robuſt and more violently exerciſed with motion of body; but they enſue very ſlowly in phlegmatic people, who are unactive, perſpire little, and put the blood into no great motion. Laſtly, thoſe who have been without food, have alſo lived without bodily exerciſe, and for the moſt part laboured under a diſeaſe of the nerves.

637. The freſh chyle, compoſed, for the moſt part, out of the aceſcent claſs of vegetables, and of a conſiſtence always thinner than that of the blood itſelf, being received into its torrent of circulation, temperates the putreſcent acrimony, dilutes the coagulation threatened, and reduces the whole maſs to that moderate degree of ſaline nature which is natural to man: and finally, the chyle, but more eſpecially that derived from the fleſh of animals, and likewiſe what is formed of farinaceous vegetables, being repleniſhed with gelatinous

lymph,

lymph, ſerves to repair the conſumption or waſte which is made from the body itſelf, to the vacuities of whoſe broken ſolids it is applied by the cauſes mentioned (959.) The drink dilutes the coheſive or grumous inclination of the blood, hinders its putrefaction, and carries off by the emunctories ſuch particles as are already putrid: and hence it is, that a perſon may live for a long time without ſolid food, if he is ſupplied with drink; but without drink, life ſubſiſts but a few days.

638. We are ſolicited to take food, as well from the ſenſe of pain we call hunger, as from that of pleaſure, which is received by the taſte (455.) The firſt of theſe proceeds doubtleſs from the ſenſible folds or wrinkles of the ſtomach rubbing againſt each other by the periſtaltic motion, of which there is an acute ſenſation, joined with a preſſure from the diaphragm and abdominal muſcles, by which the naked villi of the nerves on one ſide grate againſt thoſe of the other, after a manner intolerable. Thus we are effectually admoniſhed of the dangers enſuing from too long abſtinence or faſting, and excited to procure food or nouriſhment by labour and induſtry. To this ſenſe perhaps the gaſtric liquor or juice of the ſtomach, collected and ſharpened after feeding, does in ſome meaſure conduce, unleſs it becomes putreſcent.

639. *Thirſt* is ſeated in the tongue, fauces, œſophagus, and ſtomach. For whenever theſe very ſenſible parts, which are conſtantly and naturally moiſtened by mucous and ſalival juices, grow dry from a deficiency of thoſe or the like humours, or are irritated by a redundancy of muriatic or alkaleſcent ſalts here lodged, there ariſes a ſenſe much more intolerable than the former, as thirſt is more dangerous; whoſe uneaſy ſenſe continues until the proportion of diluting water in the blood, being recruited, reſtores the neceſſary moiſture and free ſecretion required in the parts before mentioned. From hence we learn, why thirſt attends labour, which exhales a greater proportion of the watery perſpiration; and why it is a ſymptom of fevers,

where

where there is an obſtruction of the exhaling veſſels belonging to the tongue and fauces; why ſimple water is leſs efficacious in abating thirſt, which yields nevertheleſs eaſily to ſome acid liquors, that not only moiſten and render fluid, but alſo, by their mild irritation of the tongue and mouth, provoke forward the humours, and at the ſame time correct their putrid tendency.

640. From theſe cauſes, mortals, being under a neceſſity of ſeeking food for the ſupport of life, have in all ages determined their choice to the ſucculent parts of vegetables and animals, in ſuch a manner, that water and ſalt ſeem to be added only as third aſſiſtants. And firſt, it is probable, that the primitive choice of our foods was made by experiments, according as the variety of ſmells and flavours in vegetables and their ſeveral parts invited, and as the ſtrength or recruit of our faculties thence following confirmed their utility. But by degrees, animals increaſing ſo much as to be incommodious to the huſbandmen, and vegetables alone not being ſufficient for ſupporting them under their labours, the fleſh of animals was afterwards added. At preſent, both the number and variety of ſubſtances are almoſt infinite, which we take either as food or ſeaſoning for our nouriſhment.

641. Although there are many inſtances of particular perſons, and even of whole nations, who have ſupported life only with one kind of food, either vegetable or animal, or even from a ſmall claſs of either of them; and laſtly, though ſome have lived altogether upon milk or its whey; yet it ſeems to be neceſſary, both from the nature and fabric of the human body itſelf, as well as from certain experiment, that we ought to ſupport life by the two kinds of food, ſo intermixed, that neither of them may exceed their reaſonable bounds; and this mediocrity we are taught from the loathing itſelf, which follows to any one kind of food that has been continued for too long a time together.

642. The fleſh of animals appears a neceſſary part of our nouriſhment, even from the fabric of the human

man ſtomach itſelf, reſembling that of carnivorous animals; and from the two rows of teeth, with the canine teeth in each jaw; alſo from the ſmallneſs and ſhortneſs of the inteſtinum cæcum, and from the neceſſary vigour which we require. For the fleſh of animals alone contain the gelatinous lymph ready prepared for the recruit both of our fluids and ſolids, which, being extracted from the broken veſſels and fibres, eaſily paſſes in great abundance into the blood. An abſtinence from animal food generally cauſes great weakneſs both to the body and ſtomach, being perpetually attended with a troubleſome diarrhœa. But in the amplitude and length of the inteſtina craſſa, man agrees with herbivorous animals.

643. Eſculent vegetables are generally of the aceſcent kind; only ſome few of them are either alkaleſcent, or elſe repleniſhed with a ſpicyneſs. But few of them have that animal glue which is ſpontaneouſly changeable into blood; for it is only the ſmall portion of jelly which is drawn from their farinaceous parts, that, after many repeated circulations, is converted into the nature of our indigenous juices. Yet theſe are neceſſary to avoid over repletion with blood, and of too putreſcent a kind from the uſe of animal food alone, which, from the moſt creditable accounts of the anthropophagi, prevails to ſo great a degree, as to breed the hot alkaleſcent ſcurvy, a fierce or ſavage temper, a ſtinking and leproſy of the body, with a lixivial corruption of all the juices; which are only to be cured by change of diet, in which a vegetable acidity abounds. Hence it is, that we are furniſhed but with few canine teeth; and that our appetite in health, but more eſpecially in diſeaſe, is ſtronger for acidulous vegetables, in proportion to our warmer temperature of body, and greater heat of the country or the ſeaſon of the year. Hence we ſee, that, in the hotteſt climates, people live either altogether upon vegetables, or uſe fleſh meats but very rarely, and not without danger of acute diſeaſes; while, in the colder countries, fleſh is eaten freely with leſs danger:

and hence bread, or a farinaceous aliment fimilar to it, is made a ftanding part of our food throughout the world.

644. The beft *drink* is afforded by pure water, not incorporated with falts nor with air, which may excite fermentations. Of this kind we juftly prefer that from a mountainous fpring, which runs through a fandy bed, being very cold, clear, light, and infipid. Whenever we are unprovided with fuch pure water, as is frequently the cafe in the lower flat countries, or when any increafe of the ftrength and mufcular conftriction of the ftomach is required from a fpicy ftimulus, its place may be very well fupplied by wine, prepared chiefly from grapes; but, in defect of thofe, from apples and pears; which, after a due fermentation, becomes clear, and is replenifhed with an acid falt, and oily or inflammable fpirit, well diluted in water. Liquors of the fame kind, replenifhed with a vinous or inflammable fpirit, but more flatulent, heavy, and lefs palatable, are prepared from corns roafted, afterwards extracted with boiling water, and prepared by fermentation, as a fubftitute for wine in thofe countries where the grape does not ripen.

645. But mankind have invented various pickles and fauces, fuch as falt, vinegar, and acids of various kinds, to correct the putrefcent difpofition of flefh-meats; with pepper, muftard, and other hot fpices, to ftrengthen the action of the ftomach, which is perpetually weakened by the ufe of vegetables: and to thefe add, fugar, falt, and the eaftern fpices, which are generally added either for the fake of flavouring or preferving our food. But all thefe yield no nourifhment, being deftitute of all gelatinous lymph, or any farinaceous quality. The fpirits of wine and corn may be of fome ufe as medicines, but are unfit for drinking.

646. The aliments are varioufly prepared, according to the difference of country, climate, or feafon, by which their crudity is removed, their folid fibres foftened or opened, their too much incorporated air expelled,

led, or their disagreeable acrimony reduced or changed to a flavour that is agreeable. But, even after this, many vegetable foods, and more especially flesh-meats, require to be divided, in some degree, by a previous triture in the mouth, which is particularly necessary in man, whose stomach is but little fleshy, and likewise that the food may not stay so long upon the stomach as to become putrid.

647. The measure of our food is determined by hunger, which is different according to the difference of bodies. Animal and farinaceous food nourishes most: other aliments ought to supply by their quantity, what they want in their powers of nourishment. In general, we are nourished best by a somewhat spare diet, unless subjected to much labour.

648. Into this stomach, therefore, the aliments are let down, often almost crude, and but little chewed, of various kinds; some of them being alkalescent, as flesh-meats; rancescent, as oily or fat substances; or acescent, as bread, milk, and most of the vegetable kind. These, we observe, are digested in an heat equal to that of an hatching egg, administred to the stomach by the contiguous spleen, liver, and heart; and this in a cavity altogether close or confined above (621.), as it also is below, by the ascent of the incurvated pylorus, and in a great measure by a shutting valve, and likewise constringed by a muscular force of the fibres; from whence we observe, that even milk itself is often retained in the stomach of strong animals several hours after a meal, without passing into the intestines. Observe, again, that these aliments are continually cohobated or moistened with watery juices, and at the same time are replenished with a good deal of air incorporated with them, either naturally or in the mastication. This air, therefore, expanding by the force of heat, putrefaction, or fermentation, breaks open the cells by which it was included, divides the viscid liquors, and softens or opens the solid fibres, so as to make a way for discharging their juices. But the same substance of the air, turning

to a ſolid, makes the principal glue or cement by which the animal ſolids and other bodies receive their firmneſs; and this, being extricated by heat, leaves the other elementary parts friable, or without a vinculum, as we ſee from the change which happens in Papin's digeſter, in the ſtomachs of many animals, and even in that of ourſelves. This air, ſet at liberty by the digeſtion, often diſtends the ſtomach more than the food itſelf, under the denomination of flatus. While this air is extricated, the aliments by long ſtay begin to corrupt or change into a nauſeous liquid, often aceſcent; or otherwiſe putreſcent, which however happens leſs in mankind from our uſe of bread and ſalt; orranceſcent, as appears from the flatus and matters eructated, often of a moſt fetid, cauſtic, and inflammable nature, from ſubſtances of the like diſpoſition. This putreſcency, or imperfect putrefaction, is almoſt the only cauſe of digeſtion in fiſh, ſerpents, and carnivorous birds. Hence, in mankind, metals themſelves, by long ſtay in the ſtomach, grow ſoft, and are eroded. At this time hunger is abſent, the nervous plates of the ſtomach being removed and defended from their contacts with each other by the interpoſed aliment, at the ſame time that the juice of the ſtomach itſelf is leſs ſharp, and freer from a mixture with the old remains of the laſt food, which often excite a nauſeating uneaſineſs in the nerves of the ſtomach.

649. But, that the aliment might not degenerate into a complete acidity, there is a check from the putreſcent degree of the heat, the power of the juices diſtilling from the ſtomach, and that of the ſaliva itſelf ſwallowed to the amount of half an ounce in an hour, and rather inclined to an alkaleſcency: alſo theſe juices, being ground together with the aliment, macerate, ſoften, and diſſolve the fibres themſelves and their cellular bands, leaving them a ſoft pulp like what we ſee by letting them ſtand for a long time in warm water, extract their juice, and mingle it with themſelves. There is, therefore, no particular kind of ferment in the ſtomach; from

from which the deſign of nature, the diſpoſition of the ſtomach, and its uſe, are all very remote. And yet the juice of the ſtomach alone, by its longer ſtay in fiſhes, diſſolves the bones which they had devoured.

650. For the fleſhy fibres in the ſtomach being now irritated by the flatus, weight, and acrimony of the food, begin to contract themſelves more powerfully than when the ſtomach is empty, and with a greater force in proportion as it is more full, the round ſwelling of which ſtretches theſe fibres. And, firſt, the muſcular ſtratum, which paſſes along the leſſer curvature, connects the pylorus with the œſophagus; and, being inſerted only into the left face of the former, draws it to the right. The principal ſtratum of the circular fibres contracts the capacity of the ſtomach, according to its length; grinds or intermixes its contents, together with the liquors (633.); and determines them both, like the preſſure of two hands placed oppoſite, to flow towards the pylorus: but this flux through the pylorus is not made continually, for reaſons before aſſigned (626.), as well as becauſe this motion begins from ſome part that is more irritated; and from thence the aliment is driven here upward, as in other parts downward. Theſe alternate contractions at laſt terminate in a full evacuation. In this action of the ſtomach, there is nothing which reſembles the triture made by the ſtrong gizzards of granivorous fowls, which ſome anatomiſts have aſcribed to the human ſtomach; which yet has a conſiderable degree of ſtrength, ſince the contraction of its fibres is often more than a third part of their length; for we frequently ſee the ſtomach reduced to leſs than a third of its diameter: frequently alſo the ſtomach is obſerved to be diminiſhed to much leſs than a third part, even to the breadth of an inch; which, laſtly, makes it fit for moving forward ſharp pointed ſubſtances. Yet it neither bruiſes berries, nor the ſofteſt worms.

651. But that motion which it receives from the diaphragm and muſcles of the abdomen, is ſtronger than

than the periſtaltic force of the ſtomach; for, by this, the ſtomach is more perfectly emptied by a cloſe approximation of its anterior and poſterior ſides. For it is principally by this force, that the drinks are urged on continually, but the foods only when they are diſſolved, leſt thoſe parts which are too groſs ſhould be expelled through the pylorus into the duodenum, when the ſtomuch is more that way inclined by repletion; for the ſolid aliments do not ſeem to leave the ſtomach, before they have changed their fibrous or other texture for that of a mucous, as it were cineritious, yellowiſh, ſomewhat fetid, mucilaginous, and liquid pulp. That which is firſt prepared and turned fluid, goes before the reſt out of the ſtomach; firſt water; then milk, pot-herbs, bread; and laſt of all, fleſh-meats, the harder, tougher, and longer ſkins or fibres of which paſs unchanged: but ſuch things as are hard, or too large to paſs the pylorus, are retained in the ſtomach for a long time.

652. But a conſiderable portion of the drink is abſorbed by the pendulous inhaling veins of the ſtomach itſelf, gaping like the exhaling arteries of the ſame part (633.); ſo their contents take a ſhorter way into the blood, as plainly appears from repeated experiments of injecting the veins. Does any thing paſs into the lymphatic veſſels (631.)?

653. The ſtomach, being irritated by too great a quantity or acrimony of the food, or elſe by ſickneſs, a repulſion of the bile, or other cauſe, does, by an antiperiſtaltic or reverted motion of its fibres, drive its contents upward, through the open and relaxed œſophagus, in the act of vomiting. But then this effect is partly from the preſſure of the abdominal muſcles, depreſſing the falſe ribs, and urging the contents of the abdomen againſt the diaphragm; which, at the ſame time, contracting itſelf to a plain downwards, forces the ſtomach, as betwixt the ſides of a preſs, to throw up its contents.

654. But the aliments, driven in their natural courſe to the duodenum, meet there with the influent bile and pan-

pancreatic juice, which often flow back into the ſtomach. But the former of theſe being the principal baſis of chylification, will require from us a previous hiſtory of the viſcera, which convey their blood through the vena porta.

CHAP. XXI.

Of the Omentum.

655. BY the *peritonæum*, we underſtand a ſtrong ſimple membrane, by which all the viſcera of the abdomen are ſurrounded, and in a meaſure ſuſtained. Internally this membrane is exceedingly ſmooth, and moiſtened with exhaling vapours: but outwardly it adheres to all the parts by the looſe cellular ſubſtance; which, towards the kidneys, contains a good deal of fat; but is extremely thin and ſhort before, betwixt the peritonæum and tendons of the tranſverſe muſcles of the abdomen. It begins from the lower ſide of the diaphragm, which it lines; and in certain intervals, joining with the correſponding pleura above, it completes what would be otherwiſe deficiencies in the diaphragm, as betwixt the ultimate fleſhy fibres next the ribs and at the loins; to which add, its continuations upward, through the foramina of the diaphragm. From thence this membrane deſcends, in its fore-part, behind the abdominal muſcles; in its back-part, before the kidneys; and, going into the pelvis, from the bones of the pubes, it paſſes over the bladder obliquely backward; and then reaſcends back again over the ureters by two lunar folds or plates, rejoining upon the inteſtinum rectum with that part of itſelf which inveſted the loins, and in the ſame place goes before the rectum.

656. The cellular texture which covers the peritonæum on the outſide, is continued into ſheaths in very many places; of which one receives the teſticle on each ſide; another the iliac veſſels; others the inteſtinum rectum,

rectum, the larger veſſels of the pelvis, the obturatoria, penis, bladder, and aorta, and accompany the gullet, aſcending into the breaſt, and along the vertebræ; by means of which, there is a communication between the whole body and the peritonæum, very remarkable in dropſical people.

657. But through this general extent, it ſends out various productions for covering the viſcera. The ſhorter productions of this membrane are called *ligaments;* and are all of them formed by a continuous reduplication of the peritonæum, coming from its inner ſurface, together with a cellular ſubſtance, interpoſed and extending to ſome one or other of its viſcera, where its plates ſeparate again from each other to embrace the organ, which they are to ſurround and furniſh with a coat; but the cellular ſubſtance always intervenes betwixt this membranous coat of the peritonæum, and joins with it the true fleſhy ſubſtance of the viſcus. Of productions of this kind, there are three ſhort ones belonging to the liver, one or two to the ſpleen, and others to the kidneys, lateral parts of the uterus and vagina. By this means the tender ſubſtance of the viſcera is defended from injury by any motion or concuſſion, and their whole maſs is prevented from being miſplaced by their own weight, as they receive a ſure connexion to the firm ſides of the peritonæum.

658. But the moſt ample and moveable of all theſe productions from the peritonæum, are thoſe called the *meſentery* and *meſocolon;* the deſcription of both which, although difficult in words, ought not to be ſeparated from that of the peritonæum itſelf. We ſhall, therefore, begin firſt with a deſcription of the *meſocolon*, as being the more ſimple. In the pelvis, the peritonæum ſpreads itſelf within a ſhort compaſs before the rectum; but where that inteſtine bends into a ſemilunar curve, the peritonæum there departs out far from the iliac veſſels and ſeat of the pſoas muſcle which lie upon the muſcles of the loins, and ariſes as if duplicated (657.), ſpreading itſelf in ſuch a form as is fitteſt to receive the colon

colon into its capacity. But above, on the left ſide, that the colon might be at liberty, it is conjoined to the peritonæum, with little or none of this middle production; ſpreading itſelf upon the body of the pſoas muſcle, as high as the ſpleen, where this part of the peritonæum, that gave a coat to the colon ſpread under the ſpleen, receives and ſuſtains that viſcus, by taking it into its capacity or folds.

659. From thence the peritonæum, at the pelvis, aſcends upward, expanded before the left kidney, and ſtretched outward on each ſide, forwards from that and from the right kidney, before the great blood-veſſels, under the pancreas; to which being continuous, it forms a long production, called the *tranſverſe meſocolon*, which, like a partition, divides the upper part of the abdomen, containing the ſtomach, liver, ſpleen, and pancreas, from its lower cavity. The lower plate of this tranſverſe production is ſingle, continued from the right to the left meſocolon, and ſerves as an external coat to a large portion of the lower and deſcending part of the duodenum. But the upper plate, taking a more obſtructed courſe, departs from the lumbar peritonæum at the kidney and ſeat of the vena cava, farther to the right than the duodenum, to which it gives an external membrane, not quite to the valve of the pylorus; and, beyond this inteſtine and the colon, is joined with the lower plate in ſuch a manner, that a large part of the duodenum lies within the capacity of the meſocolon. Afterwards, near the liver, the meſocolon bends itſelf inward, and deſcends laterally over the kidney of the ſame ſide, ſo as to include the right colon, which is much ſhorter than the left, even as far as the inteſtinum cæcum, reſting upon the iliac muſcle; to the appendicle of which, a peculiar long detachment adheres, as a beginning to the meſentery. There the meſocolon terminates, almoſt at the bifurcation of the aorta.

660. The whole meſocolon, and the whole meſentery, is hollow; ſo that air may be forced in between its two ſimilar plates in ſuch a manner as to expand it

into a bag. At the place where the colon ſuſtains it, and alſo from part of the inteſtinum rectum, the meſocolon, which is continuous with the outer membrane of the inteſtine, forms itſelf into ſmall ſlender bags, for the moſt part double, thick, and bifid, free at their extremities, and capable of admitting air driven in between the plates of the meſocolon.

661. From thence forward the *meſentery* follows, as a broad plaited production of the peritonæum, continuous with the tranſverſe meſocolon, and extended on the right ſide forward, and downward from the emerging duodenum; and then from the left or long meſocolon, even as low as the pelvis. Thus the meſentery is formed by the plates of the peritonæum, which lie upon the aorta, extended forward and together, under the right portion of the tranſverſe meſocolon; and, deſcending obliquely under the pancreas, it contains the long ſeries of the ſmall inteſtines, within its capacity, diſpoſed in numberleſs folds.

662. The whole ſeat and extent of the meſentery and meſocolon hold a portion of fat, collected commonly more in proportion as they go longer within the capacity that is neceſſarily formed by the reduplication of their membranes and veſſels interſperſed and ſurrounding the fat, which the arteries ſeparate, and the veins, as already mentioned, reſorb; there are alſo very numerous glands, which are moſtly conſpicuous in a young perſon.

663. The ſtructure of the *omentum* anſwers very nearly to that of the meſentery. But there are many membranes that come under this general denomination, of the ſame ſtructure and utility, all compoſed of very tender and fine membranes, eaſily lacerated, betwixt which the blood-veſſels are diſpoſed reticularly, with fat depoſited in ſtreaks near the ſides, and in the ſame directions with the reticulated veſſels themſelves. This membrane is always double; the two plates of which are joined together cloſely by a very tender cellular ſubſtance, within which the veſſels are diſtributed, and the

fat collected. And, firſt, where the top of the right kidney and the inſulcated lobe of the liver, together with the ſubjacent blood-veſſels, meet with the duodenum into an angle, there the external membrane of the colon, which comes from the peritonæum, joining with the other membrane of the duodenum, which is alſo from the adjacent peritonæum, they go together over the left kidney backward, and enter into the tranſverſe fiſſure of the liver, for a conſiderable length; from which the external membrane is continued over the gall-bladder which it contains, confining the vaſcular fabric of the liver, very ſlippery, and tinged of a yellow colour. Behind this membranous production, betwixt the adjacent duodenum, right lobe of the liver, hepatic veſſels, vena portarum, and biliary ducts and artery, lies a ſmall natural opening, by which inflated air is largely received into all that cavity of the omentum which we ſhall preſently deſcribe as a bag; and, laſtly, into the bags of the reſt of the omentum.

664. From thence, in a courſe continuous with this membrane (663.) from the pylorus and the leſs curve of the ſtomach, the outer membrane of the liver joins in ſuch a manner with that of the ſtomach, that the thin membrane of the liver is continued out of the foſſa of the venal duct, before the little lobule, into the ſtomach itſelf, ſtretched both before the lobule and before the pancreas. This is called the *little omentum hepatico-gaſtricum;* which, inflated, reſembles a cone; and, hardening by degrees when it is without fat, changes into a true ligament, by which the œſophagus and liver are conjoined together (623.)

665. But the great *gaſtrocolic-omentum* is of a much larger extent. It begins at the firſt joining of the right gaſtro-epiploic artery to the ſtomach, where it is continued from the upper plate of the tranſverſe meſocolon (659.); and from thence it proceeds forward along the great arch or curve of the ſtomach to the ſpleen, and in part is continued alſo from the right convex end of the ſtomach towards the ſpleen, even till it degenerates

into a ligament that ties the upper and back part of the ſpleen to the ſtomach. This is the *anterior leaf* of the omentum.

666. This anterior leaf or lamina of the omentum floats looſely downward before the inteſtines, ſometimes to the navel, ſometimes to the pelvis, behind the muſcles of the abdomen; and, making a thin edge, is folded back again in a direction contrary to itſelf, and aſcends ſo as to leave an intermediate vacuity, by which the fore leaf is removed from the poſterior; and being at length continued for a conſiderable extent into the outer membrane of the tranſverſe colon, and laſtly continued in the ſinus of the ſpleen by which the large blood-veſſels are received, it ends in the œſophagus, under the diaphragm. Behind the ſtomach, and before the pancreas, the cavity of this is continued into that of the leſſer omentum.

667. To this is continued the omentum colicum, which ariſes on the right ſide only from the colon and its external membrane, immediately after the origin of the omentum gaſtrocolicum from the meſocolon, with whoſe cavity it is continuous, but produced by the colon and its membrane, which departs doubled from the inteſtine, forms a production ending conically, and is terminated by a longer or ſhorter extent above the inteſtinum cæcum.

668. The uſes of the omentum are many. Its common uſe is, together with that of the meſentery, to form an ample ſpace, of a looſe texture, into which the fat may be poured from the arteries, at the time of ſleep and inactivity of body, to be afterwards diſſolved by motion, and returned again into the blood by the inſorbent veins, ſo as to make a conſtituent principle of the bile. Accordingly, you will feel the fat of the omentum to be very tenacious or viſcid betwixt the fingers, although of a thin conſiſtence, and in its whole body more pellucid than paper. For that the fat of this part returns again into the veins, appears from the different bulk and weight of fat obſervable in the various omenta of different perſons, according as they lead either an idle,

idle, laborious, or morbid courſe of life; to which add, its appearances in various brute animals, with the relation it bears to all the reſt of the fat of the whole body (20.): from experiments in frogs, where this re-abſorption of the fat may be made evident to the eye: and, laſtly, from the apparently inflammable nature of the bile itſelf. Hither we muſt alſo refer the diſorders and crudities of digeſtion, together with the coldneſs of the ſtomach, obſerved to follow after cutting out the omentum.

669. For all the blood which returns from the omentum and meſocolon, goes into the trunk of the vena portarum, and by that into the liver itſelf. The omentum is furniſhed with blood by the gaſtrocolic and by each of the gaſtro-epiploic arteries, deſcending in many ſmall branches, and ſubdivided in a reticular manner: of theſe, the arteries on each ſide run to the greateſt length; but the inner or poſterior leaf of the omentum has ſmall arteries, which go out from thoſe of the colon. Branches alſo come to it from the ſplenic, duodenal, and adipoſe arteries. The omentum colicum has alſo its arteries from the colon, in the ſame manner as the ſmaller appendices (660.) The arteries of the leſſer omentum come from the hepatics, alſo from the right and left coronaries of the ſtomach.

670. The nerves of the omentum are very ſmall, as being a fat and indolent body; yet it receives ſome little branches from the nerves of the eighth pair, both in the greater and in the leſſer curve of the ſtomach.

671. The arteries of the meſentery are, in general, the ſame with thoſe that go to the inteſtines; the ſmaller branches of which go to the ſmall glandules and cellular fat, included within the meſentery. But, to the meſocolon, ſmall arteries are diſtributed on all ſides from thoſe of the various parts connected to it; as the intercoſtals, ſpermatics, lumbals of the renal capſules, and tranſverſely from the ſplenic artery, with the pancreatic branch of the duodenum: but, in the left me-

ſocolon,

ſocolon, there are alſo ſmall arteries detached from the aorta itſelf to the glandulæ lumbales.

672. The veins of the omentum, in general, accompany the arteries, and unite into ſimilar trunks: thoſe of the gaſtrocolic omentum from the left ſide open into the ſplenic, as do thoſe of the hepaticogaſtric, which likewiſe ſends its blood to the trunk of the vena portarum: thoſe from the larger part of the right gaſtrocolic omentum go to the meſenteric trunk; as do thoſe of the omentum colicum, with thoſe of the appendices epiploides. All the veins of the meſentery meet together in one, which is truly the trunk of the vena portarum: in forming which, they are firſt collected into two large arms; of which one receives the gaſtro-epiploica, with the middle colic and iliocolic veins, and all thoſe of the ſmall inteſtines as far as the duodenum; the other arm, which goes tranſverſely acroſs the former, which ariſes above it, is embraced by the duodenum, and returns the blood of the left colic veins, with thoſe of the rectum, except the lowermoſt, which belong partly to thoſe of the bladder, and partly to the hypogaſtric branches of the pelvis. The vein which is commonly called *hæmorrhoidalis interna*, is ſometimes inſerted rather into the ſplenic than into the meſenteric vein. If it be demanded, Whether the omentum has any lymphatic veſſels? we anſwer in the affirmative: ſince there are conglobate or lymphatic glandules, both in the little omentum and in the gaſtrocolicum; alſo the ancient anatomiſts have obſerved pellucid veſſels in the omentum; and, lately, a modern has deſcribed them for lacteals of the ſtomach.

673. Other uſes of the omentum are, to interpoſe betwixt the inteſtines and peritonæum, which, by inflammation, are very apt to grow together; to keep the former in a ſtate of free motion, as well among themſelves as againſt the peritonæum, with but little attrition; and to anoint the muſcular and membranous fibres with a very ſoft oil. For theſe reaſons, even in inſects, there is a great deal of fat placed round the inteſtines,

teſtines. In the large inteſtines, there are a great many appendices, which likewiſe are produced from the large branches, and cannot altogether cover the omentum. But the ſame ſets the veſſels in order; conducts and gives them ſtrength; and exhales a ſoft vapour, which, mixed with the exhaling abdominal water, anoints and lubricates all the viſcera.

674. The meſentery ſerves to ſuſpend and diſplay the inteſtines in ſuch a manner, that they may move freely, and with a degree of firmneſs: it ſerves as a bed to ſuſtain, and ſafely conduct the numerous veſſels, nerves, and glandules; of which laſt we ſhall ſpeak hereafter: it alſo gives an external coat to the inteſtines, and forms moſt of the omenta.

675. But, beſides, the blood, returning through the meſenteric and meſocolic veins, brings with it another principal conſtituent part of the bile; namely, a ſub-alkaline watery humour, which is abſorbed by the veins from all the ſmall inteſtines, as will be demonſtrated in its proper place. Beſides this, it gives to the liver a more putrid water from the large inteſtines, which is fetid, and nearly approaches to a volatile alkaline nature, abſorbed from the fæces, that now begin to ſmell ſtrong; the exiſtence of which is eaſily proved, both from our own experiments, and the drying of the fæces when too long retained. This water is, therefore, a fluid in itſelf, and rendered more ſo by an incipient putrefaction; and, conſequently, it ſerves to reduce the tenacity of the oil belonging to the omentum and meſentery, ſo as to keep it from congealing. But more eſpecially in the bile, it conſtitutes the acrid alkaline quality, with which this humour abounds; and from thence comes the great tenuity and ſaponaceous force of the bile, ſo uſeful to dyers and painters.

CHAP.

CHAP. XXII.

Of the Spleen.

676. THE ſpleen itſelf is one of thoſe intermediate viſcera, which ſend their blood to the liver. It is a blueiſh, pulpy, ſomewhat oval viſcus, ſomething like a maſs of congealed blood in its conſiſtence, having frequently a notch or inciſure in its oval circumference; whence it is convex towards the ribs, concave inwardly, and circumſcribed with two margins or edges, of which the inferior and anterior is the ſharpeſt. It is connected to the ſtomach by the little omentum; and above that, by the upper ligament, ſupported by the ſubjacent colon, and by another ligament (658.) behind the renal capſule; to which, and to the kidneys, it adheres by the peritonæum. It alſo receives the peritoæum from the diaphragm, under the denomination of a ligament, in the back-part of its hollow ſinus, behind its veſſels. The ſituation of it varies with that of the ſtomach itſelf, which it follows. When that is empty, the ſpleen is raiſed perpendicularly, ſo as to place its extremities right up and down: but when the ſtomach is full, the middle curve or arch of it ariſes upward and foreward (622.); and at the ſame time obliges the ſpleen to change its ſituation, ſo as to lie almoſt tranſverſely with its lower end forward, and its upper end backward. Thus, being of a very ſoft and looſe texture, it grows larger by diſtention when the ſtomach is empty, and becomes leſs again when its blood is preſſed out by the diſtention of the full ſtomach againſt the ribs. From hence the ſpleen is found large in thoſe who die of lingering diſeaſes; but in thoſe who die ſuddenly, and in full health of body, it is ſmall. Another motion of the ſpleen is, that of deſcending with the diaphragm in inſpiration, and aſcending again in exſpiration; and beſides this, the ſpleen frequently varies in its ſituation with

with that of the colon. Frequently there is a ſecond or leſs ſpleen placed upon the former.

677. The *blood-veſſels* of the ſpleen are large, in proportion to its weight. The arterial trunk comes from the cœliac; the upper branch of which, proceeding in a ſerpentine courſe above and behind the pancreas, to which it gives branches, as well as to the meſocolon, ſtomach, and omentum, is at length incurvated in the direction of the ſulcus or notch of the ſpleen, which it, after a manner, perforates by ſeveral diſtinct branches, ſuſtained at the right extremity by the omentum gaſtrocolicum. The thickneſs of this artery is greater than that of the aorta. The ſplenic vein, which accompanies the artery, is conſiderably ſofter than any other veins of the body; it forms the principal left branch of the vena portarum. Beſides theſe, the ſpleen receives ſmall arteries from the great coronary, deſcending behind the pancreas, and ſometimes from the internal hæmorrhoidal. The vaſa brevia of the ſpleen and ſtomach we have mentioned elſewhere; and its ligaments and membranes receive ſmall arterial twigs from the lumbar arteries, phrenics, intercoſtals, and thoſe of the renal capſules. In like manner alſo the veins in the ſpleen, and thoſe which join it to the ſtomach, communicate with the phrenics, and with the veins of the renal capſules.

678. The *lymphatic veſſels* of the ſpleen are deſcribed to ariſe in the duplicature of the ſplenic coat or membrane (of which there is none at all), and from thence to proceed on to the receptacles of the chyle, very evident in a calf; in mankind they are rendered conſpicuous by blowing air under the membrane, by maceration, or water injected into the arteries.

679. The *nerves* of the ſpleen are very ſmall; from whence it is capable of but little pain, and is very rarely inflamed. They ariſe from a particular plexus, compoſed out of the poſterior branches of the eighth pair at the ſtomach (630.), and of certain branches from the large gangliform plexus, which produces the ſplenic

trunk of the intercoſtal nerve, from whence the branches ſurround the artery into the ſpleen.

680. The fabric of the ſpleen appears to be much more ſimple than has been commonly believed. For it is compoſed, both in us and in calves, altogether of arteries and of veins; the former of which, after ſpending themſelves in a great number of ſmall branches, are at length thickly ſubdivided into very ſoft bruſh-like bunches, very difficult to fill with injection, terminating in circles; by which there is a ready paſſage for liquors into the correſponding veins. Theſe circles, with their parallel branches, form a ſort of bunches like a pencil bruſh, but of a ſhorter rounder kind; whence many have miſtaken them for glands. Nor does the injection, rightly managed, ever eſcape from the veſſels into the intervals; nor were any hollow glandules ever diſcovered by certain obſervation. Every little arterial trunk, with the ſmaller twigs that proceed from it, are each of them ſurrounded by a very fine cellular ſubſtance or web-work, in the ſame manner with the ſmall veſſels of all the other viſcera, but here rather ſofter. The whole body of the ſpleen is outwardly ſurrounded by a ſingle membrane, which is not very tough, continued from the peritonæum, and joined to the fleſhy part of the ſpleen by a pretty thick cellular texture.

681. Hence we obſerve, that the ſpleen contains more blood, in proportion, than any of the other viſcera; ſince it has no muſcles, fat, air-veſſels, or excretory ducts, interpoſed betwixt its blood-veſſels. We learn alſo from obſervation, that the blood of this part hardly ever congeals, from the abundance of its volatile or bilious ſalts: but it looks of a dark-brown colour, and may be eaſily diluted; whence one may compare it almoſt to the blood of a fœtus.

682. The want of an excretory duct to the ſpleen, has occaſioned the uſe of it to be doubtful, and controverted throughout all ages of anatomy. To us the fabric itſelf ſeems to lead to the following uſes; although, perhaps, they do not comprehend all the uſes of the ſpleen.

ſpleen. A great quantity of blood is imported to the ſpleen (677.), and with a ſlower motion, from the ſerpentine courſe and hardneſs of the artery: but, at the time when the ſtomach is empty, this blood comes, and is received in a greater quantity by the ſpleen, not now ſo much compreſſed, therein to ſtagnate, as it would ſeem plainly from the great proportion of branches to the trunks in this part; to which add, the difficult courſe or ſlow circulation which the blood meets with in paſſing from the ſpleen through the liver: from hence the frequent ſcirrhoſities of the ſpleen; and from hence the immenſe quantity of blood with which the ſpleen is in every point diſtended, the like of which we do not ſee in any other part. Here, then, the almoſt ſtagnant blood, fomented with heat, attenuated, and in a manner diſſolved by the putrid feces of the adjacent colon, enters thus upon the firſt ſteps of a begun putrefaction, as we learn by experiments, both from its colour and conſiſtence. But the greater fluidity of the blood herein, proceeds not only from this diſſolution, but becauſe all its watery juices that enter by the artery return alſo again by the vein; for there are no ſecretory ducts in the ſpleen.

683. Moreover, when the ſtomach is full of food or flatus, the ſpleen is thereby compreſſed into a narrower compaſs, againſt the ribs and ſuperincumbent diaphragm, by which means the blood, that before was ſcarce able to creep along through the ſplenic veins, being now preſſed out more plentifully, returns with a greater celerity towards the liver; till mixing with the ſluggiſh blood in the trunk of the porta, repleniſhed with the fat or oil of the omentum and meſentery (669.), it dilutes or thins the ſame, and renders it leſs apt to ſtagnate or congeal; and, at the ſame time, it conduces to form a larger ſecretion of bile at a time when it is moſt wanted, viz. to flow plentifully to the food now under digeſtion. The ſpleen, therefore, ſeems to prepare the blood, that it may ſupply a ſort of watery juice to the bile; but ſuch as is probably of a ſubalkaline na-

ture, and rendered ſomewhat ſharp by the remora of the blood.

684. Whether is the ſpleen of a cellular fabric? Is the blood poured out into thoſe cells ſo as to ſtagnate? or is it diluted with ſome juice ſecreted by peculiar glands? We ſee nothing of this is demonſtrable by anatomy; nor does the liquor or wax injected ever extravaſate into the cellular ſubſtance, unleſs urged with much greater violence than nature ever uſes or intended. As to the old queſtion, Whether the ſpleen brews up an acid to whet or ſharpen the ſtomach; that opinion has been long diſcarded, as repugnant to the nature of all the animal juices. If it be aſked whether the ſpleen be not an uſeleſs maſs, as it might ſeem to be, from the little damage an animal ſuſtains after it has been cut out? we anſwer, That a robuſt animal, ſuffering but little injury from the loſs of a part, does not prove it to be uſeleſs; and yet there are examples, after ſuch an experiment has been made, that the liver becomes ſwelled and diſordered, makes a leſs quantity of bile, and of a darker brown colour; while the animal is perpetually troubled with flatulencies, gripes, or indigeſtion: all which are to be aſcribed to the vitiated nature of the bile, an obſtruction of the liver, and an imperfect or weak digeſtion; at the ſame time they are confirmed by repeated experiments.

CHAP. XXIII.

Of the PANCREAS.

685. THE pancreatic *juice*, which is watery, inſipid, thin, neither acid nor alkaline, is poured into the ſame place into which the bile diſcharges itſelf.

686. The *pancreas* is then a very long glandule, the largeſt of the ſalival kind, extended over the inferior lamina of the tranſverſe meſocolon; which, beyond the pancreas,

pancreas, behind its ſuperior lamina, behind the ſtomach, before the ſpleen, under and behind the liver, meets with the inferior lamina: it lies before the left capſule and the aorta; is plain, and of a triangular ſhape, with a light ſtroke on the upper part, and covered with the peritonæum, upon which the poſterior flat ſide of the empty ſtomach is ſupported; for that ſide of the ſtomach is both lower as well as poſterior. The pancreas begins ſmall from the ſpleen itſelf; and extending almoſt tranſverſely towards the right ſide, it emerges forwards to the peritonæum, acroſs the vertebræ, to the right ſide of which it grows conſiderably broad, being received betwixt the ſuperior and inferior plate of the tranſverſe meſocolon (659.); and is, finally, ſo connected by its round head to the duodenum, that this inteſtine ſerves it for a meſentery. The ſtructure of it is, like that of the ſalival glands, made up by a great number of ſmall kernels of a firm texture, connected to each other by a good deal of cellular ſubſtance. The pancreatic *blood-veſſels* are rather numerous than large, derived chiefly from the ſplenic branches: but on the right ſide it is ſupplied by the firſt artery of the duodenum, and from that other which is lower down, and is in common both to the duodenum and pancreas; both of which ariſe from the hepatic artery, and of which the former inoſculates with the latter, and both with the meſenteric artery, which ſupplies conſiderable twigs to this gland; but the ſmaller ramifications come from the phrenic and capſular arteries. The *nerves* of this gland are not of any conſiderable ſize; whence it is but little ſenſible: they are derived from the poſterior gaſtric and the hepatic plexus, from that of the ſpleen, &c.

687. The *excretory duct* of this gland runs almoſt through its middle, white and tender, ariſing every where from a great number of roots; by which, being gradually increaſed, it emerges before the vena portarum and meſenteric artery, and receives a large branch from the lateral pancreatic portion; from whence it advances to the ſame part of the duodenum into which the

the biliary duct opens; where, changing its courſe downward, it enters through the ſinus that lies betwixt the coats of the inteſtine, internally ſmooth; and here, receiving the ductus choledochus, it opens together with that into a certain fold of the ſame duodenum, deſcending towards its loweſt part. But not unfrequently it opens diſtinct, both in its duct and orifice, from that of the biliary duct; and ſometimes it is inſerted by two ducts, of which the lower one only is diſtinct and leſs; but in man, and moſt other animals, it always opens near the duct of the bile. In its mouth there is no bile.

688. The quantity of juice ſecreted by this gland is uncertain: but it muſt be very conſiderable, if we compare the bulk or weight of it with that of the ſalival glands; than which it is three times larger, and ſeated in a warmer place. It is expelled by the force of the circulating blood, with an alternate preſſure from the incumbent and ſurrounding viſcera; as the liver, ſtomach, ſpleen, meſenteric and ſplenic arteries, with the aorta. The great uſefulneſs of this gland may appear from its being found not only in man, but almoſt in all animals: nor is its uſe the leſs from that experiment which ſhows a great part of it may be cut out from a robuſt animal without occaſioning death; becauſe, in the experiment, a part of the pancreas muſt be left with the duodenum. Its effervescence with the bile ariſes from the effect of a ligature, and air mixed with the inteſtinal humour.

688. The pancreatic juice ſeems principally of uſe to dilute the viſcid cyſtic juice, to mitigate its acrimony, and mix it with the food. Hence it is poured into a place remote from the cyſtic duct as often as there is no cyſtis. Like the reſt of the inteſtinal humours, this juice dilutes the maſs of aliments, reſolves them, and does every other office of the ſaliva.

CHAP. XXIV.

Of the LIVER, GALL-BLADDER, *and* BILE.

689. THE *liver*, being the largeſt of all the viſcera, fills up a very large part of the abdomen in its upper chamber, above the meſocolon; and is yet ſtill larger in proportion in the fetus. Above, behind, and to the right ſide, it is covered by the ſuperincumbent diaphragm, from which it receives the peritonæum for a covering, under the denomination of ligaments, chiefly in three places: for on the convex part of the liver, from the paſſage of the vena cava to the tranſverſe furrow of the liver, the peritonæum deſcends double, growing broader in the forepart, under the name of *ligamentum ſuſpenſorium*, which divides the greater right lobe from the leſſer left lobe of the liver; and then parting from its duplication, it expands into the proper coat of this viſcus (623.), which is white, ſimple, and thin, like the external coat of the ſtomach; and under this is ſpread the cellular ſubſtance, by which it is intimately conjoined with the fleſh of the liver. To the lower margin of this, joins the umbilical vein; which, in an adult, being dried up, leaves only a ſmall cord, ſurrounded with much fat. In the extremity of the left lobe, and on the convex part, not unfrequently at its edge, a membrane goes to the liver from the diaphragm; which in children, and other young ſubjects, is frequently to the left ſide of the œſophagus, but in adults to the right ſide; yet always conjoined both to the gula and to the ſpleen, whenever the liver or the left ligament is very large. The right ligament ties the diaphragm in its hinder part to the thickeſt part of the right lobe. Beſides, but without any apparent length, the membrane of the right lobe of the liver is often conjoined by the cellular ſubſtance with the diaphragm; more eſpecially in old ſubjects, for in the fetus it is eaſily

eafily feparated; and then it continues its courfe betwixt the fufpenfory and left ligament, joined as before with the peritonæum, fo as to refemble a ligament. But alfo from the right kidney, the peritonæum going off to the liver, makes a reduplication like a ligament, and conjoins together the lefs omentum with the continued loofe productions of the mefocolon (663.) with the liver, ftomach, and duodenum; and likewife the fame mefocolon to the pancreas. Thus the liver is fufpended in the body, with a confiderable degree of firmnefs; yet fo as to be allowed a confiderable liberty to move and be varioufly agitated, raifed, and depreffed, by the actions of the diaphragm. The fame ligaments form a common membrane, which covers the liver as well as other vifcera.

690. Moreover, the inner concave face of the right liver lies with its forepart before the colon; and in its back part correfponds to the right kidney and renal capfule, to which it is connected by the cellular fubftance. The middle finus lies near the duodenum, which touches the gall-bladder; and alfo lies contiguous with that part that conducts the great blood-veffels. The left lobe extends largely over the ftomach; and frequently, efpecially in younger fubjects, goes beyond the œfophagus into the left hypochondrium. The lobule, in the mean time, adapts itfelf to the leffer curve of the ftomach. But, moreover, the pancreas is covered by the liver, and the right renal capfule is tied to the part of the liver fartheft to the right fide by much cellular texture.

691. The figure of the liver is difficult to defcribe. It begins in the cavity of the right hypochondrium, by a very thick folid protuberance, convex towards the diaphragm, and hollow towards the colon and kidney; having a protuberant line dividing the faces of thefe fmall hollows, which is continued to the longer appendix of the lobule. After this, the liver grows flenderer and thinner, and is at laft terminated or extenuated into a tip, almoft triangular; which, paffing into the

the left hypochondrium, goes before the œſophagus, in young ſubjects, as far as the ſpleen; but in adults, it is often ſhorter, and ends at the œſophagus. The edge, in which the convex part of the liver meets with the concave one, is wholly in the fore and lower part. The whole obtuſe margin lies backward. The upper and back part of the liver is every where convex; ſuſtains the diaphragm; and in a large part, which is ſomewhat flatter, towards the left ſide, it is placed under the heart: but the lower ſurface, being variouſly figured, reſts itſelf upon the duodenum, colon, ſtomach, pancreas, and right renal capſule. For there are ſeveral little furrows which divide the ſurface into different regions, and which did not eſcape the notice of the ancients.

692. The principal of theſe furrows is extended tranſverſely, from the right ſide to the left, and divides a third part of the liver, beginning ſlender in the right lobe, and growing broader towards the left. Before this tranſverſe ſulcus, there is an excavation in the right lobe for the gall-bladder, and then the anonymous convex lobule; after which comes the foſſa of the umbilical vein, extending tranſverſely backward, often covered with a proceſs or bridge that joins the anonymous to the left lobe; but behind the great ſulcus, firſt towards the right ſide, there is a ſlender tranſverſe eminence growing broader to the right, and moderately hollow, by which the great blood-veſſels are conducted into the liver: and this little valley was by the ancients denominated the *portæ* or gates of the liver. This joins the lobule, which I ſhall deſcribe, with the right lobe. Then the poſterior lobule, ſhaped like a nipple, obtuſely conical, projects into the leſs curvature of the ſtomach. The thick root of this and the former excavated eminence, begins from the convex part of the liver, at the diaphragm; and from thence, on the right ſide, is impreſſed with an oblique furrow, inclined to the right ſide, for the paſſage of the trunk of the vena cava, deſcending from the heart to the lumbal vertebræ; and is

frequently ſurrounded by a great part of the fleſh of the liver, like a bridge, or even ſo as to complete the circle, and form a tube. The left end of the lobule is terminated by another foſſa almoſt ſtraight backwards, but inclined to the left; which, taking its origin from the extremity of the tranſverſe one, terminates at the paſſage of the vena cava through the diaphragm. In this ſinus was lodged the ductus venoſus in the fetus, of which there are ſome remains to be perceived alſo in the adult. All that lies beyond this is the left lobe, which is ſingle, equally concave below, ſo that it may lie upon the ſtomach, and is extenuated to a thin edge.

693. This ſo large viſcus is proportionably ſupplied with veſſels, and of various kinds. The artery, which is indeed conſiderable, being the greater right portion of the cæliac, emerges from the trunk forward, and to the right, going tranſverſely before the vena portarum; and after giving off a ſmall coronary with the pancreatic and duodenal artery, the laſt of which is pretty large, it goes on and enters the liver, commonly by two branches; of which the left is betwixt the umbilical foſſa, the venal duct, poſterior lobule, with the left and the anonymous lobe, alſo the ſuſpenſory ligament; and this branch inoſculates with the phrenic and epigaſtric arteries. The right enters the liver lower, covered by the biliary ducts; and having reached the right with the anonymous lobe, there ſends off, in one ſmall trunk, the cyſtic artery, which ſoon after divides into two, and is ſpread both under and upon the gall-bladder, covered by the common coat of the liver, and ſupplies not only the gall-bladder and biliary ducts with its branches, but likewiſe ſome part of the liver itſelf. From the left branch, or ſometimes from the trunk of this, ariſes a ſuperficial artery to the biliary ducts, anonymous lobe, and glandules of the portæ. Beſides the cæliac artery, there is frequently a large right branch produced from the meſenterica major, creeping behind the pancreas; and this ſerves inſtead of the eighth branch of the hepatic

patic artery from the cæliac. But, likewiſe, the greater coronary, which is the firſt twig of the cæliac, always gives ſome ramifications to the left lobe, and to the foſſa of the ductus venoſus; which laſt branch is often very conſiderable. The leſſer arteries are thoſe ſent to the liver from the phrenic, mammaries, renal and capſulary arteries. They communicate alſo with the epigaſtrics.

694. In the fetus, the umbilical vein brings much blood to the liver, at which time the vein ſtretching to the portæ is but ſmall. It ſends forth branches while it ſtretches backwards through its foſſa; theſe branches are numerous, and very large; ſo that one of them equals the vena portarum in bigneſs, in that place where it is dilated into a tumour, which unites with the left branch of the vena portarum. But it ſends one branch through the poſterior part of the horizontal foſſa into the vena cava, or ſome of its hepatic branches: this is called the *ductus venoſus*. In an adult perſon, indeed, this duct is filled up; and the vena portarum, which now grows larger, fills the hepatic branches.

695. The vena portarum receives all the blood of the ſtomach (629.), of the inteſtines and meſentery (631.), of the ſpleen (677.), omentum (669.), and, laſtly, of the pancreas, at firſt into two trunks, the tranſverſe ſplenic and aſcending meſenteric; then into one, which is continued with the meſenterics. This is large, compoſed of ſtrong membranes, firſt a little bent behind the duodenum, where it receives the veins from its right ſide, together with the leſſer coronary; whence going higher to the right ſide, it again divides into two large trunks in the ſinus of the lobule of the liver (692.), and immediately after is again divided into two large trunks. Of theſe two, the right, being ſhorter, larger, and bifurcated, having received the cyſtic vein, goes to its own lobe. The left runs on through the remaining part of the tranſverſe furrow of the liver; and, after giving veins to the lobule, with the anonymous and left lobe, it is incurvated and enters the umbilical foſſa; from whence, about the middle, it immerges and ramifies

through the liver. There are ſome inſtances in which the venous branch of the poſterior lobule has been ſent diſtinct from the vena portarum.

696. The *vena portarum* is on every ſide ſurrounded with a good deal of cellular ſubſtance, derived to it from the meſentery and ſpleen, denſe, ſhort, and adding ſtrength to the membranes; thoſe with which it is furniſhed being harder than the aorta itſelf. Intermixed with this cellular ſubſtance, are alſo many of the ſmaller veſſels and hepatic nerves, which all come together under the denomination of a *capſula*, which is nothing more than the cellular ſubſtance, and never has truly a ſingle fleſhy fibre. By this the vena portarum is conducted to the liver, and firmly ſuſtained; inſomuch, that the branches, being cut, maintain the round lights of their ſections. But each branch of this veſſel is divided into many others, again divided and ſubdivided, after the manner of arteries, till they at length produce the ſmalleſt capillaries. In this courſe, every branch of the vena portarum is accompanied with a ſocial branch of the hepatic artery, creeping upon the ſurface of the vein, and the contiguous hepatic ducts, almoſt in the ſame manner as the bronchial arteries uſually creep along the ramifications of the windpipe in the lungs; while, in the mean time, both the artery and the vein are connected to the branches of the biliary ducts by a thin cellular ſubſtance like a ſpider's web. Some go out of the liver, being divided to the ligaments, and inoſculating with the ſurrounding veins. And the ſum of the branches in the vena portarum is always greater than the trunk; whence the lights of all the branches together greatly exceed that of the trunk (37.): from whence follows a great friction or reſiſtance (180 and 162.), after the ſame manner as we obſerve in the arteries.

697. But, ſince the blood is in this manner conveyed through the liver to the branches of the vena portarum, together with the hepatic artery, it muſt of courſe be conveyed back again by ſome other veins: and, therefore,

fore, the extreme branches of the vena portarum and hepatic artery inoſculate ultimately into other veins, which are *branches of the cava;* which ariſing from the whole circumference of the liver, run together towards the poſterior gibbous part of the liver into branches and trunks, which at laſt go off into ten or more large veſſels. The leſſer of theſe trunks, and greater number of them, paſs out through the poſterior lobule of the liver, and go to the cava through the ſulcus, that lies on the right ſide of the lobule, often completed into a circle by a ſort of bridge or production of the liver; from whence they aſcend together through the diaphragm towards the left ſide. Two or three trunks, much larger than the former, are inſerted into the ſame cava, cloſe to the diaphragm, whoſe veins they often take in by the way. The branches of the vena cava are, in the adult, generally fewer and leſs than thoſe of the vena portarum; which is an argument that the blood moves quicker, becauſe of the leſs friction (170.), and of the very collection of the blood into a leſs light or capacity, by which it is always accelerated when there is a ſufficient compreſſing force (170.) As to any valves at the openings of theſe branches into the cava, I know not of any which deſerve to be regarded. The trunk of the vena cava, paſſing through a foramen of the diaphragm, obtuſely quadrangular, ſurrounded and terminated by mere tendons (262.), is thereby rendered not eaſily changeable: and having ſurmounted this opening of the diaphragm, it then immediately expands into the right auricle. The ſmaller veins of the liver creeping about its ſurface, are ſent forth from the phrenics, renals, and azygos; or at leaſt there is certainly a communication betwixt theſe and the hepatic veins coming from the portæ.

698. That the blood comes from all parts (695.) by the vena portarum to the portæ, is proved by a ligature, by which any vein betwixt theſe parts and the ligature ſwells; but the porta itſelf, above the ligature, grows flaccid and empty. But that it afterwards goes through

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the liver to the cava, appears by anatomical injections, which ſhow open and free anaſtomoſes or communications betwixt the vena portarum and the cava, together with the common nature of the veins going to the cava. Again, the difficult diſtribution or paſſage through the vena portarum, like to that of an artery, together with its remoteneſs from the heart, and the oily or ſluggiſh nature of the blood itſelf, occaſion it to ſtagnate, accumulate, and form ſcirrhous ſwellings in no part oftener than the liver. But this danger is diminiſhed by the motion of the adjacent muſcles, and by the reſpiration; as it is increaſed by inactivity, with ſour and viſcid aliments. But, hitherto, we have been ſpeaking of the adult liver, in which both the umbilical vein and the ductus venoſus are empty and cloſed up, although they continue to cohere with the left branch of the vena portarum.

699. The *nerves* of the liver are rather numerous than large; hence, when wounded or inflamed, it is capable of no very great pain. They have a twofold origin. Moſt of them ariſe from the large gangliform plexus, made by the ſplenic branch of the intercoſtal nerve, with the addition of a branch from the poſterior plexus of the eighth pair; they accompany the hepatic artery, and, playing round its trunk, are diſtributed with that and the portal branches throughout the liver. Another faſciculus of nerves uſually enters with the ductus venoſus, and ariſes from the poſterior plexus of the eighth pair, but ſometimes from the great plexus.

700. The *lymphatic veſſels* of the liver are numerous, being conſtantly and eaſily to be ſeen about the portæ. They ariſe from the whole concave ſurface of the liver and gall-bladder, and run together into a plexus, ſurrounding the vena portarum, going afterwards to the ſmall conglobate glandules, ſeated before and behind the ſaid vein; from whence they meet together in one large trunk, which is one of the roots of the thoracic duct. Upon the convex part of the liver

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are described other lymphatics, whose insertion is not well known; but it is hardly probable that they enter the cava, nor have I been able to find that they lead to the cistern of the chyle.

701. The interior fabric of the liver is more obscure. Through the whole substance of the liver go bundles of biliary vessels, of branches of the vena portarum, and of the hepatic artery. Each vessel has both its proper cellular texture surrounding it, and similar ligaments, by which it is tied to its fellow-vessels; and, lastly, the whole bundle has its cellular texture placed round it. The branches of the vena cava lie on the outside of the rest, being less accurately received into the same bundle. Lastly, the ultimate small branches of the vena portarum, cava, and hepatic artery, together with the bilious ducts, which we shall soon describe, are united together by means of the cellular substance (696.), into a sort of mulberry-like bunches, of an hexagonal shape, surrounded with a lax cellular texture. In these bunches, likewise, there are mutual anastomoses betwixt the portal branches and hepatic artery, with the roots of the vena cava on one side, and the first origins of the pori biliarii of the liver on the other side; which last demonstrate their inosculations by anatomical injections, for liquors injected by the vena portarum return again through the porus choledochus.

702. Many eminent anatomists have taught that the fore-mentioned bunches are hollow, having arteries and veins spread upon their external surface, and deposite the bile into their cavity, after it has been secreted from the branches of the vena portarum. For this they allege arguments taken from the comparative anatomy of brutes, whose liver is made up of more round and definite bunches; and from those diseases which demonstrate cells and round tubercles, filled with lymph, chalk, and various kinds of concreted matter. To this they might have added the thick sluggish nature of the bile itself, by which it is related to mucus, and the analogy of the follicles of the gall-bladder.

703. But greater acuracy in anatomy will not allow any follicles into which the ſmall ſecretory veſſels open; for ſuch would intercept the courſe of anatomical injections, and give us the appearance of knots intermediate, betwixt the ſecretory veſſels and the biliary pores, which we have never yet been able to ſee: for the wax flows immediately, without any interruption or effuſion, into a cavity in a continued thread from the vena portarum into the biliary ducts. But, again, a follicular or glandular fabric is not allowable in the liver, from the great length of the biliary ducts. For all follicles depoſite their contents into ſome ſpace immediately adjacent; and are unfit to convey their ſecerned fluid to any length of courſe, as they deſtroy ſo great a part of the velocity received from the arteries. Laſtly, the very common preſſure which we muſt ſuppoſe to be on theſe bunches of kernels would ſo cruſh them, that no aſſiſtance could from thence be brought to promote the motion of the excretory ducts. Concretions and hydatids are formed in the cellular ſubſtance; and, laſtly, the bile, when firſt ſecreted, is ſufficiently fluid.

704. Again, we are perſuaded that no bile is ſeparated from the hepatic artery, becauſe the peculiar ſtructure of the vena portarum would be uſeleſs if it ſecreted nothing. Its office in ſecretion appears plainly by the continuations of its branches with the biliary ducts, in a manner more evident than that of the artery: but it appears by experiments, alſo, that the biliary ſecretion continues to be carried on after the hepatic artery is tied; add to this the largeneſs of the biliary ducts, in proportion to ſo ſmall an artery, with the peculiar nature of the blood collected in the vena portarum, ſo extremely well fitted for the formation of the bile. For we have already ſeen that it contains oil, which abounds more in the bile than in any other humour of the body; for it takes in the ſaponaceous water of the ſtomach by the abſorbing veins, together with the ſubfetid alkaleſcent vapours of the abdomen, which tranſpire through the whole ſurface of the inteſtines, ſtomach,

mach, omentum, liver, ſpleen, and meſentery, which are abſorbed again by the veins, as we know by inconteſtable experiments of anatomy; and, finally, the alkaleſcent ſemiputrid acrimonious humidity from the fæces while they continue to thicken in the large inteſtines, which is taken up by the internal hæmorrhoidal veins, from whence that bitterneſs, alkaleſcent and putreſcent diſpoſition of the bile is derived. But in the blood of the hepatic artery, we can find nothing peculiarly fit for the ſecretion of bile, or analagous to its nature.

705. Since, therefore, the vena portarum conveys the blood ready charged with biliary matter, fit to be ſecreted in the leaſt acini (704.), and from thence there is an open free paſſage, without any intermediate follicles, from the ultimate branches of the vena portarum into the beginning roots of the biliary ducts, and that the humours driven into the vena portarum may eaſily chuſe this paſſage, the bile will be expelled from thence by the force of the blood urging behind, as well as by the auxiliary force of the diaphragm preſſing the liver againſt the reſt of the viſcera in the very full abdomen (689.), and again, contracted in exſpiration, it will be forced into the larger branches, and laſtly into two trunks of the larger biliary duct of the liver; which trunks meet together in one upon the vena portarum, in the tranſverſe foſſa of the liver, near the anonymous lobule.

706. The fabric of this duct is made up by a ſtrong nervous membrane like that of the inteſtines, over which is ſpread an external and internal cellular membrane, and is internally lined with a looſe villous tunic, elegantly reticulated, but aſperated with many ſmall pores and ſinuſes, and continued with that of the inteſtine itſelf. But there is here no muſcular fabric apparent. From experiments it appears to be endowed with a moderate degree of irritability. That it is vaſtly dilatable, is ſhewn from diſeaſes. The ſame ſeem alſo to ſhow that this duct is endowed with a very ſharp ſenſation.

707. The hepatic duct, thus formed, goes on upon

the vena portarum, more to the right than the artery, towards the pancreas; and then defcending obliquely, covered by fome part of that gland, it goes to the lower part of the fecond flexure of the duodenum, and is inferted backward about fix inches from the pylorus, through an oblique oblong finus made by the pancreatic duct, into which it opens by a narrow orifice. The faid finus runs a great way through the fecond cellular coat of the duodenum obliquely downward; then it perforates the nervous coat, and goes on again obliquely betwixt it and the villous tunic; and, laftly, it opens into a protuberant long wrinkle of the duodenum. Thus there is almoft the length of an inch taken up betwixt the firft infertion and the egrefs of this duct through the coats of the duodenum, by a finus which furrounds and receives the ductus choledochus, in fuch a manner, that when the coats of this inteftine are diftended by flatus, or clofely contracted by a more violent periftaltic motion, the opening of the duct muft be confequently compreffed or fhut; but when the duodenum is relaxed and moderately empty, the bile then has a free exit. Any regurgitation from the duodenum is hindered by this obliquity and wrinkling of the duct, eafily preffed together or clofed and joined with a quick fucceffion of frefh bile defcending perpendicularly from the liver. Nor does wind inflated into the inteftine find any paffage into the duct.

708. But, in the portæ themfelves, this common duct receives another lefs canal of the fame kind, which lies for a good way parallel with itfelf from the gall-bladder, making its infertion in a very acute angle; and this, which is called the cyftic duct, from its origin, is fometimes firft increafed by another fmall duct from the hepatic before its common infertion. This duct is formed by the gall-bladder as a peculiar receptacle for the bile given to moft animals; but is abfent in fome, efpecially thofe of a fwifter foot, and perhaps only in fuch of thefe as are herbivorous: it is placed in an excavation of the right lobe of the liver (692.), to the right fide

ſide of the anonymous lobule, in ſuch a manner, that in infants or children it lies wholly within the edge of the liver, but in adults projects conſiderably beyond, lying upon the inteſtinum colon. Its ſituation is almoſt tranſverſe from the fore to the back parts; its neck aſcends a little upwards.

709. The figure of the gall-bladder is variable, but in general like that of a pear, terminated in its forepart by an obtuſe hemiſpherical end, which is impervious, gradually diminiſhing backward; the neck or tip of this truncated cone being inflected upwards againſt itſelf once or twice, and tied together by the cellular ſubſtance belonging to it, makes then another ſmall flexure upward, and begins the cyſtic duct; which from thence goes on towards the left ſide to the hepatic duct. Within this duct there are many protuberant wrinkles, formed by the numerous cellular bridles which tie them together; and theſe wrinkles, conjunctly in the dry gall-bladder, repreſent a kind of ſpiral valve; but being altogether ſoft and alternate in a living perſon, they do not ſtop, only leſſen the courſe of the bile, as we are aſſured from experiments, by preſſing the gall-bladder, and by inflations. Beſides, it is reticulated like the gall-bladder itſelf.

710. The outermoſt coat of the gall-bladder covers only its lower ſide, being the common covering of the liver itſelf ſtretched over the gall-bladder, and confining it to the liver within its proper ſinus. The ſecond coat is the cellular ſubſtance, and of a looſe texture. The third coat has ſometimes ſplendent fibres, chiefly longitudinal; but ſome obliquely interſecting each other in various directions. At other times it has none at all; ſo that we may doubt of its muſcular nature, eſpecially as the irritability of the gall-bladder is ſlow and obſcure. Next to theſe come the nervous coat, then the ſecond cellular, and laſt the villous tunic; which are all found here as in the inteſtines, except that the laſt, in the gall-bladder, as well as in the biliary ducts, is reticulated and full of cells. Within the gall-

bladder, but more especially about its neck and middle part, we observe muciferous pores, capable of receiving a horse-hair; and besides these, the exhaling arteries discharge some quantity of a watery humour into the cavity of the gall-bladder, as we observe in other cavities.

711. All animals, between their gall-bladder and liver, or between the ducts coming from both, have, besides some peculiar openings in the gall-bladder, into which some ducts originating from the liver, or the hepatic biliary duct, discharge their contents. In mankind these ducts have not been shown by any certain experiment, and the gall-bladder is easily loosed from the liver, without a drop of bile distilling either from it or from the liver. There is also a thin water in the bladder as often as the cystic duct is obstructed.

711. The bile flows both out of the bladder and liver, according to its nature, as long as there is no impediment in its way; so that both ducts swell when that passage is obstructed, and the cystic lies in a straight line with the choledochus. Nor is it credible that all the bile should be diverted into the gall-bladder before it flows into the duodenum. There is not a perpetual obstacle which hinders the efflux, and peculiarly resists the hepatic bile, and admits the cystic; the passage into the ductus choledochus is larger and straighter, the ductus cysticus much less than the hepatic, nor is that duct so well formed for receiving all the bile; the choledochus being much larger than the cystic duct, cannot therefore be made only for the reception of its bile. There are many animals in which the hepatic duct discharges its contents into the intestine without any communication with the cystic. In living animals, even when the cystic duct is free, the bill appears to descend into the duodenum with a perpetual current. That the quantity is very considerable, appears from the magnitude of the secretory organ, and the excretory duct, so many times larger than the salival ones; from diseases, in which four ounces of the cystic bile only

only have flowed out duly through an ulcer of the ſide. But the hepatic bile goes into the bladder, as often as there is any obſtruction in the duodenal ſinus, from flatus or any other cauſe compreſſing the exit of the ductus choledochus. Accordingly, we find it extremely full, whenever the common biliary duct is obſtructed or compreſſed by ſome ſcirrhous tumour, whence the gall-bladder is ſometimes enlarged beyond all belief; and if the cyſtic duct be tied, it ſwells betwixt the ligature and hepatic duct; and in living animals, the hepatic bile viſibly diſtils into the wounded gall-bladder, even to the naked eye. The retrograde angle, or direction of this duct, is not repugnant to ſuch a courſe of the bile; for a very ſlight preſſure urges it from the liver into the gall-bladder; and even wind may be eaſily drove the ſome way, more eſpecially if the duodenum be firſt inflated. Nor does there ſeem to be any ſort of bile ſeparated by the gall-bladder itſelf. Whenever the cyſtic duct is obſtructed by a ſmall ſtone, or a ligature made upon it, we find nothing ſeparated into the gall-bladder more than the exhaling moiſture, and a ſmall quantity of inſipid mucus ſecreted from the follicles (710). In many animals, we meet with no appearance of any gall-bladder, when at the ſame time there is a plentiful flux of ſtrong well prepared and ſalutary bile diſcharged into their inteſtines. Again, it does not ſeem probable, that the cyſtic branch of the vena portarum can ſeparate bile into the gall-bladder; for that vein in itſelf is a mere reconductory veſſel: nor can any be ſeparated from the hepatic artery; for it muſt be vaſtly beyond probability, that ſuch a ſtrong bile as that of the gall-bladder ſhould be ſeparated from a milder blood than the more ſoft hepatic bile prepared from the blood which is moſt fit for that purpoſe (704).

712. Laſtly, the bile flows alſo from the gall-bladder to the liver, and at length returns into the blood when its paſſage into the inteſtines is totally intercepted, ſometimes alſo from a cauſe latent in the nerves. This

paſſage

paſſage is pernicious, and produces the jaundice; which, therefore, ſtones thrown out of the inteſtines cure, by reſtoring its free courſe into the duodenum.

713. Therefore a portion of the hepatic bile being received into the gall-bladder, there ſtagnates, only a little ſhook by the reſpiration; and there, by degrees, exhales its thinner parts, which, as we ſee, filtrate through and largely penetrate the adjacent membranes. The remainder, as being a fluid of an oily ſubalkaline nature, digeſting in a warm place, grows ſharp, rancid, more thick, bitter, and of a higher colour: for this is all the difference betwixt the cyſtic and hepatic bile; which laſt we find weaker, leſs bitter, lighter coloured, and of a thinner conſiſtence, while it remains within its proper hepatic ducts. That this difference betwixt them proceeds only from ſtagnation, appears from ſuch animals as have only a larger porus hepaticus, inſtead of a gall-bladder; for here we find the bile, which ſtagnates in the larger hepatic pore, is conſiderably more bitter than that in the ſmaller pores of the liver; as for example, in the elephant. But the gall-bladder gives this particular advantage, that it receives the bile when the ſtomach, being empty, has no call for it, that afterwards it may be able to return it in greater plenty, when we principally want it for the digeſtion of the aliments now flowing in great quantity into the duodenum. This flow of the bile is quicker in proportion through the cyſtic duct, as the ſection of that duct is leſs than the ſection of the gall-bladder.

714. The gall-bladder, indeed, hardly touches the ſtomach, but the beginning of the deſcending duodenum. But when the ſtomach is extremely diſtended, and in a very full abdomen, it makes a conſiderable preſſure both upon the liver and duodenum; by which the gall-bladder is urged, and its bile expreſſed. Thus the bile flows through a free paſſage, from the gall-bladder into the common duct, and the duodenum: and this it does more eaſily in perſons lying on their back; in which poſture the gall-bladder is inverted,

with its bottom upward. Hence it is that the gall-bladder becomes ſo full and turgid after faſting. The expulſive force of the bile is but little more than that of the preſſure received from the ſtomach and diaphragm; for as to any muſcular force reſiding in the fibres of the proper membrane, which may be thought to contract the gall-bladder, it muſt be very weak and inconſiderable.

715. The hepatic bile is always bitter, but the cyſtic is more ſo; always viſcid; of a full yellow colour, with a tincture of green; miſcible, by triture, either with water, oil, or vinous ſpirits; coagulable by mineral acid liquors; diſſoluble by alkalies, eſpecially the volatile kinds; and extremely well adapted to diſſolve oily, reſinous, or gummy ſubſtances; quickly putrefying, and by putrefaction ſpontaneouſly degenerating to a muſk-like odour. Its chemical analyſis, and experiments of mixture with various ſubſtances, demonſtrate, that it contains a large portion of water, and a conſiderable quantity of inflammable oil, which, in ſtones of a gall-bladder, appears very evidently. The bile, therefore, is a natural ſoap; but of that ſort which is made from a volatile ſaline lixivium, mixed with oil, and has its water along with it. This, therefore, being intermixed with the aliment, reduced to a pulp, and ſlowly expreſſed from the ſtomach by the periſtaltic force of the duodenum and preſſure of the abdominal muſcles, incorporates them all together; and the acid or aceſcent qualities of the food are in ſome meaſure thus ſubdued, the curd of milk is again diſſolved by it into a liquid, and the whole maſs of aliment inclined more to a putrid alkaleſcent diſpoſition: it diſſolves the oily matters, ſo that they may freely incorporate with the watery parts, and make up an uniform maſs of chyle to enter the lacteals; the ſurrounding mucus in the inteſtines is hereby abſterged and attenuated, and their periſtaltic motion is excited by its acrimony; all which offices are confirmed, by obſerving the contrary effects from a want or defect of the bile. Nor is the hepatic

bile

bile ſufficient to excite the neceſſary motion of the inteſtines, if the cyſtic is wanting; both which are of ſo much uſe and importance to the animal, that we find, by experiment, even the ſtrongeſt will periſh in a few days, if the flux of bile to the inteſtines be intercepted, by wounding the gall-bladder.

716. Thus it ſlowly deſcends along with the alimentary maſs; and having ſpent its force, or changed its bitterneſs by putrefaction, moſt of it is afterwards excluded together with the fæces; but probably ſome of the more ſubtle, watery, and leſs bitter parts, are again taken up by the vena portarum. It returns the leſs into the ſtomach, becauſe of the aſcent of the duodenum, which goes under the ſtomach, with the reſiſtance it meets with from the valvula pylori, and the advancement of the new chyle which the ſtomach adds to the former: in man, however, it frequently enters; and always in birds. The bile is of a ſweet ſoft nature in the fetus; for in them the fæces are not very fetid to ſupply putrid alkaline vapours to the liver, nor are there any oily or fat ſubſtances abſorbed from the inteſtines. As the bile is a viſcid fluid, and thickens by inactivity of body in fat animals, and in us from the ſame cauſes, eſpecially when the blood moves languid from grief; ſo it eaſily coagulates into an hard, ſomewhat reſinous, and often ſtony ſubſtance, inſomuch that ſtones of the gall are much more frequent than thoſe of the urinary bladder, as we are taught by our own experiments. Its uſe is manifeſt, as, being triturated with the aliments, it diſſolves oil, reſiſts acidity, and thus ſtimulates the inteſtines to contraction.

717. The uſe of the liver, beſides ſecreting the bile, is manifeſt in the fetus. It ſeems to tranſmit the blood brought back from the placenta, and to break its force. Even in an adult perſon it has the ſame uſe though leſs manifeſt, namely, to retard the return of the blood coming back from the viſcera appointed for preparing the chyle.

CHAP.

CHAP. XXV.

Of the Small INTESTINES.

718. BY the *ſmall inteſtines*, anatomiſts underſtand one continued almoſt cylindrical tube, but whoſe tranſverſe ſection is nearly oval, the obtuſe end being towards the unconnected ſide of the inteſtine. This tube is continued from the end of the ſtomach, the right orifice of which it embraces (625.); and, being produced thro' a long tract, ends by an expanſion into a a much larger inteſtine. Anatomiſts have uſually reckoned three ſmall inteſtines, tho' nature has formed but one. However, the duodenum has generally pretty certain bounds, terminating with its end in that part of the abdomen which is above the tranſverſe meſocolon (659.) But that ſmall inteſtine which lies below this meſocolon, commonly called the *jejunum*, has no certain mark or boundary to ſeparate it from the lower portion, which is commonly called the *ilium*: although the former, abounding more with valves and blood-veſſels, has, in general, a more florid appearance, and is furniſhed with longer villi internally; and the ilium again, having fewer of thoſe vaſcular ramifications, like little trees, abounds more with a ſort of minute glandules: however, theſe differences inſenſibly diſappear one in another, without affording any certain limits betwixt the two inteſtines; but is great in the extreme terminations, but obſcure in the neighbouring parts.

719. The *duodenum* ſeems to be denominated from its length. It is larger, and more lax or open, than the other ſmall inteſtines, more eſpecially in its firſt flexures; which is partly owing to its not being circumſcribed in ſome places with any external membrane, and in other places only for a ſmall compaſs. It is florid and tender, having its fleſhy fibres ſometimes of a conſiderable thickneſs. Its origination begins round the ring-

like valve at the mouth of the pylorus; from whence being undulated or inflected, but generally in a tranſverſe courſe, to the right downward and backward in an empty ſtomach, it goes under the gall-bladder, to the neck of which it is contiguous (714.) From thence it deſcends obliquely and backwards to the right ſide as far as the lower plate of the meſocolon, where it is perforated by the biliary duct, and in that courſe is intercepted betwixt the upper and lower plate of the meſocolon. From thence at laſt it proceeds tranſverſely, but a little aſcending behind the pancreas and large meſenteric veſſels, and goes on to the left ſide along with the left renal vein, where, going out from the duplicature of the meſocolon, and bending round before and to the right of the ſaid veſſels, it paſſes through a peculiar foramen, in which the meſentery and left part of the tranſverſe meſocolon adhere to the inteſtine itſelf; from thence it deſcends forward, towards the lower part of the abdomen, into which it advances under the denomination of the *jejunum*. The largeneſs of this inteſtine, with its aſcent from the inſertion of the biliary duct, joined with the conſequent fold about the root of the meſentery, cauſe a remora of its contents, by which the bile, pancreatic juice, and alimentary pulp, are here firſt intimately blended together.

720. The reſt of the ſmall inteſtine, having no certain ſeat or diviſion, is continued by innumerable and uncertain convolutions, not to be deſcribed, ſo as to fill out the lower part of the abdomen and pelvis ſurrounded by the colon on each ſide, and lies between the bladder and uterus below.

721. The fabric of the ſmall inteſtine is almoſt the ſame with that of the ſtomach and œſophagus. Its external coat, excepting part of the duodenum, is received from the peritonæum or meſentery, applied on each ſide to the obtuſe end of the oval inteſtine, and ſeparated by the intervening cellular ſubſtance, which is often repleniſhed with fat, but more cloſely embraces or adheres to the muſcular fibres in the unconnected

ſide

ſide of the inteſtine; where the outer and muſcular coats ſtrictly cohere, without ſhewing any remarkable difference from what we have obſerved of them in the ſtomach. By this external membrane, and by the meſentery (661.), the inteſtines are ſupported with a conſiderable degree of firmneſs, at the ſame time that they are allowed every way a free liberty for motion.

722. But the fabric of the *muſcular coat* differs from that of the ſtomach, in the figure of its fibres. The largeſt and moſt conſiderable body of theſe fibres is circular, cloathing the tube on each ſide, reſembling each other both in their parallel diſpoſition and appearance, which is that of imperfect arches or ſegments of circles, cemented one to another, paler than other muſcular fibres, and yet remarkably contractile. The longitudinal fibres are, in the ſmall inteſtines, much fewer in number, ſcattered round their whole extent, interſperſed with the former, and are more eſpecially ſpread upon the looſe or unconnected ſide of the inteſtine.

723. Within the muſcular coat, is ſeated the *ſecond cellular*, of a larger or looſer extent here, as it was in the ſtomach; and this being ſpread on all ſides round the nervous coat, which it includes, is, in us, ſeldom repleniſhed with fat. But the *nervous* coat, being like that of the ſtomach, ſerves as an internal foundation or ſupport to the whole inteſtinal tube; being compoſed chiefly of compacted fibres, which, by inflation, may be parted one from another, ſo as to reſemble a web-like or cellular ſubſtance. Next to this, follows the *third cellular* coat, which is almoſt like the ſecond; and then the innermoſt or *villous* coat, which differs, in ſeveral reſpects, from that which we deſcribed in the ſtomach: for firſt it is folded on all ſides into wrinkles that are ſemicircular, the extremities of which correſpond one to another oppoſitely, but uncertain in their proportions; into which wrinkles the nervous coat ſlightly enters, whilſt the reſt of the intermediate ſpace betwixt the folds of the villous tunic is filled up by the

third cellular ſtratum. Theſe *plicæ* or folds of the inteſtine begin within one inch of the pylorus, and are moſt numerous in the firſt and middle part of the inteſtines, but gradually grow fewer in number downward. Here each ſmall twig of the artery, which is ſpread in the cellular ſubſtance, upon the convexity of the inteſtine on one ſide, is anſwered by another twig, diſpoſed in the ſame manner, on the oppoſite ſide. The plicæ are, at firſt, confuſed in the duodenum, and afterwards become more conſpicuous as the inteſtine advances; but the appearance of acute imperfect circles or valves is given to them by anatomical preparation, in which their natural ſtate is altered. They are indeed ſoft, and eaſily inverted, ſo as to give way, in any direction, to the courſe of the alimentary pulp; upon which, however, their number has ſufficient influence to retard the motion, while, at the ſame time, they enlarge the ſurface of the villous membrane.

724. We come now to the true villous coat, which we call ſo in other parts by analogy. Namely, the whole internal ſurface of the inteſtine and its valves, together with the ſmall cavities interpoſed betwixt them, ſend out on all ſides innumerable ſmall fluctuating fleeces like a piece of velvet, the extremities of which are obtuſely conical productions of the inner coat of the inteſtine, and from the cellular ſubſtance, intercepted between the duplicature, and from the ſmall veſſels and nerves wrapped up in that celluloſity, and likewiſe from the lacteal veſſel which we ſhall afterwards ſpeak of, ſo as very much to reſemble the papillæ of the tongue, only of a ſofter texture.

725. The chief ſmall veſſel of each villoſity is an oval veſſel opening by a ſlender duct in the ſurface of the villous coat, often filled with milk, which the neighbouring ſmall veſſels every where ſurround.

726. In the internal ſurface of this villous coat, open an infinite number of pores; ſome *larger*, others ſmaller. The former lead to ſmall conſpicuous ſimple glandules of the mucous kind, ſeated in the ſecond cellular

ſtratum,

ſtratum, and like to thoſe of the vaſcular follicles ſeated in the mouth and pharynx, which likewiſe open with numerous patulent orifices into the inteſtines. In the duodenum theſe are aſſembled together in ſeveral places, without running together; nor can they always be demonſtrated; but many of them are quite ſolitary or aſunder in the ilium, or often aſſembled only a few together; though, in many places, a conſiderable number of the ſame kind are aſſembled together, into a little army of an elliptical figure. They have every where a villous membrane.

727. Throughout the whole tract of the inteſtines are found *pores* of a *leſs kind* ſurrounding the baſis of the villi, and moſt ample or conſpicuous in the large inteſtines, where they were firſt obſerved; but have been lately diſcovered, by a more careful inquiry, in the ſmall inteſtines likewiſe. Theſe alſo ſeem to depoſite a liquor of the mucous kind.

728. The *veſſels* of the ſmall inteſtines are very numerous. The common larger trunk belonging to the inteſtine that occupies the ſpace below the meſocolon is called the *meſenteric artery*, being the largeſt of thoſe produced by the aorta above the renal arteries. This, deſcending behind the pancreas to the right ſide of the jejunum, and before the colic branches, ſends out more eſpecially a long trunk to the bottom of the meſentery and termination of the ilium towards the right ſide; as on the left ſide it ſends out numerous branches, the firſt and laſt being ſhorter, the middle ones longeſt. Theſe laſt, ſubdividing into ſmaller, join with thoſe in their neighbourhood in ſhape of convex arches; which again ſend out other branches united in like manner, to the repetition of almoſt the fifth ſeries of arches, until the laſt ſend ſtraight and very numerous branches to the inteſtine; where, forming their laſt convexity, their numerous ſmall branches are detached on each ſide the inteſtine.

729. The diviſion of theſe branches in the inteſtine, is much after the ſame regular manner; ſo that one comes

comes out from the meſentery, through the cellular ſubſtance, on the foreſide of the inteſtine, as the other does, in the like manner, upon the lower ſide; which, having given ſmall branches to the outermoſt and fleſhy coat, come to the ſecond cellular one: there the anterior trunk, running out towards the obtuſe vertex of the inteſtinal ellipſis, is continued ſtraight into the poſterior branch ſimilar to itſelf; and, according to its ſize, gradually ſends off ſmaller ſhrub-like twigs, inoſculating with each other, and with their oppoſites, by innumerable circles. From this arterial net-work, ſmaller twigs penetrate from the nervous tunic into the third cellular ſtratum, and are, with that, continued to the ultimate extremities of the villi, where they at laſt open by exhaling orifices, and diſcharge a watery humour into the inteſtine; for this continued courſe is eaſily imitated and ſhown, by injecting water, fiſh-glue, or mercury. But late induſtry has diſcovered, that theſe arterial extremities firſt open into an hollow veſicle; from whence their depoſited juice flows out through one common orifice. For the reſt, the arteries in this part form numerous reticular inoſculations, that, by avoiding all obſtructions, they may be able to ſupply the inteſtines equally on all ſides; and that any obſtructing matter may, upon occaſion, be eaſily removed back from the narrower extremities to the larger arterial trunks.

730. The laſt trunk of the meſenteric artery inoſculates with the ilio-colic. The duodenum has various arteries. The firſt and uppermoſt from the right hepatic goes round to the convexity of the inflexure of this inteſtine, which it ſupplies in its way to the pancreas, and inoſculates together with the lower or left pancreatico-duodenal artery, which makes a like arch round the curvature of the duodenum into the pancreas; being, at laſt, inſerted into the lower duodenal arteries, produced by the meſenteric in its paſſage before this inteſtine. As to the ſmall arteries which go from the ſpermatics to the duodenum, and from thoſe of the

renal

renal capſule, we deſignedly omit any further notice of them.

731. The meſenteric *veins* meet all together, in the ſame courſe or diſpoſition with the arteries, in the meſenteric trunk of the vena portarum; except the right duodenal vein, which goes immediately into the trunk of the vena portarum itſelf; and except thoſe ſmall veins which run in company with the ſmall arteries (730.) and are inſerted into the ſpermatics and lumbals. Nor have I been able to diſcover any other veins of the meſentery ariſing from the cava. It is a property in common to all theſe veins to be without valves, and to make free communications with the arteries. Thoſe veins in the villous coat, which is for the moſt part compoſed of veins, abſorb thin humours from the inteſtine; as appears from the injection of watery liquors, which readily run through the ſame way; and, from analogy, in aged perſons, in whom the meſenteric glands, and conſequently the lacteals that paſs through them, are frequently cloſed up; add to this, that birds have no lacteal veſſels, and the celerity with which watery liquors paſs to the blood and through the kidneys, compared with the ſmallneſs of the thoracic duct, chiefly from thoſe experiments which have confirmed by ocular demonſtration the paſſage of water from the cavity of the inteſtine into the vena portarum.

732. The *nerves*, tho' ſmall, are numerous, whence the inteſtines receive no little degree of ſenſibility; they ariſe from the middle plexus of the ſplenic nerves, and, embracing the meſenteric artery, play round it in great numbers, wrapped up in a very denſe cellular plate. The duodenum has likewiſe ſmall nerves from the poſterior hepatic plexus of the eighth pair. From this great ſenſibility of the inteſtines it is probable, that the ultimate branches of the nerves penetrate into the third cellular coat.

733. From the exhaling arteries diſtils a thin watery liquor into the cavity of the inteſtines, like the juice of the ſtomach, not acrid, but ſaltiſh. The quantity of this liquor

liquor may be computed from the large extent or ſum of all the excretory orifices, and from the ſection or light of the ſecretory artery, larger than which we ſee no where in the body; add to this, the laxity of the parts perpetually kept warm and moiſt, and the copious diarrhœa or watery diſcharge that often follows the uſe of purgative medicines. But the mucus ariſing from the pores or cells before-mentioned (726, 727.) ſerves to lubricate and defend the internal ſurface of the villous membrane, and to guard the ſenſible nerves from ſtrongly acrid or pungent particles. Hence we ſee, it is more abundant at the beginning of the larger inteſtines, becauſe there the maſs of aliment begins to be more feculent, acrid, and tenacious.

734. The mixture of this liquor with the pulp-like maſs of the aliment, together with the bile and pancreatic juice, is made by the motion of the ſurrounding muſcles of the abdomen; but this force is quite ſmall, and unfit for moving forward the aliments. But for this purpoſe ſerves eſpecially the *periſtaltic motion*, which is more particularly ſtrong and evident in the ſmall inteſtines. For any part of the inteſtine, irritated by flatus or any ſharp or rough body, contracts itſelf, even after death, moſt violently in that part where the ſtimulus is applied, in order to free itſelf from the offending or diſtending body, which it expels into the next open part of the lax inteſtine; where, being received, it is again propelled forward, by exciting a like ſtimulus and contraction as before. This contracting motion of the inteſtines is made in various parts of the gut, either ſucceſſively or at the ſame time, wherever the flatus or aliment excite a ſtimulus; and this, without obſerving any certain order. So well fitted, however, are the inteſtines for this motion, that they emulate, and even exceed, the irritability of the heart, or at leaſt are ſcarcely exceeded by it. When they are not irritated, they remain at reſt, as I have often obſerved; and we may ſuppoſe this to be the cauſe why the fat remains in the belly. The air acts chiefly as a ſtimulus to the inteſ-

tines,

tines, next to it is the aliment, and laſtly the bile. This motion is performed by a wonderful ſort of alternate creeping and revolution of the inteſtines, which diſſection eaſily demonſtrates in living brute animals, and unhappy caſes of wounds in the abdomen and ruptures have manifeſted in the human ſpecies. And ſince here, among ſo many inflexions, the weight of the aliment is but of little force, it eaſily aſcends or deſcends through the irritated inteſtine, which thus empties itſelf. From hence the *antiperiſtaltic* motion is intelligible, by which the pulp of the alimentary maſs is oftener or longer applied with a gentle force to the triture of the inteſtine, to the exhaling diluent liquor, and to the mouths of the abſorbing veins. But all the contents of the inteſtine are determined downward to the large inteſtines, becauſe the ſtimulus begins above, from the left opening of the ſtomach; and ſo, by the ſucceſſion of new chyle, repeating the ſtimulus above the contraction, it deſcends, when there is no reſiſtance made to it, into the lower part of the ileum, at its opening into the colon: here the looſe part of this inteſtine readily receives what is preſſed into it by the contraction from above, and as eaſily unloads itſelf into the large unactive cæcum; from whence it is again repelled upward, and in part urged on by the preſſure of the ſucceeding maſs. Anatomiſts obſerve, that this motion is made ſtronger downward than upward, and that the ſuperior parts of the inteſtines are more irritable than the lower. But as often as an inſuperable obſtacle reſiſts the paſſage of the aliment, there will be the ſeat of the principal contraction, and the aliment likewiſe is driven upward from the valve of the colon through the whole length of the inteſtines, into the ſtomach, and laſtly into the mouth.

735. This periſtaltic motion of the inteſtines is performed by the conſtriction of their circular fibres, which exactly know how to empty the tube, without injuring the inteſtine againſt pins, needles, or any other ſharp bodies lodged within their contents, which they

tenderly promote forward. But the revolutions of the inteſtines, drawn upward and downward, and the ſtraightening of crooked parts of them one before another, which is ſo remarkably conſpicuous in brute animals, are performed by the long fibres, which we ſee contract themſelves at the ſeat of the preſent ſtimulus, and dilate the following portion of them to receive what enſues. By the ſame contraction, the villous membrane of the inteſtines, within their cavity, is urged and reduced into longer folds; whence the mucus is expreſſed and applied to that part of the alimentary maſs, where it was required by the force of irritation and ſtimulus. Theſe long fibres frequently make intro-ſuſceptions of the inteſtines, and generally without any bad conſequences, by drawing up the contracted portion of the inteſtine into that which is looſe, in ſuch a manner, that the former is ſurrounded by the latter, which is relaxed.

736. The alimentary pulp, therefore, diluted with the pancreatic juice and that of the inteſtines, intimately mixed with the ſaponaceous bile and circumjacent mucus, is more perfectly diſſolved than by the efficacy of the ſtomach, in proportion as the ſides of the inteſtines come into a larger contact, and approach nearer together; to which add, the longer ſeries of the periſtaltic motions, and the greater quantity of diſſolving juices. In this manner, the alimentary pulp, intermixed with air, forms a froth, without any kind of fermentation, which air is the ſame with what we commonly eructate from the ſtomach; but yet, at the ſame time, the acid or aceſcent force is ſubdued, while the oily or fat parts, diſſolved by the bile (715.), intermix with the watery juices, and put on the chyle its uſual milky appearance, like an emulſion, of a bright colour in the duodenum, at the firſt entrance of the biliary duct; from whence downward it cloſely adheres to the villous coat of the ſmall inteſtines. But the gelatinous juices of fleſh meats, diluted with a large portion of water, and likewiſe from their own ſubviſcid na-

ture,

ture, do more particularly adhere to the villous coat, and enter it in the way of abſorption. So water and watery liquors are all very greedily drank up by the veins: and yet the feculent remains never grow thick in the ſmall inteſtines, as far as I have been able to obſerve, becauſe the watery part is repaired by the arterial vapour and mucus; nor do they become fetid in any conſiderable degree, as well becauſe of the great quantity of diluting juices, as becauſe the quick progreſſion will not allow them time enough for a putrefaction. Thoſe remains, which are of a more earthy, groſs, and acrid diſpoſition, which were excluded by the mouths of the abſorbing lacteal orifices, do, by their weight, or by the muſcular contractions, deſcend ſlowly into the large inteſtines, ſo as to complete their whole courſe in the ſpace of about twenty-four hours. But within three, four, or a few more hours time, all the chyle of the aliment is commonly extracted.

737. The conſiderable length of the ſmall inteſtine, which is five or more times longer than that of the body, the great ſurface of the villous membrane increaſed by folds, the incredible number of exhaling or abſorbing veſſels, the ſlow courſe of what remains through the large inteſtines, and the great quantity of the inteſtinal juice poured into the alimentary maſs, do all of them concur, in the ſmall inteſtine, abundantly to perform what is required in the emulſions of the food for our healthy juices, and for their abſorption into the lacteals and the meſenteric veins: alſo for abſterſion of viſcidities from the inteſtine; for the avoiding adheſions and coagulations; for the deſtruction of any acid diſpoſition not yet ſubdued; and for the ſubduing any venomous quality in many juices, which, being directly mixed with the blood, inſtantly kill, but are thus ſent in by the mouth without damage. Hence, in general, the inteſtines are long in animals that feed upon any hard diet, but ſhorter in carnivorous ones, and ſhorteſt in all thoſe that live upon juices; and, even in man, an uncommon ſhortneſs of the inteſtines has been

known to be attended with hunger, and a flux or discharge of fetid and fluid fæces.

738. The heat by which the aliment is fomented, and which is exceedingly proper for the ſolution of the gelatinous matter, and exciting a beginning putrefaction, is hence the principal cauſe of the fetor which is gradually produced in the aliment; thence alſo is the cauſe of that thinneſs by which the uſeful part of the aliment is fitted for abſorption. But the air alſo, incloſed in the viſcid aliment, operates here, as in the ſtomach, by breaking the coheſion of the aliments, if any yet remain whole. The inteſtinal water dilutes the little maſſes of aliment; and if any hard part remains, this liquor ſoftens it by maceration. The bile being intimately mixed with oil, diſſolves the ſame, and renders it miſcible with water.

CHAP. XXVI.

Of the Large Intestines.

739. WHAT remains, after the chyle has been abſtracted, conſiſts of ſome portion of the bile, but mucilaginous and degenerate; ſome part of the human mucilages; moſt of the earthy parts that were lodged in the food; and all thoſe parts which by their acrimony were rejected by the abſorbing mouths of the lacteals, yet changed by means of putrefaction (736.); with all the ſolid fibres and membranes, whoſe coheſion was too great to be overcome by the maceration and periſtaltic motion in the inteſtines.

740. All theſe remains paſs from the extremity of the ileum into the cæcum, in which they are collected and ſtagnate; namely, the extremity of the ſmall inteſtine, called the *ileum*, applies itſelf obliquely, in ſuch a manner, to the right ſide of the colon, reſting upon the right ileum and its muſcle, that, in general, it aſcends in a curve, but more in its lower ſide, and leſs in

in its upper, which is almoſt tranſverſe. But finally, the nervous and villous parts of the ileum are ſo extended betwixt the departing fibres of the muſcular and nervous coat of the colon, as to hang pendulous within the cavity of this large inteſtine, with a double eminent wrinkle or ſoft fold, compoſed of the villous and nervous coat of the thick inteſtine, and of the ſmall inteſtine likewiſe, and of the interpoſed fleſhy fibres of the ileum and colon, joined together by a good deal of the cellular ſubſtance. The upper tranſverſe fold is ſhorter, as the lower is broader and more aſcending, being conjoined together by a ſmall production of the ſame kind, more eſpecially in the right ſide, adjacent to them. Betwixt theſe two folds, the mouth of the ileum opens, like a tranſverſe ſlit. But when this inteſtine is inflated, the ſtructure of it changes very much, repreſenting theſe parts to us under the figure of membranes and hard valves. After the cellular plate has been entirely removed from them, the ileum comes clean out from the colon, and the valvular appearance is no more to be ſeen; but if a large part of it only be drawn out, leaving a ſmall portion inſerted behind, it reſembles a ſphincter.

741. Below the entrance of the ileum, at the diſtance of ſome inches, the great inteſtine deſcends and forms a blind or impervious extremity, called the *cæcum*, reſting upon the ileum. From the lower part of this, towards the right ſide, extends a ſmall worm-like proceſs, in adults of conſiderable length, like a long extended cone or little inteſtine, variouſly incurvated, ſometimes downward, and full of ſmall mucous glands, which pour out a gluey mucilage to the fæces; but, in the fetus, the colon itſelf is extended into a conical *appendix*. But the weight of the ſuperincumbent fæces, depreſſing the ſpace on the right ſide of the appendix; the ſtrength of the cellular texture uniting the left part of the cæcum with the ileum, of the fleſhy fibres uniting both inteſtines; the very contractile force of the ligaments; the fitneſs of the anterior ſac of the cæcum, which

which eaſily receives the fæces from the inteſtinum ileum; all contribute to remove the appendix from the middle, and make it to go out from the left extremity of the colon: and thus is produced the thick and pendulous globe of the colon lying fartheſt to the right ſide, and which is proper to adult perſons. When, therefore, the remains of the alimentary maſs are ſent from the ileum into the colon, they fall by their weight firſt into the cavity of the cæcum, or impervious bag-like appendix: here, by ſtagnating, and the warmth of the parts, they begin to putrefy, according to their particular nature; and here, eſpecially, the fetid ſmell, obſervable in the execrements, begins.

742. The *colon* is an inteſtine altogether continuous, as one and the ſame with the cæcum; namely, the largeſt of the great inteſtines, and by much the ſtrongeſt. Beginning upon the ileum (740.), it aſcends over the right kidney, and lies under the liver, with an angle in the right hypochondrium; being connected to the viſcera, on each ſide, by the peritonæum. From thence it paſſes under the liver and ſtomach, for the moſt part, tranſverſely to the ſpleen, under which it ſtretches (676.), and in the deep receſs under the left ribs is often twiſted upon itſelf. From thence, again, continuing its deſcent to the left ileum, it forms a large flexure (658.); from which flexure it is continued, in its lower part, through the pelvis, under the denomination of *rectum*.

743. The ſtructure of the colon is in general the ſame with that of the ſmall inteſtines, but it has ſeveral things peculiarly differing from them. And firſt, all the longitudinal fibres are collected together into three bundles which run through the whole extent of the inteſtine; and of theſe one, and that the largeſt, lies naked, the other ariſes from the omentum; and the third is contained in the meſocolon. Theſe are ſhorter than the inteſtine, and contract it ſo that the nervous and villous membrane (744.) protuberates inwardly. Theſe fibres are connected moſt accurately with the external

coat

coat of the inteſtines; but in the intermediate places, and chiefly at the meſocolon, is ſeated the firſt cellular ſtratum repleniſhed with fat. At firſt, being dilated, they adhere to the vermiform appendage. In the extremity of the colon there are often only two ligaments, where the two leſſer join into one. They diffuſe themſelves upon the rectum in ſuch a manner as to occupy the whole.

744. Again, the fleſhy and nervous coat, and third cellular ſtratum, with the villous tunic of the colon, are extended into much larger wrinkles in the parts betwixt the ligaments, often projecting in a threefold rank, ſuſtained by the ligaments, that they may be able to reſiſt and ſupport any ſhock or preſſure from the motion of the fæces. In the beginning of the colon, they obſerve their three-fold order, exactly enough, at regular diſtances; but in their progreſs they vary more by degrees, being leſs, ſometimes double, often ſolitary, ſmall and large intermixed, or none at all. Where the ligaments which contract the colon diſappear, theſe valves almoſt diſappear entirely. Laſtly, the villous coat is thinner, without villi, but porous and wrinkled, furniſhed as well with large peculiar pores of its own leading to round folicles or cells which are ſolitary, as with innumerable ſmall pores leading to ſmaller follicles, both which ſupply a great quantity of mucus.

745. The *blood-veſſels* of the large inteſtines are partly from the greater and left meſenterics, and partly from the hypogaſtrics. The middle colic artery ariſes from the large meſenteric trunk, as that deſcends behind the tranſverſe meſocolon, where it ariſes up with one, two, and ſometimes three branches, going to the right ſide with the ilio-colic; and to the left, where, with the lower meſenteric, it meets it in a very large arch, which makes the moſt conſiderable arterial inoſculation in the whole body. Again, under the meſocolon, from the ſame large meſenteric artery, ariſes a conſiderable branch that goes directly to the fold of the ileum with the colon, and upward to the right colon with the middle colic;

colic; but to the left it runs together with the mesenteric, out of the middle of which it gives a branch that runs along the worm-like appendix of the mesocolon, and terminates itself in both the anterior and posterior fold, by which the ileum is inserted into the colon. Lastly, the lower mesenteric, arising by its proper trunk from the aorta, betwixt its bifurcation and the renal arteries, goes to the left colon: above, it runs by a large arch, together with the middle colic, and being bent downward in three or four trunks, it spreads over the flexure of the colon, and descends even into the rectum. Here the rectum receives various branches from the middle hemorrhoidal, arising from the last trunk of the hypogastrics, and conjoined with the former. The ultimate arteries are from the same trunk, but distributed without the pelvis. We neglect here the smaller colics, arising from the spermatics, intercostal, omental, capsulary, and lumbal arteries. The veins, taking the same course with the arteries, run together into the gastrocolic, and the internal hemorrhoidal, and hence into the vena portæ; lastly, they unite with the middle and external hemorrhoidals, and the trunks of the iliacs.

746. The division of the vessels to the large intestines, differs much from that of the small intestines. The arches the trunks send off, are neither so frequent nor so often subdivided; they run further entire upon the intestinal tube, accompanied with fewer glands, and their branches are distributed not so much like trees; they are divided by lesser angles, more flexible, and form fewer net-works in the cellular substance; but they distil an exhaling moisture into the cavity of the intestines, as the veins likewise absorb a thin fetid vapour from the fæces. The external, and perhaps also the internal ones, swelling into varices, pour out the hemorrhoidal blood; which is always preternatural, although sometimes infarctions of the vessels of the porta are relieved by that evacuation.

747. But there are also *lymphatic* vessels, arising from

from the whole tract of the colon and rectum, which conjoin with thofe of the loins. We are not without examples of the chyle entering thefe lymphatics from the colon inftead of lymph; which is an argument that they are of fome further ufe in this part, by conveying nourifhment to the blood.

748. The *nerves* of the large inteftines are, from the left colic plexus, compofed by the defcending branches of each renal plexus, and others arifing from the intercoftal trunk of the thorax and loins, with others produced from the large mefenteric plexus. Thefe nerves accompany the lower mefenteric artery, and pafs with them to the colon. The lowermoft nerves arife from the plexus juft mentioned, and go to the rectum, within the pelvis; others are from the lower intercoftals, and the nerves of the facrum, which terminate likewife in the rectum. Thefe nerves are of the fmaller kind; which renders the inteftine lefs fenfible, that it might better fuftain the preffure of the hard and acrid fæces.

748. The inteftinal fæces, therefore, retained in the blind beginning of the colon or large inteftine (740.), there grow dry by the abforption of moift vapours, fo as to be capable of receiving a figure from the round contracted parts of the colon; they afcend from the bottom of the cæcum, elevated by the long ligaments, which end in the worm-like appendix. And here the manner in which the fæces are propelled by the contraction of the circular fibres, appears better than in the fmall ones. The longitudinal fibres of the inteftine, being attached to the contracted parts as fixed points, draw up and dilate the lower parts of the inteftine; then the next parts of the inteftine, to which the fæces are brought, being irritated and contracted in like manner, are immediately after drawn together by the round and long fibres, by a fucceffive repetition of which the fæces finifh their courfe entirely, through the whole large inteftine, for the moft part in 24 hours in a healthy perfon. For wounds in mankind, and the comparative anatomy of brute animals, demonftrate this periftaltic

motion of the inteſtines to the eye; which is alſo confirmed by the antiperiſtaltic motion, and its conſequences, by which the matter of glyſters is returned up through the mouth. The ſame fibres reſiſt the air contained in the inteſtines; and wind isſaid to be generated as often as theſe fibres being overcome by its impulſe yield, and the inteſtine is dilated.

750. While the groſs fæces aſcend by the folds (740.) or valves of the ileum, the weight of them depreſs the lower fold to the left ſide, which draws back the ligament common to each valve, in ſuch a manner as to compreſs and exactly cloſe the upper fold downward, that nothing may return back into the ileum; which might eaſily happen in a fluid ſtate of the fæces, if this port was not ſo accurately ſhut up. The fæces, when in danger of falling down from the upper parts, depreſs the upper valve, and thus accurately exclude themſelves. This happens very exactly with the fæces, but not ſo accurately with water. From thence they continue to move ſlowly forward, more dry, conſiſtent, and figured by the ſame cauſes (749.) through the whole tract and repeated flexures of the colon, which is ſometimes of five or ſeven feet in length, ſo as to retain the fæces a ſpace of time ſufficient to give no interruption to the affairs of human life; which time is leſs in proportion than twenty-four hours, as the ſmall inteſtines retain their contents a ſhorter interval of the ſame ſpace.

751. At length the figured excrement falls into the *rectum*, which is inflected firſt a little downwards and then forward, of a broad depreſſed figure, at firſt deſcending contiguous to, and afterwards ſpread under, the bladder, or vagina, but connected more with the former than the latter. Here, for a great while, and often to a great quantity, the fæces are collected together, in a part which is looſe, or openly ſurrounded with ſoft viſcera and muſcles, with a good deal of fat.

752. The ſtructure of the rectum differs very much from that of the other inteſtines. The external membrane or peritonæum is only ſpread before it, while behind

behind it is ſupported by a broad ſtratum of the cellular ſubſtance, repleniſhed with fat, and many conglobate glandules, connecting this inteſtine all the way to the os ſacrum. The muſcular fibres in this inteſtine are much ſtronger and more numerous, more eſpecially the longitudinal ones, than in the other inteſtines; being compoſed of the three ligaments of the colon, expanded and ſeparated firſt over the anterior face, and then over the whole inteſtine; which they dilate againſt the advancing fæces, and draw back the inteſtine after it has excluded them. But the tranſverſe fibres are alſo ſtrong; and the laſt of them are oval, forming a protuberant ring, which is the internal *ſpincter* itſelf, by which the opening of the anus is cloſed.

753. Moreover, the villous tunic, extremely full of pores, and of a rough ſurface, full of reticulated polygonous and tender wrinkles, has likewiſe ſome ſinuſes peculiar to itſelf. Namely, that part of the inteſtine which is next to the ſkin or outward opening, forms a white firm circle like a valve, into which deſcend the longitudinal folds, but incurvated and approaching one to another in the circle itſelf. Betwixt thoſe folds, are intercepted ſinuſes, hollow upwards, and of a greater depth towards the lower extremity of the inteſtine. Into the cavity of theſe open the mouths of the large mucous glandules; while the margin of the anus itſelf is defended by ſebaceous glandules, that it might not be excoriated by the harder acrid fæces.

754. There are alſo proper muſcles which govern the anus. Of theſe the outermoſt is the *ſpincter*, which is broad and fleſhy, conſiſting of two plates of half-elliptic fibres, which croſs each other towards the coccyx, and towards the genital parts. And there they are inſerted by fleſhy bundles into a callous cellular fabric deſcending from the coccyx. But forward, they are firmly attached, by denſe portions of the ſame kind, to the ſkin of the perinæum; but by three ſtronger portions in the middle, and two in the ſides, they are

inserted into the bulb of the uretha, whose lateral parts they surround, betwixt the sphincter and levator. The fibres, therefore, of the sphincter, placed betwixt the anterior and posterior face of the rectum, ascending in a direct course, close the opening of the anus, which they surround. With the internal spincter, the external one is conjoined by fleshy portions, that they may co-operate together. The constriction of them is not perpetual but voluntary; for the anus seems to close itself naturally, if the smallness of its opening be compared with the largeness of the intestine above, and with the corresponding wrinkles (753.), aided by the strength of the transverse fibres of the internal spincter, and the incumbent bladder.

755. But there is another office belonging to the *levators*, which are broad complicated muscles. They descend broadly from betwixt the opposite protuberances of the ossa ischia, placed under the rectum and bladder; and serve to sustain the rectum on each side, and prevent it from subsiding, or from an unsightly eversion. Moreover, the same fibres of the levator, declining broadly from each other, in the nature of a sphincter, to which they join, serve to dilate its orbicular fibres, and open the anus; but, at the same time, they both elevate and sustain the intestine from prolapsing downward by the pressure of the hard fæces. They arise, as is well known, from the spine of the ischium, os ileum, and synchondrosis of the ossa pubis, terminated by the margin of the great foramen of the pubes, and that part of the ischium, which is above the tubercle. Finally, they meet together in one above the coccyx, into which they are inserted by numerous fibres.

756. Therefore, whenever the fæces are collected to some quantity, within the rectum, so as to be troublesome by their weight, irritation, or acrimony, they excite an uneasiness through the adjacent viscera; and are then urged downward, by a voluntary pressure through the straits of the collapsed intestine (754.), by the

the force of the incumbent diaphragm, exciting an effort; which urging downward with great force, the viſcera of the abdomen, which is always full, are determined downward, through the inner rim of the pulvis, ſo as to urge upon the contents of the leſs reſiſting bladder and rectum. When the reſiſtance of the anus is thus overcome, the compreſſing forces of the diaphragm abate, and the fæces continue to diſcharge from the body, urged only by the periſtaltic motion itſelf of the inteſtine. After the fæces are expelled, the inteſtine is drawn back or up into the body, by its longitudinal fibres; after which, the opening of the anus itſelf is cloſely contracted by the two proper ſphincters, as at firſt.

757. Theſe fæces in man, and carnivorous animals, are very fetid, almoſt putrid, ſubalkaline, ſoft, and contain much oil intimately mixed with ſalts, which are left both by the aliments, as well as by the bile and other humours of the human body. An acrid and fetid water returns from the fæces into the blood; hence, coſtiveneſs in fevers is hurtful, as it increaſes putrefaction by the effuſion of the above-mentioned matter.

CHAP. XXVII.

Of the Chyliferous VESSELS.

758. THE chyle is a white oily juice (736.) extracted from the aliments, which is afterwards poured into the blood. That its principal compoſition is of water and oil, ſeems evident, from the ſweetneſs of its taſte, from the whiteneſs of its colour, from its aceſcent and coagulable nature, and from its lightneſs by which it ſwims on the blood: in all which properties it very much reſembles an emulſion. It is compoſed of a vegetable farina, with animal lymph and oil. It every where retains the properties of the volatile

latile and oily aliments. It changes into milk with very little alteration. But afterwards it becomes more manifestly glutinous; since the pellucid serum it contains, either by exhaling the watery part, or by applying an intense heat, coagulates into a kind of jelly.

759. That the chyle is absorbed into the lacteal vessels, by the adhering villous coat, has been a long time known, by experiments of injecting tinctured liquors, which readily describe the same course; from the white liquor of the lacteals, let out from blood-vessels; and from the venous nature of them. But late experiments have taught us this in a much better manner. The chyle is absorbed by a small opening in the extremity of each of the villi, by the same force which is common to all capillary tubes, by which it is taken up into the cavity of the absorbing duct at the time when the intestine is relaxed; but the vesicle, by which the absorbing duct begins in the intestine, being pressed by the succeeding constriction of the muscular fibres in the peristaltic motion, urges the contents further on into the duct, which begins to appear within the second cellular stratum. But there is a two-fold stratum of these absorbing vessels, one anterior, the other posterior, as we observed before of the blood-vessels (729.). From thence, uniting into a larger canal in the first cellular stratum, the absorbed liquor enters into the lacteal vessel, which, in general, follows the course of the arteries, and likewise accompanies their arches, but conjoined with others similar to it into a very obliquely angled net-work. This kind of vessels hitherto has been observed only in quadrupeds. In the large intestine they arise without the above-mentioned vesicle. Very many arise from the first part of the small intestines under the mesocolon; some from the duodenum, and some from the large intestines themselves.

760. The lacteal vessels are furnished with valves in the very first cellular texture of the intestine, like those of the lymphatics, joined together by pairs, of a semilunar figure (57.), which admit the chyle passing from the

the inteſtines, but prevent its return, and ſuſtain its weight. Through this whole courſe, the chyle is urged on by the periſtaltic motion of the inteſtines, as well as by the contractile force of the veſſels themſelves, which, even after death, is ſtrong enough to propel the chyle; to which add, the conſiderable preſſure of the abdominal muſcles, and other parts, determined by the valves.

761. But betwixt the plates of the meſentery, at the diviſions of the veſſels, are found an infinite number of ſmall conglobate glandules, but ſomewhat ſofter and more ſpungy, made of a cellular texture, full of juices, covered with an external membrane, leſs hard than in other parts, and painted with numberleſs ſmall blood-veſſels. Some lacteal veſſels are ſeen to paſs theſe glands: moſt part enter them; and, being divided and ſubdivided through their cellular fabric, compoſe the greateſt part of the gland. And, again, other lacteal veſſels are produced out of every gland; and, being mutually joined among themſelves, go off in little trunks, of which the ultimate and largeſt ones go out from the gland. In the ſame manner the chyle enters other glandules twice, thrice, or four times; nor does any lacteal veſſel arrive at the thoracic duct without entering ſome of theſe glandules, although it always paſſes by ſome without entering them. But that this is the true courſe of the chyle, by which it paſſes from the inteſtines to the meſenteric glands, appears from a ligature, by the veſſel growing turgid betwixt the ſaid ligature and the inteſtine; and from ſcirrhoſities in the glands, by which they are rendered more conſpicuous; and from the nature of the valves themſelves hindering any return back to the inteſtines.

762. What alteration the chyle undergoes within the cellular fabric of theſe glands is not yet ſufficiently known; but it appears, in general, that ſome thin liquor diſtils from the arteries in this part, ſerving to dilute the chyle, into which it is poured. For it is obſerved, that after the chyle has ſurmounted all the glands, it appears more

more watery; and thin liquors, injected through the arteries, paſs out into the cellular fabric of the glands, and mix with the chyle. Laſtly, that kind of cream appears manifeſtly in the glandules of infants.

763. From the laſt glandules, which are collected together in the centre of the meſentery, the lacteal veſſels go out very large, and few, to the number of four, five, or more, which aſcend together with the meſenteric artery, and intermix with the lymphatic plexus, that aſcends from all the lower parts of the body, creeps over the renal vein, and then goes along with that which takes its courſe behind the aorta from the lumbal glandules, and with the hepatics. Here the lymphatics take a variable courſe, but moſt frequently terminate in a veſicle of conſiderable breadth at the ſide of the aorta, betwixt that and the right appendix of the diaphragm: there it uſually appears ſomewhat turgid, two or more inches long; and often aſcends above the diaphragm into the thorax, conical both above and below: it is called the *receptacle of the chyle.* In this the gelatinous lymph of the lower limbs, and of the abdominal viſcera, mixes with the chyle, and dilutes its white colour; thus ſometimes it appears filled with a pellucid or reddiſh humour, but frequently alſo with a white milk. But there are ſome inſtances where there are only two or three ſmall and narrow ducts, inſtead of this receptacle or ciſtern of the chyle. This, however, is moſt frequent, and ſuffers a conſiderable alternate preſſure from the diaphragm and aorta, by which the chyle is moved faſter through it, in proportion as the light of the ciſtern is greater than that of the thoracic duct, into which it empties itſelf. Yet ſometimes, though rarely, this veſicle is ſo ſhort, that it may be compared with an egg; but for the moſt part it is broadeſt in the middle, and decreaſes conically towards each end.

764. That the chyle comes from the inteſtines into this duct, is ſhewn from injections, by which quickſilver has ſometimes been driven from the firſt lacteal veſſels to the thoracic duct; from ligatures made on the

the duct itself, or the red veins which receive it, and by which the first and second lacteal vessels swell; and from the manifest flux of the chyle into the thoracic duct when the ligatures are removed.

765. The *thoracic duct*, as it is called from its course, is generally single; or, if it be double for some part of its course, it soon after unites into one again, which goes behind the pleura, betwixt the vena azygos and the aorta; and, ascending in an inflected course, it receives in its way the lymphatic vessels of the stomach, œsophagus, and lungs, and passes through the conglobate glands, of which there are many incumbent on and about it; and these lymphatics, as they advance towards the duct, are collected into large bunches. It is, in general, cylindrical; and often forms insulations, by splitting or dividing into two or more; after which it unites into one again, more especially in its upper part. It has few valves, and those not very conspicuous. About the fifth vertebra of the back, it generally crosses behind the œsophagus, and then ascends along the right side of the thorax, behind the subclavian blood-vessels, till it has arrived near the sixth vertebra of the neck.

766. There, bending down, it often divides into two, and each descending branch dilates into a sort of vesicle that enters, either with distinct or united openings, into the juncture of the subclavian and jugular vein internally, by an oblique course from the upper, posterior, and lateral part downward towards the left, and forward, going either with one or with two branches under the subclavian, on the outer side of that juncture. It has a true circular fluctuating valve placed over it, which keeps off the blood by its descent. It is rarely otherwise disposed; and more rarely split into two, lengthwise, for distinct insertions into the subclavian; and yet more rarely apt to send off a branch into the vena azygos. Near its insertion it receives the opening of a large lymphatic vessel, transversely from the arm; and another descending from the head, in one or more trunks.

767. It appears that the chyle flows through the thoracic duct into the blood; becauſe, on tying the red veins, both the thoracic duct and lacteal veſſels which are inſerted into it ſwell up.

768. I have attributed the firſt cauſe of motion in the chyle, and of its abſorption, eſpecially to the attraction of the capillary veſſels, which obſerves alternate pulſes with the periſtaltic contraction of the inteſtine. The attractile force fills the villoſity; the periſtaltic force empties the villoſity, and moves the chyle farther forward. The reſt of its motions ſeem to depend on the ſtrength of the membrane of the lacteal veſſel itſelf, which, even after the death of the animal, expels the chyle, ſo that the veſſels become pellucid, which before were milky. The alternate compreſſing force of the diaphragm alſo is of ſome efficacy in this caſe, and the motion of the chyle through the thorax is ſomewhat accelerated by the conduit itſelf; which being preſſed, moves the chyle ſo much the more quickly forward, as itſelf is larger than the thoracic duct.

769. The chyle, mixed with the blood, does not immediately change its nature; as we learn from the milk, which is afterwards made of it. But after five or more hours have paſſed from the meal, almoſt to the twelfth hour, during all which ſpace a woman will afford milk; after it has circulated near 80,000 times through the body, fomented with heat, and mixed with a variety of animal juices, it is, at length, ſo changed, that a part of it is depoſited into the cellular ſubſtance, under the denomination of fat; a part of it is again configured into the red-blood globules (147.); another part, that is of a mucous or gelatinous nature, changes into ſerum; and the watery parts go off, in ſome meaſure, by urine, in ſome meaſure exhaled by perſpiration; while a ſmall part is retained in the habit, to dilute the blood. Nor is it any thing uncommon for a pellucid lymphatic liquor to fill the lacteals, in a dying animal, inſtead of chyle; or for ſome of them to appear milky in one part of the meſentery, and limpid or

pellucid in another; ſince, as to their fabric and uſe, they alſo agree to anſwer the end of lymphatics. There are not, therefore, two kinds of veſſels from the inteſtines; one to carry the chyle only, and another peculiarly for the conveyance of lymph.

770. After the digeſtion has been completed ſome time, the lacteal veſſels abſorb pellucid watery juices from the inteſtines, whence they appear themſelves diaphanous; but the thoracic duct is more eſpecially a lymphatic of the largeſt order, conveying all the lymph of the abdomen, lower extremities, and moſt parts of the body, to the blood (53.)

CHAP. XXVIII.

Of the KIDNEYS, BLADDER, *and* URINE.

771. THE chyle which is taken into the blood, contains a good deal of water; the proportion of which would be too great in the veſſels, ſo as to paſs into the cellular ſubſtance, if it was not expelled again from the body. Therefore a part of this is exhaled through the ſkin (436.); and another part, as large, or often larger than the former, is ſtrained through the kidneys, and is expelled out of the body.

772. Theſe *kidneys* are two viſcera, placed on each ſide the ſpine of the back, behind the peritonæum, incumbent upon the diaphragm, and upon the pſoas and quadratus muſcles of the loins; but in ſuch a manner, that the right kidney is commonly placed lower and more backward than the left. Before the right kidney is placed the liver, upon its upper part (690.), and then the colon covers the reſt of its anterior face; and the left kidney is alſo covered by the ſpleen, ſtomach, part of the pancreas, and the colon. They are tied by reduplications of the peritonæum to the colon, duodenum, liver, and ſpleen. Their figure is externally convex, with a ſemielliptic deficiency in their inner ſide;

laterally they are flat or depreſſed, inwardly hollow, unequally divided into one upper, or longer and thicker plane, and lower ſlenderer extremity. They are firmly inveſted by a ſtrong external membrane, which is denſe, adheres very cloſely, and does not come from the peritonæum. Betwixt that membrane and the peritonæum of the loins, there is always interpoſed a conſiderable quantity of fat, by which the whole ſurface of the kidney is ſurrounded on all ſides, and a neſt is completed, which the kidney does not totally fill, though anſwering to its ſhape. From the kidney the peritonæum aſcends to the liver, ſpleen, colon, and diaphragm, and prepares as it were ligaments for the kidney.

773. The *blood-veſſels* of the kidneys are very large, as well the arteries, which together exceed the meſenteric, as the veins. And firſt, the renal *arteries* paſs out from the aorta under that of the meſentery, not always in the ſame manner, yet ſo that the left is commonly ſhorter than the right, and each of them frequently in two, three, or four diſtinct trunks. From thoſe trunks ariſe the renal arteries of the lower ſort, with the adipoſe ones belonging to the fat cortex or capſule of the kidney (772.); and not unfrequently they give origin to the ſpermatics. The fat, rather than the kidney, receives the ſmaller branches from the ſpermatics, and arteries of the loins. The arteries are thick, ſo that there is a great quantity of membranes in proportion to their light; they are alſo made of very ſtrong ones, and exceed the ſtrength of the aorta by a third part.

774. The renal *veins* are very large, more eſpecially the left, and more inconſtant in their courſe than the arteries: for the right is often without a branch, ſhort and concealed; while the left always generates the ſpermatic and capſular vein of the ſame ſide, and almoſt conſtantly receives the laſt branch of the vena ſine pari; and being of a conſiderable breadth, it extends a long way tranſverſely, and produced to the left, before the

the aorta, with the duodenum incumbent upon it. Both the arteries and veins of the kidneys arise from the great trunks laterally, a little descending in an obtuse angle; and divide themselves into many branches, a little before they enter the kidney. That the passage of the blood through the renal arteries into the veins is very expeditious, readily appears from the easy course that is afforded to water, wax, or even air, injected. The uppermost veins of the fat of the kidneys come from the capsular vessels, the middle from the renal ones, and the lowermost from the spermatics.

775. There are *lymphatic* veins, considerably large, found about the renal blood-vessels, which give origin to the cistern of the chyle (763.), which are said to receive the dispersed branches that are spread under the cellular coat of the kidney, and which are rendered manifest by putrefaction, or liquor injected into the renal arteries, or even into the ureter.

776. The *nerves* of the kidneys are small, but numerous; arising from a considerable plexus, mixed on each side with ganglions which are generated by the branches of the great semilunar ganglion, conjoined with others from the intercostal trunk, creeping along from the thorax itself. They enter the kidney, together with the artery, and send off the middle mesenteric (748.), and likewise the spermatic nerves. As these nerves are small, they afford but a moderate degree of sensibility to the kidney.

777. Upon the top of each kidney is seated the *renal capsule;* which in the fetus is large, even larger than the kidney itself, but not afterwards increasing in the adult: it is glandulous, of the conglomerate kind, divided into lobes, of an oval shape in the fetus, and triangular in the adult; and connected on the right side to the liver, spleen, pancreas, on both sides to the diaphragm and kidney; to all which it adheres by as many connecting twigs. From a careful observation, it seems to be inwardly hollow, separable like a ventricle, of a smooth surface, and terminating inwardly, as if cut

cut with a razor, full of a liquor of a yellowiſh red colour, and of a fluid conſiſtence, almoſt like blood. The arteries of theſe capſules are many, chiefly of three kinds; the uppermoſt from the phrenics, the middle ones from the aorta, and the lower ones from the renals; but the veins are only a large one on each ſide, that of the right to the cava, and the left to the renal vein of the ſame ſide. The ſaid vein creeps almoſt naked, in branches, through the tender ventricle, in a ſulcus, dividing the capſule, and ſends branches through its internal ſuperficies. The uſes of this gland are as yet unknown; although we are led to believe, from the ſituation, that it is ſubſervient to the kidney, and of greater uſe to the fetus; ſince it is conſtantly found near the kidneys, and in ſo many different animals. It has no viſible excretory duct, nor does it diſcharge any juice, by viſible pores, into the vein.

778. The internal fabric of the kidney is ſimple enough, and ſufficiently known. The blood-veſſels having entered the interval betwixt the upper and lower ſtratum of the kidney, ſpread into its ſubſtance, ſurrounded with a cellular ſheath, and divide into branches which go out between the branches of that which is called the *artery of the pelvis*, by columns interpoſed betwixt the papillæ. From thence, both in the papillæ and among them, making arches, they ſurround the origin of the papillæ, nearer to the circumference; but ſometimes joined by ſmall branches: from whence proceed innumerable little twigs, of which ſome return into the papillæ by the intervals between them and the columns; others tend towards the external ſurface of the kidney, and ſometimes, paſſing through the proper coat of the kidney itſelf, enter into its adipoſe covering, where being changed into minute ſerpentine curls, reflected again towards the trunk of the artery from whence they roſe, they form a boundary to the kidney, and are then gradually ſtretched out and mix themſelves among the uriniferous tubes. But from the cortex, as it were by ſome little flames, are produced

bundles

bundles of the uniferous tubes collected in great numbers into threads, of which every one contains very many little tubes. That they are continuous with the arteries, or at leaſt that they receive their branches into them, we know, from experiments which ſhew that water, or even air, paſſes eaſily from the arteries of the kidneys into the ureter; and laſtly from diſeaſes, in which the blood takes the ſame courſe. Between theſe papillæ, and about their origin, are ſituated ſome roundiſh knots, which the lateſt anatomiſts take to be the arterial glands, producing the proper and more narrow urinary ducts. Between theſe ſmall ducts run many arteries parallel to one another. It is probable, that the cortex conſiſts of curved veſſels, which eminent anatomiſts have ſuppoſed to be ſmaller than the red ones.

779. Thoſe *uriniferous ducts*, gradually converging towards the middle of the kidney, are joined together like rays; and are inſerted in great numbers into one blind duct, ſuch as perfect the reſt of the papillæ; and each of which is terminated in its convex extremity by conſpicuous pores. The number of theſe papillæ is not altogether certain, but there are thirteen or more of them; ſome of which are obſerved to be ſimple, ſome triple, and ſome quadruple. Theſe were in the fetus ſo diſtinct, that the kidney then appeared to conſiſt of as many diſtinct or ſmaller kidneys, as there are of theſe papillæ, connected together by a looſe cellular membrane; and furniſhed every one with its proper cortex of ſerpentine veſſels, and its compages of ſtraight uriniferous ducts, the baſis of all which is in the circumference of the kidney, and their vertices converge towards the centre. The oppoſite cortices of two of theſe little kidneys make a column, becauſe it ſeparates two papillæ. In adults, the cellular ſubſtance being condenſed, unites the renal portions and their papillæ into one even kidney; however, it again almoſt recovers the condition which it had in the fetus, if the intervening cellular plates are relaxed by often injecting

injecting of water. The kidney is alſo remarkably larger in the fetus than in the adult.

780. Round the protuberant ſurface of the ſaid papillæ, is extended a looſe membranous covering, in ſuch a manner, diſtinct from the papillæ itſelf, as to form a larger ſpace, like a cylindrical tube or funnel, for receiving the papillæ into its cavity, and ſometimes there are two in the neighbourhood of each other. Two or three of theſe tubes meet together in one; and with others of the ſame kind, they at laſt form by that union three hollow trunks, the upper, middle, and lower, which again unite and open, but without the kidney, into one conical canal, called the *pelvis*.

781. The blood of the renal artery being leſs fluid, as is generally believed, than that of the brain, and probably ſtored with more water, brought by the ſerpentine circles of the arteries, depoſits great part of its water into thoſe rectilineal tubes of the papillæ; a great portion of which water contains oils and ſalts, intermixed with earthy particles, or ſuch other matters as are thin enough to paſs through with it. But the ſmall diameter of each uriniferous duct itſelf at its origin, and its firm reſiſtance, ſeem to exclude the milk or chyle and the coagulable lymph. Hence, therefore, it is, that the blood paſſes ſo eaſily through the open uriniferous tubes, whenever it is urged with an increaſed celerity; or that, by a morbid relaxation, they tranſmit not only the oily parts of the blood, but even the milk and ſalts of the meat and drink. But when the ſtrength of the kidney is reſtored by aſtringent medicines, the urine returns to its natural ſtate. The nerves likewiſe have a power of contracting or relaxing theſe paſſages; and thus we ſee that urine, which in health is of a yellow colour, becomes watery from ſudden grief of mind. A vaſt quantity is prepared; equal to that of perſpiration, and ſometimes even more.

782. The urine, by fire or putrefaction, ſometimes by diſeaſe, and in ſome animals more eaſily, changes into a volatile alkaline nature, intimately mixed with a fetid

fetid oil, partly empyreumatic, yellow, and volatile, and in part very tenacious, to be separated only by the last degrees of fire, under the denomination of phosphorus; a substance shining of itself, and taking fire in the air: and lastly, it abounds more with earth than any other juice of the human body, both of a cretaceous and sparry nature; the latter coming chiefly from the drink, the former also from the solid parts of the body themselves dissolved and mixed with the blood. But there is also a considerable proportion of sea-salt residing in fresh urine; from which it is even separable, after a long putrefaction, in the making of phosphorus; in which process a very great part of the urine is changed into volatile alkali. Nor is the urine wholly destitute of a vitriolic acid, or at least one much a-kin to it; both in that taken from men, as well as in the stale of cattle. There is, again, a sort of fusible salt separable in the urine, which is cooling, and a-kin to nitre. In fevers, the oily and saline parts of the urine are greatly augmented both in bulk and acrimony.

783. The *ureter* being a continuation of the pelvis, carries on the urine received from the kidney, by pressure from the incumbent viscera, the contraction of the abdominal muscles with those of the loins, and the force of the circulation urging the blood behind the secerned fluid, and lastly the weight of the urine itself. First, the ureter is covered by the peritonæum and cellular membrane; but its muscular coat is weak, obscure, if any: it has then a second cellular coat; a firm, white, nervous one; a third cellular one, lined with the innermost, which is of a smooth membranous fabric, porous and glandular internally, and in general moderately irritable. It is of different diameters in different places, and every where swells into vesicles. It descends over the psoas muscle, crosses over the great iliac blood-vessels into the pelvis; goes behind the urinary bladder; and in the conjunction of the descending and transverse portions of the bladder, enters obliquely betwixt the muscular fibres and nervous coat; and so

again, betwixt the nervous and villous coat, in ſuch a manner that the mouths of the two ureters are in the neighbourhood of each other, and open by an orifice obliquely cut off; but they have no valves, neither at their opening in the bladder, nor in any part of their courſe. From their oblique inſertion into the bladder, a protuberant line is formed, by the greater thickneſs of the nervous coat, which deſcends to the caput gallinaginis.

784. That the urine is ſeparated in the kidneys is ſhown by the very nature of the thing, as it can be drawn out by preſſing on its ſmall canals. That it deſcends by the ureter is ſhewn by the ſurpriſing ſwelling of the kidney, and that part of the ureter which is above the ligature, as well as the emptineſs of that part which is below it. In the bladder alſo, as well as in the kidneys and ureters, there is an immenſe ſwelling as often as the bladder cannot receive the urine, or cannot emit it; an obſtacle being generated in either place.

785. Nor does there ſeem to be any other way for the urine to paſs. For although it is certain, that the ſtomach, like all other membranes, exhales a moiſture through its coats; though it is not improbable, from experiments, that the bladder alſo abſorbs; and although the paſſage of mineral ſpaw waters, by urine, be extremely quick; yet it does not thence follow, that there muſt be ways, different from that of the ureters, to convey the water from the food to the bladder. For the bladder is, on all ſides, ſeparated from the cavity of the abdomen by the peritonæum; nor is it very likely, that the vapours, which either go out from the bladder, or which are derived towards it from other parts, can here find open pores through the peritonæum; nor do membranes imbibe much that are already wetted, ſo as to fill their pores with humours. But the urine alſo which is contained in the bladder, diſtends it even to death; nor does it find any paſſage through which it can eſcape into the pelvis; and on the other hand, when

when the ureters are obſtructed with ſtones, ſo that the bladder receives nothing from them, it is either quite empty, or contains a very acrimonious and thick urine, manifeſtly indicating that the water can find no other way from the pelvis into the bladder. And a careful attention to the manner in which mineral waters are diſcharged by urine, ſufficiently demonſtrates, that there is no ſuch rapidity therein as is commonly imagined; but the ſtimulus of the cold water drank, does, like the external cold applied to the ſkin, cauſe a concuſſion of the bladder and urinary parts, by which they are ſolicited to repeated diſcharges of the old urine which was before in the body, and not immediately of that which was laſt drank. Again, the largeneſs of the renal veſſels demonſtrates, that not much leſs than an eighth part of the blood ſent to the body is received at a time, and conſequently there are above 1000 ounces of blood conveyed through the kidneys in an hour; whence it will appear but a moderate allowance, for 20, or even 50, ounces of water to diſtil from that quantity of blood driven through the kidneys in the ſame time. Finally, it is certain, that both man and brute animals periſh if the ureters are cloſed up by a ligature; we then obſerve alſo, that no urine can be found in the bladder.

786. The *urinary bladder* is ſeated in the cavity or bowl of the pelvis, which is an appendix to the abdomen, ſurrounded on all ſides by bones; but laterally, and at the bottom, only incloſed by muſcles; and is always larger in women than in men. It is ſituated, ſo as to cohere with the os pubis by a large portion of cellular ſubſtance, by which it is connected to the peritonæum, from thence backward, and for a ſmall part of its ſurface before; but behind, it is extended to a greater length over the bladder, deſcending almoſt as far as the inſertions of the ureters; from whence it returns back again, either over the rectum or uterus in women. Behind the bladder lies the rectum, the ſeminal veſicles, and proſtate gland, with the levatores ani. In the fetus, the bladder is very long, and ſomewhat conical,

extending itſelf much above the oſſa pubis; but in the adult, it hardly ariſes above thoſe bones, even when inflated, becauſe, in them, the pelvis is much larger and deeper in proportion.

787. The figure of the bladder is, in general, oval, flatter before, more convex behind, terminated at bottom by a very obtuſe or flat head, that lies incumbent upon the rectum. Such is the figure of it in an adult man: but, in the fetus, it is almoſt cylindrical; and, in women who have had many children, ſo much flattened laterally by preſſure, that it reſembles a ſort of triangular cone. This change of the figure of the bladder ſeems to ariſe from the weight of the urine, gradually extending more the lower parts of the bladder, which are moſt preſſed; by which means the ſides are drawn together from above, ſo as to render it ſhorter and broader. It is of different magnitudes; ſo that, in diſeaſes, by frequent irritation and contraction, it ſometimes becomes very ſmall.

788. The fabric of the bladder is much like that of all large membranous receptacles. The firſt membrane is cellular; in its forepart lax, and repleniſhed with fat; but backward it is thinner, where it unites with the rectum. In this there is a net-work of veſſels, chiefly of veins. Next to this follows a muſcular coat, very difficult to deſcribe, conſiſting of pale contractile fibres, diſpoſed in various reticulated bundles, not continued one to another, but interrupted with net-like ſpaces, in which the nervous coat lies uncovered. The principal ſtratum of theſe is longitudinal; which, ariſing before from the proſtate, is frequently, though not always, ſo connected to the ſynchondroſis of the oſſa pubis, or the membranes covering it, as ſeemingly to ariſe from thence; thence, aſcending and growing broad, they ſpread towards the conical extremity of the upper ſide of the bladder: here paſſing on, they deſcend over the poſterior ſurface, and grow there conſiderably broader, till at length they are finally terminated in the proſtate; but laterally they go off like the palms of one's hands,

and

and are mixed from the anterior and posterior planes. These fibres must necessarily depress the bladder, and consequently propel the urine towards its bottom part.

789. The remaining fibres are very difficultly reduced to any order. They fill the intervals of the former; by arising from the prostate backward, and ascending inflected, they form a stratum, partly oblique, and partly transverse, the interior ones more than the others, both in the forward and back part of the bladder.

790. The contractile force of the bladder is gentle, but perpetual; so that it contracts from its greatest dilatation to its very least size, without any alternate relaxation, and remains long in its state of greatest contraction. The urine is the least uneasy stimulus; water injected is more so, and a stone the most of any kind of irritating substance. When distended beyond measure, it loses its powers; so that either it cannot expel, or cannot retain, the urine.

791. Within the muscular coat is spread the second cellular stratum, of a tender elegant fabric, that may be inflated, and softer than that observed in the intestines. Next follows the nervous coat, as a continuation of the skin, and resembling the nervous coat of the stomach: the inner one is more obscure; difficultly separable from the nervous one; continuous with the epidermis; and, like it, easily separable, having a great deal of mucus, and folded into various wrinkles, without any certain order. In the surface of this last, the pores of the mucous cryptæ sometimes appear conspicuous, but not always without difficulty, pouring out a viscid soft glue. The mucus itself is very manifest, and is prepared in the greater quantity in proportion to the irritation of the bladder. For this mucus there is the highest necessity, to diminish the sensation of the acrimony of the urine.

792. The *vessels* and *nerves* of the bladder are in common with those which go to the genital parts, where we shall describe them. Those which come from the epigastrics are but small. They form principally

pally a net-work in the firſt or outer cellular ſtratum, and then another in the ſecond ſtratum of the ſame ſubſtance. The arteries exhale through the villous coat, as we learn by experiment from anatomical injections; and the veins likewiſe abſorb again, to which is owing the greater conſiſtence and higher colour of the urine by a long retention of it. The lymphatic veſſels in the outer cellular ſtratum, are eaſily demonſtrated; but their origin is from another part, probably from the adjacent rectum.

793. The ſame urinary bladder is of the nature of other membranous ſacs, ſo that it both tranſmits water through the inorganic pores of its membranes, and through the ſame abſorbs the water in which it is immerſed.

794. Into this bladder the urine conſtantly flows, in a continued thread, as we are aſſured, from experience, in morbid and uncommon caſes, in which the extremities of the ureters have appeared to the eye. By ſtaying ſome time in the bladder, and from the abſorption of the more watery part, the urine acquires an higher colour, becomes ſharper and reddiſh-coloured. Nor are we fully acquainted with the cauſe which retains the urine in the bladder. The ſpincter is obſcure; the depreſſion of the bladder ſeems to aſſiſt, as it deſcends convex below its mouth upon the inteſtinum rectum, ſo that at laſt the urine arrives at the entrance of the urethra when any quantity of it is collected. Certain it is, that the urine does not flow ſpontaneouſly even from a dead carcaſe.

795. At length, by its bulk and acrimony, irritating the ſenſible fabric of the bladder, it is thence expelled, firſt by the motion of the diaphragm and abdominal muſcles, by which the inteſtines are urged againſt the bladder in a perſon who is erect, whereby the urine makes itſelf a way through a narrow and impeded paſſage; and again, by the periſtaltic motion of the bladder itſelf, ariſing from the contraction of its muſcular fabric (788, et ſeq.)

796. There ſeems by the urine, beſides the particles of

of food and water, much matter to paſs off that is noxious to the human body; eſpecially calcareous earth reſorbed from the bones and ſolid parts, and which would not fail to produce bony cruſts and calculi wherever it was ſtopped; the ſparry or gypſeous earth of fountains; an acrid oil mixed with ſalt, ſo as to aſſume a volatile nature. The urine, by its retention, diſpoſes to the generation of the ſtone and gout: when ſuppreſſed, it produces ſharp fevers; and at laſt flows back to the brain, and overflows and deſtroys it.

797. From the anterior vertex of the obtuſe or greater end of the bladder, not from its bottom, goes out a ſlender canal with a ſmall orifice, as a continuation of the bladder itſelf, under the denomination of the *urethra;* and in this, there is a manifeſt continuation of the cuticle of the internal coat of the bladder, with its ſurrounding cellular ſubſtance, and more eſpecially a ſolid nervous coat, of which it is principally compoſed. It is variable in its diameter and direction; in women, it is ſtraight, tranſverſe, and ſhort. I do not find a valve in its mouth.

798. This canal of the urethra is firſt ſurrounded, on all ſides, by the proſtate gland; from whence it goes out naked, for a ſmall ſpace, that is immediately continuous below with the incipient bulb of the uretha, which likewiſe ſurrounds it on all ſides above; but the cavernous bodies of the penis chiefly cover it above and laterally, ſo as to form a common groove for its reception, and add ſtrength or firmneſs to this otherwiſe lax tube. It begins wide from the bladder, and contracts itſelf conically in the proſtate; from which, being at liberty, it becomes cylindrical, and enlarges at the firſt acceſſion of the bulb; in the penis it is almoſt cylindrical, and again dilates itſelf a little before its termination.

799. This canal is governed by various muſcles, either proper to itſelf, or belonging to the parts adjacent. And firſt, in women, there are manifeſtly fibres placed round the egreſs of the incipient urethra, which

are moſtly tranſverſe, but ſome variouſly decuſſating each other; whoſe office, and ſupport in the vagina, manifeſtly appear; namely, to depreſs the urethra, like the ſpincter, about the opening of which they are diſpoſed, and by this means to cloſe its opening againſt the reſiſting contracted vagina and ſpincter of the anus. In man there are tranſverſe fibres of the ſame kind; but, forming an arch that opens upward, they run into the conjunction of the bladder with the proſtate, covering the longitudinal bundle of fibres and proſtate itſelf, which covering of fibres thus becomes fit for contracting the orifice of the bladder.

800. The firſt tranſverſe muſcle proceeding from that bunch of the iſchium which ſends forth the erector muſcle of the penis, goes tranſverſely towards the other os iſchium, partly paſſes into it, is partly inſerted into the middle bulb of the urethra, and partly degenerates into the accelerator. It preſſes upon, ſhakes, and draws backward, the bulb of the urethra. The other, produced from a branch of the os iſchium, is inſerted into the iſthmus of the urethra before the bulb, and dilates it.

801. But likewiſe the levator of the anus ſeems to raiſe the urethra againſt the os pubis, ſo as to cloſe the opening of the bladder into it; and, in ourſelves living, we may perceive the accelerator conſtringed, together with the ſpincter, at the root of the penis, ſo as perfectly to cloſe the opening of the urethra, and preſs back the urine even while it is flowing; whence there is no room to doubt, but this muſcle gives a moderate tightneſs for retaining the urine.

802. An effort being now made (795.) by the preſſure of the diaphragm, the urine runs forth with a greater celerity, in proportion as it comes through a canal ſmaller than the diameter of its large receptacle; and, being once diſcharged, frees the body from uneaſy ſenſation. The laſt drops, which remain in the lower part of the bulb, irritating by their weight, are expelled by the accelerator muſcle; namely, a ſtrong muſcular expanſion, placed round the

the bulb, whofe fibres are difpofed in the fhape of a feather, meeting together in the middle of the bottom-part of the bulb, and in their fore-part fixed by two tendons into the cavernous bodies of the penis, and in their back-part connected by three mufcular portions to the fpincter of the anus, two of which portions may be alfo referred to the levators of the anus. This mufcle, when the fpincter is firmly fhut, draws the bulb upward; and, with a confiderable force, alternately contracts or fhakes the urethra, fo as to expel the laft drops of the urine.

803. The pyramidal mufcle of the abdomen may be thought to draw the bladder downwards by the rope of umbilical veffels, and likewife to relax it, and fit it for the action of the long mufcular fibres. But this cannot be admitted, feeing the mufcle itfelf is often wanting; neither can it bring down the bladder, and very rarely comes to the navel.

804. But as the urine is fharp, and the membrane of the urethra very fenfible, and becaufe the air will likewife enter it; for thefe reafons nature has fupplied this canal with a large quantity of mucus. This mucus is not only generated from the fources in the bladder, but more efpecially from two conglomerate glandules; one of which is feated on each fide in the angle, betwixt the bulb of the urethra and the cavernous body of the penis; from whence it fends out a flender duct, running for a confiderable length through the urethra. I am ignorant of any glandule of the ifthmus different from the cellular texture. Moreover, the whole urethra is full of mucous finufes, of a cylindrical figure; very many of which defcend towards the glans, though fome run in a contrary direction, having fmall mucous cryptæ placed at their fides, which depofite there a fluid mucus, and difcharge it into the urethra. A larger fort of thefe mucous cryptæ are difpofed along the upper fide of the urethra, beginning before the bulb, at the origin of the glans. There are others, ftill fmaller, mixed with thefe large ones, and placed laterally, and

about the urethra. In women alſo there are many and larger of theſe mucous ciſterns, which open into their much ſhorter urethra, more eſpecially at its opening.

805. The neceſſary cleanlineſs and avocations of human life require the urine collected to be diſcharged only at certain times. But theſe advantages could not be obtained without ſome danger of diſeaſe, from the depoſition of the earthy parts of the urine continually confined and at reſt; ſo that, by repeated additions of the like matter cemented together, a ſtone may be at length formed. But the plenty of mucus, with which the urinary paſſages are commonly defended, is, for the moſt part, a ſufficient guard againſt this diſorder, as we ſee the generality of people are free from the ſtone; unleſs the urine is more than commonly charged with an earthy, tartareous, or chalky matter, increaſed by the uſe of hard water full of ſelenitic matter, drinking wine; very viſcid food, inactivity of body, and a retention of the urine beyond the calls of nature; or ſome viſcid body capable of attracting the calculous matter; or finally, a diſorder of the kidneys, laying a foundation for the earthy matter firſt to adhere together.

CHAP. XXIX.

Of the Genital Parts *in* Man.

806. THE veſſels belonging to the genitals conſtantly ariſe near thoſe of the kidneys, and almoſt in all kinds of animals; by which nature ſeems to have intended a double uſefulneſs in one organ, which might be able to diſcharge the urine, and bear a relation likewiſe to the genital parts, though placed at a conſiderable diſtance, in a ſpace betwixt the tops of the thighs, and ſubſervient to cleanlineſs, modeſty, eaſineſs of the birth, and the force of throes in delivery.

807. The

807. The ſemen maſculinum is firſt formed in the teſticle; then repoſited in the ſeminal veſicles; afterwards ejected from the penis, into the uterus, where it renders the female ovum prolific: and therefore this muſt be the order of our inquiry into theſe particulars. The human *teſticles*, but ſmall in proportion to the bulk of the body, are, in the fetus, lodged within the abdomen behind the peritonæum; from whence, by degrees, they deſcend into the groins; and are at laſt, in a more advanced age, thruſt down below the groin, perhaps partly by their weight, and partly by the impulſe of the influent blood; yet ſometimes they are obſerved to remain behind in the groin of adults. They deſcend by a paſſage, which in the fetus is open, cellular, and called the *proceſs*, leading from the cavity of the peritonæum into the ſcrotum; and the ſame paſſage, after the teſticle is tranſmitted, is contracted by a law of nature, and preſerves the teſticle.

808. The teſticle is defended by various integuments; of which the firſt and outermoſt is that of the *ſcrotum*, made up of a cloſe cellular ſtratum, repleniſhed with veſſels, and cloſely adhering to the ſkin: which laſt has a kind of elaſtic or contractile motion at the approach of cold and in the act of venery, altho' without any muſcular fabric; yet it has commonly action enough to wrinkle the ſcrotum, and draw up the teſticles. This cellular coat, commonly called *dartos*, is placed round each of the teſticles ſeparately, by the conjunction of which together in the middle, is formed a kind of ſeptum, which appears more remarkable in a dry preparation; and this ſeptum is often imperfect in its upper part, towards the penis.

809. Within the dartos is ſpread a looſe cellular ſtratum, without any fat, except in the lower part of the ſcrotum, and may be inflated like the ſame ſubſtance in other parts. Next follows a muſcle, from its office called *cremaſter;* which ariſes from the degenerating fibres of the leſs oblique muſcle of the abdomen, and from the tendon of the external obliquus, called by

ſome a *ligament*, and by others *fibres*, deſcending from the os pubis backward into a vagina or capſule, which, every way ſurrounding the teſticle, ſerves to compreſs, elevate, and forward its contents.

810. Next to this follows the ſecond cellular ſtratum, whoſe ſpungy fabric is continued with the outermoſt, that lies round the peritonæum; and this ſecond ſtratum is called *tunica vaginalis*. In this the veſicles or cells of its fabric appear larger than elſewhere, and may be inflated one after another. At the beginning of the teſticle, above the epididymis, it is, in a manner ſo ſeparated from the reſt above the teſticle, towards the rings of the abdominal muſcles, that the inflation can hardly be continued through. Betwixt this laſt membrane and the following is a ſpace, into which are exhaled thin vapours, and ſometimes a water is collected. The inner coat, called *albuginea*, is a ſtrong, white, compact membrane, which immediately inveſts and confines the proper ſubſtance of the teſticle itſelf.

811. The teſticle more properly ſo called, is of an oval figure, with an acute vertex, looking upwards and a little outwards. The *epididymis* is a kind of additament to the teſticle; and is a flat ſubſtance, reſembling thick tape, which goes round the poſterior margin of the teſticle, to which it is connected by the cellular texture, and by blood-veſſels. In the lower part it is plain; on the upper part it adheres to the teſticle by a thick and convex head, as it does alſo on the lower part. In the middle, it is partly attached by its baſis, and being partly free makes a blind ſac.

812. To the teſticle the *ſpermatic* arteries deſcend, one on each ſide, generated by the aorta below the renal arteries; but not unfrequently from the renal arteries themſelves, from thoſe of the capſules, or from the aorta itſelf above the emulgents. This artery, the ſmalleſt in the body in proportion to its length, deſcends a long way outward before the pſoas muſcle, and gives ſmall branches to the fat of the kidney, to the ureter, meſocolon,

mefocolon, glandules of the loins, and to the peritonæum; but more efpecially towards the bottom of the kidney, it gives a remarkable branch inflected and covered with fat, yet leffening itfelf, that takes a ferpentine courfe behind the peritonæum, as far as the ring of the abdomen. This ring is formed entirely of the tendinous fibres, defcending from the external oblique mufcle, interrupted in their oblique defcent by a long aperture, growing wider downward; from this aperture part of the fmaller inner fibres are broadly detached to the os pubis, and others croffing cohere with the fibres belonging to the other fide of the mufcle, which, being collected together, is called the *inner column*. Other ftronger external fibres, diftinguifhed from the former by the aperture, are broadly inferted by a thick bundle into the outer fide of the os pubis, under the denomination of the *external column;* from whence various fibres run off to the fafcia lata and groin. The upper part of this opening is in fome meafure clofed up by fibres, arifing from the outer column, and afcending in a curve direction round the inner and weaker column. Below thefe fibres there is often a fmall opening left, parted off by tendinous fibres, thro' which defcends the fpermatic artery, with the vein, and vas deferens, with a good deal of cellular fubftance by which they are wrapt together into a cylindrical cord; before the external column, through no perforation of the peritonæum, which it has every where lying on this fore part of it. At the bafis of this ring, the *ductus deferens* is joined with the rope of veffels, and the whole bundle arrives at the groin, and thence at the fcrotum. The fpermatic artery gives many fmall branches to the cremafter, to the cellular coat, and to the feptum of the fcrotum; and then defcends in a double plexus, to the tefticle; of which the principal comes from betwixt the epididymis and origin of the vas deferens, at the middle and lower part of the tefticle, and then goes, by tranfverfe branches, through the albuginea: the other plexus, that accompanies the vas deferens in the upper

part

part of the teſticle, has a like termination, and is variouſly inoſculated with the former. There are other ſmall arteries, which go to the coverings of the teſticle from the epigaſtrics, and others from thoſe of the bladder, which follow the courſe of the vas deferens, both which communicate with the ſpermatic veſſels.

813. Many of theſe ſmall arteries play about the epididymis; but the larger of them ſpread tranſverſely through the albuginea, which they perforate in ſeveral places, to enter the innermoſt fabric of the teſticle, through which they are minutely ramified in all points, and ſeparated by numberleſs membranous partitions. There is no large anaſtomoſis or communication betwixt the ſpermatic artery and vein here, any more than in other parts of the body; but ſome red blood is received into thoſe branches that paſs through the albuginea to the innermoſt ſubſtance of the teſticle. But from the long courſe of this artery, the ſmallneſs of its diameter, the number of ſerpentine flexures, the great ratio of the dividing branches to their trunk, and the coldneſs of their ſubcutaneous diſtribution, demonſtrate, that the blood flows not only in a ſmall quantity, but very ſlowly, to the teſticle.

814. The *ſpermatic vein* of the right ſide, is inſerted into the cava; but that of the left pours its blood into the emulgent vein, or into both: it is enormouſly larger than the artery, and takes the ſame courſe in company with that; but both its trunk and branches are much larger and more numerous, very ſerpentine, and formed into a bunchy plexus of conſiderable length, which is interwove with the artery, and continued as low as the teſticle, there by degrees dividing into two like the artery. There are ſome valves in this vein, but rare.

815. Theſe external coverings of the teſticle have ſmall arteries from the epigaſtrics; the ſcrotum from the crural arteries, and thoſe of the trunk, with an internal branch, which is called the *external pudenda;* the

the fellow veins go to the ſaphena, and to the crural trunks.

816. The *nerves* of the teſticle are many, whence it has a peculiar tenderneſs of ſenſation; inſomuch that faintings and convulſions follow from bruiſing or injuring the teſticle, and particularly a conſtriction of the jaws. Some of them ariſe deep from the renal plexus, from the meſenteric plexus, from the trunk of the intercoſtal nerve, and laſtly from the meſocolic plexus, and follow the courſe of the ſpermatic veſſels. Others are proper to the ſurface of the coverings of the teſticle, from the ſecond, third, and fourth pair of the nerves of the loins.

817. I have frequently obſerved *lymphatic* veſſels in the ſpermatic cord, which are judged to ariſe from the teſticle itſelf, and mix themſelves with thoſe that accompany the inguinal blood-veſſels. The induſtry of late anatomiſts has traced them even to the network of the teſticle itſelf.

818. The blood, moved ſlowly and in a ſmall quantity through the ſpermatic artery, by which it is brought to the inner fabric of the teſticle (813.), is there drained into very ſmall veſſels, which carry their fluids to the *ſeminal veſſels*, although we are ignorant of the manner by which the arteries communicate with theſe canals, the bundles of which form the whole ſubſtance of the teſticle. Theſe ſeminiferous veſſels are exceeding ſmall, ſerpentine, firm, or ſolid, and have a very ſmall light in proportion to their membranes; they are not, however, blind, as I have ſeveral times filled them through the vas deferens. They are collected together into bundles, above twenty in number, divided by diſtinct cells or partitions, which deſcend from the albuginea to conduct the arteries and veins. In each of theſe cells there is a ſeminiferous duct, to convey the ſecreted humour from the ſeminiferous vaſcules. Twenty or more of theſe ducts form a *net-work*, adhering to the ſurface of the albuginea, and forming inoſculations one with another; and quickſilver is very eaſily poured from them

into the ſurrounding cellular texture. From that net in the upper part of the epididymis, aſcend 20 or 30 ducts, which, being contorted together into folds, form as many *vaſcular cones*, that are joined together by an intermediate cellular ſubſtance; and lying incumbent one upon another, then form the head of the epididymis, and in that head ſoon meet together into one duct without the teſticle.

819. This duct being intricately wove by an infinite number of folds and ſerpentine flexures, after a manner not imitated in any other part of the body, and connected together by a great number of looſe cellular ſtrata, is afterwards collected by a membrane of the albuginea into one bundle, called the *epididymis*. But the duct of which it is compoſed, grows larger as it deſcends, being largeſt at the bottom of the teſticle; from whence again aſcending along the poſterior face of the teſticle, in a direction contrary to itſelf, it by degrees ſpreads open its ſpiral convolutions, and comes out much larger, under the denomination of *ductus deferens*. Almoſt always, however, a ſmall veſſel ſeparates ſomewhere from the ductus deferens, and aſcends along with the cord, having an uncertain termination.

820. This is the courſe deſcribed by the ſemen, propelled forward by the motion of the ſucceeding juices in the teſticle; and perhaps, in ſome meaſure, though ſlowly, by the contraction of the cremaſter: as we may reaſonably ſuppoſe, from the numberleſs ſpires and convolutions formed by the epididymis, obſtructing almoſt every kind of injection; and, as we may conclude, from the length of time that is required to fill the ſeminal veſicles again, after they have been once exhauſted.

821. The cylindric ductus deferens being made of a very thick ſpungy ſubſtance, included betwixt two firm membranes, bored through with a very ſmall tube, aſcends in company with the cord of the ſpermatic veſſels, and together with them paſſes through the ring of the abdomen (812.): thence it deſcends into the pelvis; and applying itſelf to the bladder betwixt the

the ureters, it ſoon after meets the ſubjacent receptacles, called the right and left *veſiculæ ſeminales*. Here it goes along the inner ſide of the veſicle, as far as the proſtate glandule; and dilating in its paſſage, forms a ſerpentine flexure, that begins itſelf to put on a cellular appearance. But very near the proſtate, being continued from theſe cellular bendings, with a conical duct coming out from the veſicle, it unites in a very acute angle, which does at the ſame time itſelf form a conical duct; which being continued rather with the vas deferens, and ſinking through the proſtate gland, is there wrinkled into a large fold, and going off outwards at right angles from its companion on the other ſide, and afterwards ſtraitened, it opens into the urethra, through a little hollow protuberance, which has a long tail or deſcent, and is laterally perforated with two very ſmall openings, one on each ſide. By injecting a liquor into the ductus deferens of a dead ſubject, we perceive that it flows both into the urethra and into the ſeminal veſicle, but more readily into the former: but in a living perſon the ſemen never flows out but in the act of venery; and conſequently the ductus deferens conveys all its ſemen, without further delay, over a retrograde angle, to the *ſeminal veſicles*.

822. By this laſt denomination we call a ſort of ſtrong convoluted inteſtine-like membrane, placed under the baſis of the bladder, connected towards its neck by a good deal of cellular ſubſtance: from this ten or more blind gut-like cells or inteſtinuli go off laterally, in ſome meaſure ramified and divided, but ending in impervious conical extremities. This kind of inteſtine, intermixed with a great deal of firm cellular ſubſtance and ſmall veſſels, is ſo contracted together, as to lie within a ſhort ſerpentine heap. For the reſt of its fabric, it ſeems to have externally a pulpy and thick membrane, and likewiſe ſomething ſimilar to the ductus deferens. Internally it is wrinkled, having a ſort of villous appearance; and is beſides ſaid to have ſmall pores and glandules, with which I am unacquainted,

quainted, but various and hollow cells it certainly has.

823. The liquor depoſited into this reſervoir, is in the teſticle yellowiſh, thin, and watery: and the ſame nature it retains in the veſicle, only becomes there ſomewhat thicker and higher coloured; and laſtly, it is white in mankind, when it goes off mixed into one with the liquor of the proſtate. It has a ſort of heavy or ſtrong ſmell, of a peculiar kind in each claſs of animals; and it is the heavieſt humour in the human body. In water, however, a part goes off into a kind of cuticle, like a cobweb, that ſwims in the liquid; the greater part, which is ſeemingly of a pulpy nature, falls to the bottom. In the ſemen which is long kept by chaſte people, ſhining globules mixed with the white liquor are eaſily to be ſeen. It has a very great quantity of mucus.

824. Without the conveyance of this into the womb, no claſs of animals, of which there are two ſexes, can be fecundated ſo as to propagate their ſpecies. The reaſon of this was concealed from us, till the microſcope taught, that in man, as well as in all other male animals, the ſeminal liquor is full of living animalcules, reſembling eels, only with a thicker head; and that theſe are always preſent in healthy ſemen, from the time that a perſon comes of age; but, before that time, and in thoſe who are ſterile from a gonorrhæa, they are abſent. That they are animacules, appears evidently from their various motions, reſtings, and geſtures of body.

825. It has been much doubted what could be the uſe of theſe animalcules; and in another place we ſhall conſider the diſpute concerning the opinion that they are as it were the firſt appearance of the future animal. To me, in the mean time, the nature of the ſeminal animalcules ſeems to be the ſame with that of the eels in vinegar or paſte.

826. That the ſemen is produced from the lymph of the blood, and that the chyle is added to the lymph, will appear probable from the ſudden alacrity to venery that

that happens after eating, and which is leſſened by faſting. It is compounded of the liquor of the teſticles and ſeminal veſſels, the former indeed being more evident in ſome animals, and the coagulable milk of the proſtate gland. That liquor, however, only fecundates which is generated in the teſticles; as we ſee from geldings, which, though they have the ſeminal veſſels and proſtate, are yet barren.

827. The ſeminal fluid is retained in the veſicles as long as a man neither exerciſes venery, nor ſports in imaginary dreams. But it is always a ſtimulus to the animal appetite of venery, as long as it is there preſent in any quantity. But beſides this, there is a conſiderable ſtrong, volatile, and odorous part of the ſemen abſorbed again into the blood, where it produces wonderful changes as ſoon as it begins to be formed; ſuch as the protruſion of the beard, the covering of the pubes, a change of the voice and paſſions, horns in cattle, &c. for theſe changes in the animal are not the conſequences of age, but of the ſeminal fluid, and are always abſent in eunuchs. The growth and ſtrength of caſtrated animals are conſtantly diminiſhed; and in like manner the fierceneſs of their temper, and the ſtrong ſmell of their whole body, are remarkably weakened. And from the examples of ſome animals, and even of mankind, it appears, that the irritation of this fluid has occaſioned death, by exciting convulſions. A retention of the ſemen may follow from a narrowneſs of the excretory duct, a ſcirrhoſity of the proſtate, and other cauſes not ſufficiently known.

828. The quantity of ſemen expelled at one time from the human veſicles is but ſmall, more eſpecially in a man who has not long abſtained from venery; and it is natural to think that the liquor can be but ſlowly produced from ſo ſmall a ſubcutaneous artery. Its generation is accelerated by love, by the preſence of the beloved woman; ſo that it diſtends its veſſels with a ſenſe of pain. Nature herſelf, therefore, enjoins venery, both for preſerving the human race, and likewiſe the

health of every ſound man. But that it comes from the teſticle, is ſhewn by diſeaſes, in which the ductus deferens being obſtructed, a ſwelling of the teſticle has enſued. From the veſicle it does not go out, except by the venereal act.

829. Seeing the ſemen is in ſmall quantity, that it might be projected with a greater force, and to a further diſtance, nature has joined another humour, which is generated by the *proſtate*. This is a gland, ſhaped like a heart, with the ſmall end foremoſt, ſo as to ſurround the origin of the urethra, but moſt round its upper ſide. This is one of the hardeſt and moſt compact glands, of a peculiar fabric, yet not evidently conglomerate; it prepares a thick, white, ſoft, or cream-like liquor in a large quantity, which is poured out at the ſame time and from the ſame cauſes (840.) with the ſemen itſelf, into a little valley or channel at each ſide of the openings of the ſeminal veſicles, where, mixing with the ſeminal fluid, it imparts thereto the white colour and viſcidity with which it is predominant.

830. But it was neceſſary for this canal of the urethra to be firm and capable of a direct figure, that it might be able to throw the ſemen with ſome ſtrength into the diſtant womb; and therefore a three-fold cavernous body ſurrounds it. The firſt and proper cavernous body of the urethra begins, as ſoon as that canal has paſſed the proſtate, with a thick origin, almoſt like a heart, firſt under the urethra, and then above it, but thinner; from thence it ſurrounds the whole canal, through the whole length of the penis, till the lower part terminates in the glans, while the upper part is reflected back from the extremity of the urethra, and, being dilated, returns in a direction contrary to that of the penis, which being circumſcribed by a broad circumference, gradually extenuated, and ſomewhat round, terminates the extremities of the cavernous bodies, upon which it is incumbent, and with thoſe for the moſt part communicates by an imperfect ſeptum. The fabric of this body is cellular, but of a larger ſort than

than the cells of the cavernous bodies, being composed rather of plates than fibres, interwoven like a net, and intercepted betwixt two firm membranes.

831. Into this cavernous body of the urethra, the blood is poured out from the arteries, which come from deep branches sent off from the external hæmorrhoidals (836.); the truth of which is demonstrated by the injection of any kind of fluid, which, being urged into the said arteries, easily flows into these cellular spaces, surrounding the urethra. But these are not naturally turgid with blood, because there are veins open and numerous enough in proportion to drink up and return what is poured in by the arteries; but if the return is impeded by compressing those veins from the powers hereafter mentioned (839.), the blood is then retained within the cellular spaces, while the arteries continue to import it more swiftly and strongly than the veins return it. Thus the stagnant blood distends the bulb of the urethra, together with its cavernous body, and the glans itself. But this is performed generally at the same time when the other cavernous bodies of the penis, with which this of the urethra has no communication, are likewise rigidly distended.

832. But the cavernous bodies of the penis arise from the ossa ischii and pubis, where they are conjoined by a white, cellular, very dense, and firm substance; from whence inclining inward towards each other, they take betwixt them the urethra, a little before its bulb, where, changing their direction, they go on parallel, conjoined together, and with the urethra extended forward along their middle, and terminate with an obtuse end in the glans, and laterally they are comprehended by the cavernous body of the urethra. These bodies are covered with a very firm integument, and their internal flesh is spungy, like that of the urethra (830.), like which it is capable of being distended by the reception of the blood. Betwixt both cavernous sacs there is a middle septum or partition, composed of firm parallel tendinous fibres, growing narrower downward; but

not

not continuous one to another, that the intermediate ſpaces might be larger and more numerous, as they are more forward; and that they might leave a free communication betwixt the right and left ſpungy body. Other ſuch robuſt fibres run through the cavernous bodies, and are very firmly inſerted into the ſides of their membranous ſac, ſo as to prevent an aneuriſm or over-diſtention of the penis.

833. Theſe cavernous bodies are ſurrounded with a good deal of very tender cellular ſubſtance; of which that ſide lying next the cavernous bodies is denſe and firm, like a membrane; but from thence outward, towards the ſkin, its fabric is cellular and very tender, without including any fat, and continuous with the cellular membrane of the ſcrotum, but always the more tender the nearer the ſkin it is; and, by blowing air into it, it appears to have a fine ſilky texture. But the glans (830.) is naturally covered in ſuch a manner, that the ſkin is continued from the penis, and folded back againſt itſelf, as we obſerve in the eye-lids; both folds of the ſkin being covered with its proper cuticle, and ſtuffed, each with its proper cellular ſtratum, under the name of *preputium*, or prepuce; which may be, like a cap, drawn back from, and again brought over, the glans; at which it changes into a tender papillary body, vehemently ſenſible, covered with its proper cuticle and cellular ſubſtance, ſpread over the reflected cavernous body of the urethra (830.); and, finally, is continued with the membrane of the urethra itſelf. The ſaid prepuce is tied by a double triangular ligament, by which the common ſkin is conjoined to that which makes the covering of the glans. Upon the excavation that ſurrounds the crown of the glans, as well as upon the crown itſelf, are ſeated ſimple ſebaceous follicles, which ſeparate a liniment of a peculiar, ſomewhat fetid ſmell, from the nature of their ſeat, ſerving to abate the attrition of the ſkin, as in other parts of the body. Finally, the whole body of the penis is ſuſtained by a firm cellular plate, compacted into a kind of triangular liga-

ment,

ment, which defcends from the fynchondrofis of the offa pubis, and is from thence continued into the denfe cellular ftratum that furrounds the hard cavernous bodies.

834. The whole human penis forms a cylindrical body, depreffed on the upper part, of variable magnitude, whofe ufe is to be received into the female parts of generation, and to carry thither prolific femen.

835. Thefe cavernous bodies then of the penis, having their fpungy fabric diftended in coition by the blood retained by the veins, and ftill propelled by the arteries, become rigidly turgid, and fuftain the otherwife flaccid or but weakly filled urethra, in fuch a manner that it may be able to conduct the femen into the diftant womb. All this is demonftrated from the diffection of brute animals in the act of venery, from an artificial erection, and from the injection of liquid matters into the veffels of the penis. The caufe is in love, in the defire of pleafure, the friction of the glans, various irritations of the bladder, tefticles, feminal veffels, urethra, from the urine, from abundance of good feed, from the venereal poifon, from cantharides, whipping with rods, or convulfion of the nerves. But the caufe of this diftention remains ftill to be explained. The diftribution of the blood-veffels into the genital parts are therefore to be here defcribed, to make it evident how ready the compreffing caufe conftantly is to act upon the veins.

836. The aorta at the fourth vertebra of the loins, and the vena cava at the fifth, are divided, the former before the latter. The common iliac branches, not yet arrived to the middle of the interval in the thighs, fend off inward and downward a confiderable artery, called the *hypogaftric*, which in the fetus is larger than the femoral artery, and in the adult is equal to it. This defcending into the pelvis, divides into four, five, or fix principal branches; of which the firft is the *iliacus anterior*, which fupplies branches upward to the dura mater, cauda equina, and loins, and afterwards into

to the os ſacrum. The next, or *ſacro-lateral* artery, goes off from the bone of that name, when it does not ariſe from the former; and the third, or *iliaca-poſterior*, is diſtributed to the glutei muſcles. The fourth is the *iſchiatica deſcendens*, to ſeveral muſcles, nerves, and levators of the anus. The fifth trunk is that of the *hæmorrhoidea infima* or *pudenda communis*, which in the cavity of the pelvis ſends conſiderable branches to the bladder, and to the rectum gives the middle hemorrhoidal joined with the meſenterics; after which, going out of the pelvis, it creeps by the ſide of the obturator, and gives off the *external hæmorrhoideals* to the ſphincter and ſkin of the anus: then dividing, it goes with an internal branch to the bulb of the urethra and ſurface of the proſtate, where the external is again divided: here it enters deeply the cavernous body of the penis, and runs through its whole length; while by another branch often joined with the veſſels of the bladder, it runs along the back of the penis, according to the direction of its bodies, and terminates with them by ramifications into the ſkin. The ſixth is the *obturatrix*, ſpent upon the joint of the femur and adjacent muſcles. The laſt is the *umbilical artery*, to be deſcribed in treating of the fetus; although in adults it ſends off ſome branches to the bladder, from its thick callous vagina. Sometimes one or more of theſe arteries come from the common trunk. The ſkin of the penis and ſcrotum have their arteries from the epigaſtric, and from the internal branch of the crural. Theſe external arteries communicate in many places with the internal.

837. The *veins* are, in general, diſtributed in like order with the arteries. They come off in two trunks from the iliacs, joining together into a net; and then the *hæmorrhoidal* vein, bending round under the os pubis, forms a large plexus, ſpread with the veins of the pelvis upon the proſtate and ſeminal veſicles: from hence the *vena penis* ariſes, which is often ſingle, and furniſhed with valves to forward the return of the blood.

blood. The external veins of the penis and ſcrotum go to the ſaphena and crural, communicating in ſeveral places with the internal veins, more eſpecially at the baſis of the prepuce.

838. *Lymphatic veſſels* of the penis are, by moſt eminent anatomiſts, ſaid to run under the ſkin towards the groins. The *nerves* of this part are both numerous and very large, and accompany the arteries of the penis from the trunk of the great ſciatic nerve. But the bladder, rectum, and uterus, are ſupplied by the *lower meſenteric* plexus, which ariſes from the middle one, deſcending into the pelvis.

839. In order to diſtend the penis, there muſt be either a compreſſure of the vein (837.), bringing back the blood from the cavernous bodies of the penis or urethra; or at leaſt it is neceſſary that there be a conſtriction of the leſſer veins that every where open within the cavernous bodies, to hinder them from abſorbing and returning the blood from the arteries. The firſt, however, may be effected by the levator, drawing up the proſtate and bladder : but it is very probable, that, as we ſee in the nipples of the ſuckling mother, in the gills of the peacock, and in the bluſhing or redneſs of the face from paſſions of the mind, as well as from brute animals, which all couple without the uſe of any erector muſcle; from the erections which take place in animals totally different from man, and eſpecially thoſe which take place in birds very ſwiftly; from the libidinous reſt of the erector muſcles themſelves in the erection of the penis, and from their unfitneſs for compreſſing the veins; from all theſe it is probable, that the courſe of the blood through the vein may be retarded, without the immediate uſe of any muſcle; and that by the power of the latent multitude of ſmall nervous bridles, by whoſe conſtriction, from the force of pleaſure, the veins are compreſſed and ſtraitened, ſo as to return leſs blood to the trunks, at that time, than what is imported by the arteries, which are not only free from any ſtricture, but, by the increaſe of the pulſe,

bring a greater quantity of blood, which cause also contributes to produce the erection. But the cause of this constriction in the nervous bridles or sphincters themselves depends upon a mechanical irritation of the nerves, and from something more subtile, by which means the penis is immediately erected.

840. A long continued and violent erection is commonly joined, at last, with an expulsion of the semen; and this requires much greater force than is requisite for the erection only. For the semen follows at that time when the irritation of the nerves is arrived at its greatest height: and in natural venery indeed, when at length the cellular spaces of the urethra and its continuous glands, which are at last filled, become so far distended with a large quantity of warm blood, that the nervous papillæ, stretched out in the latter, become violently affected from the irritating or pleasurable cause; the seminal vesicles are evacuated by the levator muscles of the anus, which press them against the resisting bladder with a convulsive motion, excited either by a voluptuous imagination, or from the pruritus that is exquisite in the nerves of the glans, principally in its lower part, which is in the neighbourhood of the frenum. Hence the semen is never discharged with any of the urine, in an healthy man; because the expulsion of it requires the bladder to be closed or drawn up firmly together; for, while lax, it affords little or no resistance to the seminal vesicles. The transverse muscles seem to dilate the canal of the urethra for the reception of the semen expressed from the vesicles.

841. Soon afterwards the powers constringing the urethra are, from the irritation of the very sensible fabric of that canal, put into action. To this constriction conduce principally the accelerator (802.), which makes a powerful concussion of the bulb and adjacent part of the urethra, so as to propel the contents more swiftly, in proportion as the bulb has a larger diameter than that of the urethra. But that this may act firmly, the

sphincter

ſphincter of the anus, together with that of the bladder, muſt be well ſhut. The accelerator muſcle ſeems alſo principally concerned in the erection, by compreſſing the veins of the corpus cavernoſum of the urethra. At the ſame time the *erectores penis*, as they are called, ariſing from the tubercles of the iſchium, become ſtrong, and are inſerted into the cavernous bodies, ſuſtaining the penis as a ſort of medium betwixt the tranſverſe and perpendicular direction. Thus the ſemen is drove into the vagina and into the uterus itſelf, in a prolific coition: the whole action of which is very impetuous, and comes near to a convulſion; whence it wonderfully weakens the habit, and largely injures the whole nervous ſyſtem, as the maladies ariſing from thence ſeem to indicate, which come from the affection of the nerves, without which the ſemen cannot be expelled.

CHAP. XXX.

Of the Virgin Uterus.

842. THE *uterus* is ſeated in the upper part of the pelvis, with the bladder before, and the rectum behind it, without adhering to either of them, and has its mouth turned a little forwards. In an adult woman, it is contained within the pelvis; but in an infant, it lies above it. In women, the peritonæum deſcends from the os pubis into the pelvis, over the poſterior face of the bladder, down to the bottom or mouth of the uterus: from whence again it aſcends over the foreſide of the uterus; and paſſing round its convexity, deſcends on the poſterior ſide down to the vagina, from whence it extends laterally or tranſverſely on each ſide, including the rectum with lunated folds, which is all the difference betwixt the female and male peritonæum. But this ſame peritonæum, coming into the pelvis from the iliac veſſels, and broadly adhering to the ſides of the

the uterus and vagina, is folded back over itſelf, and divides the pelvis into two parts, the anterior and poſterior, like a partition, under the denomination of *ligamentum latum*. Thus the peritonæum accurately connects the uterus, without the intervention of any fat, ſo as to ſerve it on all ſides as an external coat or covering. It does not, however, hinder the uterus from being totally free and moveable.

843. The body of the uterus is uſually diſtinguiſhed from its neck. The body is flatly convex before and behind, with acute edges on each ſide and at the meeting of its convexities, but converging gradually afterwards for ſome way; in its upper part, moderately convex. It has a peculiar fabric, being made up of a cloſe, firm, but ſomewhat ſucculent and cellular fleſh, in which we perceive the appearance of muſcular fibres, more eſpecially in thoſe women that have born children: ſome of which fibres are flat, and mixed with one another into a kind of net-work; others run along the uterus longitudinally, from the bottom to the mouth of the uterus, diſpoſed in various circles, and particularly at the fundus betwixt the tubes, and likewiſe in the neck near the mouth. In beaſts, the uterus is manifeſtly muſcular; and in women, likewiſe, gives evident ſigns of a contractile power. Its outer coat is received from the peritonæum. As for any mucous ſinuſes variouſly branching and dividing within the fleſh of the uterus, after repeated inquiries we now declare, that we have not been able to find any; only ſome veins, ſurrounded with cellular ſubſtance, by which their diameters are ſuſtained. The internal membrane of the uterus is continued from the cuticle; in the upper part of the cavity, fleecy; and in the lower part, callous, like valves. The cavity of the uterus is ſmall, for the moſt part triangular upward, and below like a compreſſed cylinder. The cylindric part, which is called the *cervix* or *neck*, is compreſſed, thick, and has alſo a cylindric cavity within. It is altogether rough, with callous wrinkles riſing up into an edge, whence they incline

incline towards the vagina. These recede laterally from the anterior and posterior margin, joining together by small wrinkles, in the intervals of which are small mucous sinuses, with small pellucid spherules, filled with a very clear liquor, in some parts interspersed through the upper region of the cervix uteri, differing both in their number and magnitude. It is not uncommon for the uterus to be distinguished by a line or protuberance extended through its middle. The cervix is terminated by the os internum uteri, with a transverse rim, forming protuberant lips, which project for some length into the vagina, are received by its blind extremity, and project into it obliquely forward. But it is full of mucus, and mucous sinuses situated in its swelling lip.

844. The triangular part of the uterus sends out, from its lateral angles, canals, in some measure folded together by the cellular substance, growing gradually broader, and, being again a little contracted towards their extremity, they proceed towards the ovary, first in a transverse direction, and afterwards a little descending, but with some variation, under the denomination of the uterine *tubes*. Their external membrane is from the peritonæum: for they are included within the duplicature of the broad ligament, which is a production of that membrane; internally they are wrinkled almost reticularly, lined with mucus, extended to a considerable length by intervening plates or folds which broadly crown the opening of the tube, which is also connected to the ovary. Betwixt the two membranes is something of a spungy cellular substance, of a slender texture. They also contain usually a mucus, the origin of which is not known. There are also great numbers of vessels, and perhaps some muscular fibres, but the latter are more obscure. They are supported by the proper fold of the peritonæum which goes out from the broad ligament.

845. But the *ovaries*, included in the same duplicature of the broad ligament behind the tubes, are seated transversely,

tranfverfely, and conjoined to thefe tubes by a ligamentary expanfion of their own, which is long enough to allow them a free motion. They are fomewhat of an oblong or oval figure, depreffed on each fide, convex upon their unconnected fide, and half elliptical; but that which is connected with the ligament is ftraight. Their membrane, which comes from the peritonæum, is thick, and almoft cartilaginous. Their fabric nearly enough refembles that of the uterus itfelf; being a clofe, white, cellular fubftance, compacted together, without any fat. The margin of the broad ligament, receding from the uterus to fuftain the ovary, has fomething of a more folid and thick fubftance, refembling a ligament, yet is not a hollow or true canal.

846. But, in the ovary even of a tender virgin, are fituated round vefícles made of a pretty ftrong pulpy membrane, connected every where to the ovarium by cellular threads, which are filled with coagulable lymph; of an uncertain number and magnitude, being found in one ovary to 15 and upwards. Thefe remarkable bodies are found very widely diffufed through all animals, even fuch as have but one fex.

847. Laftly, the uterus fends out from the fame lateral angles of its triangular body downward, a kind of fafciculus, compofed of long cellular fibres and fmall veffels, which, becoming fmall in its progrefs, goes out of the pelvis through the ring of the abdomen (812.) into the groin, where it fplits into branches, and diffolves into fmall veffels, which communicate with the epigaftrics. Whether or no it has any long fibres propagated from the uterus itfelf, does not plainly appear.

848. The *arteries* of the uterus are from the hypogaftrics; a confiderable branch of which goes off, like that to the bottom of the bladder in men; or at leaft it arifes from the umbilical trunk, or immediately below that trunk, and makes the common artery belonging to the uterus, bladder, and rectum. It fpreads on the lower parts of the uterus, almoft at the extremity of its neck; and, afcending upwards, fends tranfverfe in-

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flected branches to the uterus, makes numerous anaſtomoſes with the *ſpermatics*, and often gives arteries to the tube itſelf. Another plexus of branches tends downwards to the vagina, and follows it a long way; although there is otherwiſe a proper vaginal artery originating in the pelvis, and branches ſometimes come from the meſocolic. There are alſo ſeminal veſſels which have the ſame origin as in men; and form a plexus, which, from its ſimilitude to the tendrils of a vine, is called *pampiniformis*. This plexus, deſcending over the pſoas muſcle into the pelvis, divides into two plexuſes. The poſterior ſurrounds the ovary itſelf, with many circles, elegantly diſtributed through its ſubſtance and the ova themſelves. The anterior both ſupplies the tube, and deſcends to the uterus itſelf, in which it ſends out winding branches upward and downward, and ſome branches that are detached to the bladder. Another artery is the *middle hæmorrhoidal*, coming from the common trunk of the pundendeal, a conſiderable way forward with the vagina; to which, and to the bladder and rectum, it is diſtributed. The beginning of the vagina likewiſe, and the clitoris, have arteries from the external hemorrhoidal, which are diſtributed like thoſe of the penis, ſome inwardly, others ſuperficially, both of which inoſculate with the veſical branch.

849. The courſe of the uterine *veins* is like to that of the arteries, originating from the trunks of the hypogaſtrics; they are the internal uterine, the vaginal, the middle hemorrhoidal, the external circumflex, and thoſe of the clitoris. But they make a remarkable plexus on each ſide, which occupies the ſides of the vagina below the clitoris. Below that, it is joined into a continued plexus with its companion on the other ſide. A plexus alſo from the external hemorrhoidal, and joined with the veſical veſſels, goes to the clitoris, as well as to the penis. It has no valves, except a few in the ſpermatics. Theſe, in a very large bundle, go to the ovarium, and wings of a bat.

850. Within the uterus itſelf the arteries terminate in exhaling branches on its internal cavity. By childbirth theſe go off into little pendulous productions, like very ſmall eels. Thus the veins of the uterus are at the ſame time very large ſinuſes; for the veins are enormouſly augmented, and open with very large mouths into their cavity.

851. *Lymphatic veſſels* are found in the uterus of brutes, but more rarely in the human; they have been obſerved, however, by very eminent anatomiſts.

852. The *nerves* are ſupplied from the lower meſocolic plexus, united with thoſe of the ſacrum, which ſends out large branches to the bladder, womb, and rectum; beſides which, there are a few nervous twigs that deſcend through the broad ligament to the ovaries, and others from the nerve that goes with the veſſels to the clitoris. But the ovary has alſo its proper nerves from the renal plexus, ſimilar to thoſe which go to the teſticles of the male. The great number of the nerves, therefore, make theſe parts extremely ſenſible.

853. The deſcriptions we have hitherto given, are in common to all ages of the female; but about the 13th year, or ſomewhat later, nearly at the ſame time when ſemen begins to form itſelf in the male, there are likewiſe conſiderable changes produced in the female. For, at this time, the whole maſs of blood begins to circulate with an increaſed force, the breaſts are filled out, and the pubes begins to be cloathed: at the ſame time the menſes in ſome meaſure make their appearance; by a common law of nature, although in different countries both the time and quantity of the flux is different.

854. But, before the menſtrual flux, there are various ſymptoms excited in the loins, heavy pains, ſometimes like colic pains, with an increaſed pulſe, headachs; and cutaneous puſtules commonly precede, and a white juice commonly flows from the uterus. For now the fleecy veſſels of the uterus, which in the ſtate

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of the fetus, were white, and tranfuded a fort of milk, as in the young girl they tranfuded a ferous liquor, do now begin to fwell with blood; the red parts of which are depofited through the veffels into the cavity of the uterus. This continues fome days, while, in the mean time, the firft troublefome fymptoms abate, and the uterine veffels, gradually contracting their openings, again diftil only a little ferous moifture as before. But then the fame efforts return again at uncertain intervals in tender virgins; till at length, by degrees, they keep near to the end of the fourth week; at which time follows the flux of blood, as before, which is periodically continued to about the 50th year; though the diet, country, conftitution, and way of life, caufe a great variation in this difcharge. Pregnancy commonly produces a ftoppage of the menfes.

855. This difcharge of blood from the veffels of the uterus itfelf, is demonftrated by infpection in women who have died in the midft of their courfes; and in living women, having an inverfion of the uterus, the blood has been feen plainly to diftil from the open orifices: in others, in whom, when the menfes have been deficient, the uterus has appeared full of concreted blood. It alfo appears from the nature of the uterus itfelf, full of foft fpungy veffels, compared with the thin, callous, little fleecy, and almoft bloodlefs fubftance of the vagina. But that this is a good and found blood in an healthy woman, appears both from the foregoing and innumerable other obfervations. For nothing hinders the blood from being fent forth thro' the vagina, as in other cafes it is through the inteftinum rectum, and laftly through the remoteft parts of the body.

856. Since none but the human fpecies are properly fubject to this menftrual flux of blood, (although there are fome animals who, at the time of their vernal copulation, diftil a fmall quantity of blood from their genitals), and fince the body of the male is always free from the like difcharge, it has been a great inquiry in all

ages, what ſhould be the cauſe of this ſanguine excretion peculiar to the fair ſex. To this effect the attraction of the moon, which is known to raiſe the tides of the ſea, has been accuſed in all ages; others have referred it to a ſharp ſtimulating humour, ſecreted in the genital parts themſelves, the ſame which is the cauſe of the venereal deſire. But if the moon was the parent of this effect, it would appear in all women at the ſame time; which is contrary to experience, ſince there is never a day in which there are not many women ſeized with this flux; nor are there fewer in the decreaſe than the increaſe of the moon. As to any ſharp ferment ſeated in the uterus or its parts, it will be always inquired for in vain; where there are none but mild mucous juices, and where venery, which expels all thoſe juices, neither increaſes nor leſſens the menſtrual flux: and women deny, that, during the time of their menſes, they have any increaſed deſire of venery; ſeeing at that time moſt of the parts are rather pained, and languid; and the ſeat of venereal pleaſure is rather in the entrance of the pudendum than in the uterus, from which laſt the menſes flow. But, laſtly, that the menſtrual blood is forced out by ſome cauſe exciting the motion of the blood againſt the veſſels, appears from hence, that, by a retention, the courſes have been known to break through all the other organs of the body, where no vellicating ferment could be ſeated, even ſo as to burſt open the veſſels of each organ; nor is the effect of the retained blood circumſcribed by thoſe parts which pour out the venereal humour.

857. Nature has, in general, given women a body with ſofter or looſer veſſels, and ſolids that are leſs elaſtic; their muſcles are alſo ſmaller, with a greater quantity of fat interpoſed both betwixt them and their fibres; the bones too are ſlenderer and leſs ſolid, and their ſurfaces have fewer proceſſes and aſperities. Moreover, the pelvis of the female is, in all its dimenſions, larger; the oſſa ilia ſpread farther from each other; and the os ſacrum recedes more backward from the bones

of

of the pubes, while the oſſa iſchii depart more from each other below; but, above all, the angle in which the bones of the pubes meet together to form an arch, is in the female remarkably more large or obtuſe: which differences are confirmed by the obſervations of the greateſt anatomiſts; and from neceſſity itſelf, which requires a greater ſpace for a greater number of viſcera in the pelvis. Moreover, the uterine arteries are conſiderably large, more ſo than in men; and have a greater proportion of light, with reſpect to the thickneſs of their coats: but the veins are, in proportion, leſs ample than in the men; and of more firm reſiſting texture, than in other parts of the body. From hence it follows, that the blood, brought by the arterial trunk to the womb, by paſſing from a weaker artery into a narrow and more reſiſting vein, will meet with a more difficult return, and conſequently endeavour to eſcape or go off by the lateral veſſels.

859. The female infant new-born has her lower limbs very ſmall; and the greater part of the blood, belonging to the iliac arteries, goes to the umbilicals, ſending down only a ſmall portion to the pelvis. Hence the pelvis is ſmall, and but little concave; ſo that the bladder and uterus itſelf, with the ovaries, project beyond the rim of the pelvis. But when the fetus is born, and the umbilical artery is tied, all the blood of the iliac artery deſcends to the pelvis and lower limbs, which of courſe grow larger, and the pelvis ſpreads wider and deeper: ſo that, by degrees, the womb and bladder are received into its cavity, without being any longer compreſſed by the inteſtines and peritonæum, when the abdominal muſcles urge down upon the lower parts of the abdomen. When now the increaſe is perfect, or next to it, then in general we find thoſe arteries of the uterus largeſt, which in the fetus were leaſt, and eaſily injected with wax; and all things are changed in ſuch a manner, that the hemorrhoidal artery is now in place of the hypogaſtric (836.), when formerly the umbilical had been the trunk of that artery. More

 blood,

blood, therefore, at that time comes into the uterus, vagina, and clitoris, than was formerly in uſe to do.

860. At the ſame time, when the growth of the body begins conſiderably to diminiſh, the blood, finding eaſy admittance into the completed viſcera, is made in a greater quantity, the appetite being now very ſharp in either ſex, in both which a plethora from thence follows. In the male, it vents itſelf frequently by the noſe, from the exhaling veſſels of the pituitary membrane being dilated to ſo great a degree without a rupture, as to let the red blood diſtil through them (458.); and now the ſemen firſt begins to be ſecreted, and the beard to grow. But in the female, the ſame plethora finds a more eaſy vent downward; being that way directed partly by the weight of the blood itſelf, to the the uterine veſſels now much enlarged, of a ſoft fleecy fabric, ſeated in a looſe hollow part, with a great deal of cellular fabric interſperſed, which is very yielding and ſucculent, as we obſerve in the womb; for theſe cauſes, the veſſels being eaſily diſtendible, the blood finds a more eaſy paſſage through the very ſoft fleecy exhaling veſſels, which open into the cavity of the uterus, as being there leſs reſiſted than in its return by the veins, or in taking a courſe through any other part; becauſe, in females, we obſerve the arteries of the head are both ſmaller in proportion, and of a more firm reſiſting texture. The return of the ſame is therefore more ſlow, both becauſe the flexures of the arteries, from the increaſed afflux of the blood, become more ſerpentine and fit for retarding the blood's motion, and likewiſe becauſe it now returns with difficulty through the veins. The blood is, therefore, firſt collected in the veſſels of the uterus, which at this time, by repeated diſſections, are obſerved turgid or ſwelled; next it is accumulated in the arteries of the loins and the aorta itſelf, which, urging on a new torrent of blood, impelled from the heart by degrees, augments the force, ſo far as to open and wedge the red blood into the ſerous veſſels, which at firſt tranſmit an increaſed quantity

quantity of warm mucus, afterward a reddiſh-coloured ſerum; and by further opening, they at laſt emit the red blood itſelf, which, however, in this diſcharge, has uſually a greater proportion of ſerum. The ſame greater impulſe of blood, determined to the genital parts, drives out the hitherto latent hairs, increaſes the bulk of the clitoris, dilates the cavernous plexus of the vagina, and whets the female appetite towards venery. Accordingly we find, that the quantity of the menſtrual flux, and the earlineſs of their appearance, are promoted by every thing that either increaſes the quantity or momentum of the blood with reſpect to the body in general, or which direct the courſe of the blood more particularly towards the uterus; ſuch as joy, luſt, bathing of the feet, a rich diet, warm air, and lively temperament of body. It is diminiſhed by thoſe things which diminiſh plethora and the motion of the blood, as want, grief, cold air, ſloth, and diſeaſes which have gone before.

861. When ſix or eight ounces of blood have been thus evacuated, the unloaded arteries now exert a greater force of elaſticity, and, like all arteries that have been overcharged with blood, contract themſelves by degrees to a leſs diameter, ſo as at length to give paſſage only to the former thin exhaling moiſture; but the plethora or quantity of blood, being again increaſed from the ſame cauſes, a like diſcharge will always more eaſily enſue through the veſſels of the uterus, after they have been once thus opened, than through any other part. Nor is there any occaſion to perplex ourſelves about the cauſe, why this periodical diſcharge is, for the moſt part, nearly regular or menſtrual; for this depends upon the proportion of the quantity and momentum of the blood daily collected, together with the reſiſtance of the uterus, which is to yield again gradually to the firſt courſe. Therefore this critical diſcharge of blood never waits for the interval of a month, but flows ſooner or later, according as the greater quantity of blood in plethoric women is determined, by luſt or other cauſes, towards the uterus. Finally, they ceaſe

to

to flow altogether, when the uterus, like all the other ſolid parts of the body, has acquired ſo great a degree of hardneſs and reſiſtance, as cannot be overcome by the declining force of the heart and arteries, by which the blood and juices are driven on through all the veſſels. This increaſed hardneſs in the old uterus is ſo remarkable in the arteries and ovaries, that it eaſily diſcovers itſelf both to the knife and the injections of the anatomiſt. But, in general, brute animals have no menſes; becauſe, in them, the womb is in a manner rather membranous than fleſhy, with very firm or reſiſting veſſels, which, with the difference of their poſture, never permit a natural hemorrhage from the noſtrils or other parts. They are wanting in men, becauſe in that ſex there is no ſpongy organ fit for retaining the blood; and likewiſe becauſe the arteries of the pelvis are both harder in proportion than the veins and leſs, and thus the impetus of the blood in the lower limbs is turned away, and which veſſels in men are larger, as thoſe of the pelvis are ſmaller.

862. It will, perhaps, be demanded, why the breaſts fill out at the ſame time with the approach of the menſes? We are to obſerve, that the breaſts have many particulars in their fabric, common to that of the uterus; as appears from the ſecretion of the milk in them after the birth of the fetus, which increaſes or diminiſhes in proportion as the lochial flux is either increaſed or diminiſhed; from the ſimilitude of the ſerous liquor, like whey, found in the uterus, ſo as to reſemble milk, in thoſe who do not ſuckle their children, being of a thin and white conſiſtence, appearing very evidently in brute animals; alſo from the turgeſcence or erection of the papillæ or nipples of the breaſt by friction, analogous to the erection of the clitoris. Therefore, the ſame cauſes which diſtend the veſſels of the uterus, likewiſe determine the blood more plentifully to the breaſts; the conſequence of which is an increaſed bulk and turgeſcence of the conglomerate glandules and cellular fabric which compoſe the breaſts.

CHAP.

CHAP. XXXI.

Of CONCEPTION.

863. IT is very difficult to difcufs this fubject, as we have to fearch out what happens in the inward parts of a woman, when in her begins to germinate the life of a new man, whom, in proper time, fhe brings forth into the light. We fhall relate, in the firft place, therefore, thofe things which experience fhews to be true; and then add thofe hypothefes by which learned men have endeavoured to fupply fuch things as are not evident from the fubject itfelf. How few things are afcertained on this fubject, and how difficultly they are afcertained, I have learned by too much experience.

864. That fome light may be thrown on fuch a dark fubject, we fhall begin with the moft fimple animals, and afterwards take notice of what nature has added in others whofe fabric is more compounded. The fmalleft animals then, which have very few or no limbs, the leaft diftinction of parts, the fhorteft life, the vital functions both few and very fimilar to one another; thefe animals bring forth young ones like themfelves, with no diftinction of fexes, as all of them are fruitful, and none imparts fecundity to the reft. Some of them exclude their young whom they have conceived in their body, through a certain cleft; from others, fome limbs fall off, which are completed into animals of a kind fimilar to thofe from which they have fallen off. This kind of generation is extended very wide, and comprehends the greater part of animal life.

865. The next to thefe, which are a little more compounded, all bring forth their young; yet in fuch a manner, that in their bodies is generated a certain particle peculiar to themfelves, diffimilar to the whole animal, and contained in fome involucra, within which

lies

lies the animalcule that is afterwards to become ſimilar to that within which it is produced; this is commonly called an *egg*. A great part of theſe animals is immoveable.

866. The animals which follow are not indeed numerous, but have both eggs, and male ſemen beſides; ſo that both ſexes are joined in the ſame animal. But we call it *male ſemen*, becauſe it is neceſſary for ſprinkling the eggs in order to render them prolific, although it never grows alone in the new animal. In this claſs, therefore, a juice is prepared by its own proper organs, which is likewiſe poured on the eggs through organs proper to itſelf, but different from the former, in order to generation.

867. Thoſe animals are much more numerous which have both a male juice and female eggs; yet ſuch as cannot fecundate themſelves, but ſtand in need of real venery. For two animals of this kind agree in the work of fecundation, in ſuch a manner, that each impregnates the other with its male organs, and again ſuffers itſelf to be impregnated in its female ones by the male parts of the other.

868. And now the nature of animals approaches nearer and nearer to that of the human race; of which, namely, ſome individuals of a ſimiliar kind have only male organs, and the ſame males ſprinkle their ſeed on the female eggs of others. Very many cold ones ſprinkle their ſeed upon the eggs after they are poured out of the body of the mother. Warm animals inject their ſemen into the uterus of the female. But now, if eggs are generated within the body of the female, they are brought forth covered with ſhells or membranes; but if the female has a live fetus in its uterus, it is born quite free of any involucrum: but the difference between theſe oviparous and viviparous animals is but ſmall; ſo that in the ſame claſs, and the ſame genus, ſome animals lay eggs, others produce live fetuſes; and laſtly, the ſame animal ſometimes lays eggs, and ſometimes brings forth live young.

689. From

869. From this review of animals it appears, that all animals are produced from others ſimilar to themſelves; many from a part of it ſimilar to the whole; others from an egg of a peculiar ſtructure; but that all theſe do not ſtand in need of male ſemen. Laſtly, the more moveable and lively animals only, whoſe bodies are of a more complicated ſtricture, are endowed with a double ſyſtem for generation; and the difference of ſexes ſeems to be added for the bond of ſocial life, and for the ſafety of a leſs numerous progeny.

870. For the certain effuſion of this male juice into the female organs, both ſexes are inflamed with the moſt vehement deſires: the male indeed has the moſt lively ones, becauſe the female is at all times ready to ſuffer the venereal congreſs; and thence it behoves the male to be animated with a deſire of venery, when he has plenty of good ſeed, and ſuch as is of a prolific nature. Therefore this is the greateſt cauſe of venereal deſire in him; but in females, of the brute kind eſpecially, ſome kind of inflammation in the vagina, which excites an intolerable itching.

871. But nature has firſt added to the womb, both in women and in quadrupeds, a vagina or round membranous cavity, eaſily dilatable, which, as we have already ſeen (843.), embraces and ſurrounds the projecting mouth of the uterus; from whence it deſcends obliquely forward under the bladder, and reſting upon the rectum with which it adheres, and laſtly opens under the urethra with an orifice a little contracted. This opening, in the fetus and in virgins, has a remarkable wrinkled valve, formed as a production of the ſkin and cuticle, under the denomination of *hymen*, which ſerves to exclude the air or water; not perhaps without ſome kind of moral uſe, ſeeing this membrane, as far as I know, is given to women alone. It is circular, excepting a ſmall deficiency under the urethra, which yet is not always conſtant, but ſpreads itſelf very broadly below towards the anus. This membrane being inſenſibly worn away by copulation,

its lacerated portions at laſt diſappear. The caruncles, which are called *myrtiformes*, are partly the remains of the ſhattered hymen, and laſtly the valves of the mucous lacunæ hardened into a kind of fleſh.

872. The fabric of the *vagina* is ſomewhat like that of the ſkin, compoſed of a firm, denſe, or callous cuticle, covering a thick, white, nervous ſkin, in which, more eſpecially at its end, appear fleſhy fibres. Its internal ſurface is, in a great meaſure, rough, beſet with many callous warts, which, though hard, are ſenſible: beſides which, there are thin plates, terminated with a protuberant inclined edge, pointing downward, ſo as to form two principal rows, ſpreading betwixt thoſe warts; and of theſe, the uppermoſt are extended under the urethra, where they are larger, as the lower are incumbent on the anus. From each of theſe to the other are continued, on both ſides, ſeveral rows of leſſer valve-like papillæ, variouſly inflected into arches, and which ſeem to be deſigned for increaſing the pleaſure, and facilitating the expanſion when it is called for. It is furniſhed with a proper mucus of its own, ſeparated from particular ſinuſes in ſeveral parts, but more eſpecially in its poſterior and ſmoother ſide.

873. At the entrance of the vagina are prefixed two cutaneous productions or appendages, called *nymphæ*, continued from the cutis of the clitoris, and from the glans itſelf of that part; and theſe, being full of cellular ſubſtance in their middle, are of a turgeſcent or diſtendible fabric, jagged and repleniſhed with ſebaceous glandules on each ſide, ſuch as are alſo found in the folds of the prepuce belonging to the clitoris. Their uſe is principally to direct the urine, which flows betwixt them both from the urethra, that in its deſcent it may be turned off from clinging to the body, in which office the nymphæ are drawn together with a ſort of erection. Theſe membranous productions deſcend from the cutaneous arch ſurrounding the *clitoris*, which is a part extremely ſenſible, and wonderfully influenced by titillation; for which it is made up, like the penis, of

of two cavernous bodies, arifing in like manner from the fame bones, and afterwards conjoining together in one body, but without including any urethra. It is furnifhed with blood-veffels, nerves, and levator mufcles, and a ligament fent down from the fynchondrofis of the os pubis, like thofe in men, like unto which the clitoris grows turgid and erect in the venereal congrefs, but lefs in thofe who are very modeft; but from friction, the clitoris always fwells up and is erected.

874. The mufcle, termed *oftii vaginæ conftrictor*, arifing on each fide from the fphincter of the anus, and increafed by the acceffion of a branch from the os ifchium, covers the vafcular plexus, from whence it proceeds outward in the direction of the labia externa, and is inferted into the crura clitoridis; thus it feems to comprefs the lateral venal plexufes of the vagina, whence it every way conduces to retard the return of the venal blood. The tranfverfe mufcle of the urethra, and the bundle from the fphincter inferted into it, have the fame fituation as in men.

875. When a woman is invited either by moral love, or a luftful defire of pleafure, and admits the embraces of the male, whofe penis, entering the vagina, is rubbed againft its fides, until the male feed breaks out and is poured out into the uterus. It then excites a convulfive conftriction and attrition of the very fenfible and tender parts, which lie within the contiguity of the external opening of the vagina, after the fame manner as we obferved before of the male (840.). By thefe means the return of the venous blood being fuppreffed; the clitoris grows turgid and erect, more efpecially in luftful women; the nymphæ fwell on each fide, as well as the venal plexus, which almoft furrounds the whole vagina, fo as to raife the pleafure to the higheft pitch: in confequence of which there is expelled, by the mufcular force of the conftrictor (874.), but not perpetually, nor in all women, a quantity of lubricating mucous liquor, of various kinds. The principal fountains of this are feated at the firft beginning or opening of the

urethra, where there are large mucous ſinuſes placed in the protuberant margin of this uriniferous canal. Moreover, there are two or three large mucous ſinuſes, which open themſelves into the cavity of the vagina itſelf, at the ſides of the urethra, in the bottom of the ſinuſes which are formed by the membranous valves ſulcated upward. Laſtly, at the ſides of the vagina, betwixt the bottoms of the nymphæ and the hymen, there is one opening, on each ſide, from a very long duct; which, deſcending towards the anus, receives its mucus from a number of very ſmall follicles.

876. But the ſame action which, by increaſing the pleaſure to the higheſt degree, cauſes a greater conflux of blood to the whole genital ſyſtem of the female (563.), occaſions a much more important alteration in the interior parts. For the hot male ſemen, penetrating the tender and ſenſible cavity of the uterus, which is itſelf now turgid with influent blood, does there excite, at the ſame time, a turgeſcence and diſtention of the lateral tubes, which are very full of veſſels, creeping betwixt their two coats, and now ſtiff with the great quantity of blood they contain; and theſe tubes, thus copiouſly filled and florid with the red blood, become erect, and aſcend, ſo as to apply the ruffle or fingered opening of the tube to the ovary. In the truth of all theſe particular changes, we are confirmed by diſſections of gravid or pregnant women, under various circumſtances; alſo from the comparative anatomy of brute animals, and from the appearances of the parts when diſeaſed.

877. But, in a female of ripe years, the ovary is extremely turgid, with a lymphatic fluid, which will harden like the white of an egg, and with which little bladders are diſtended. In a prolific copulation, ſome one of the more ripe veſicles is burſt, a cleft manifeſtly appears, and at length pours out a clot of blood. Within this veſicle, after copulation, a kind of fleſh grows up, at firſt flocculent, then granulated, and like a conglomerate gland, conſiſting of many kernels joined

ed together by a cellular ſubſtance; which fleſh by degrees becoming larger and harder fills the whole cavity of the veſicle, and is hardened into the nature of a ſcirrhus, in which, for a long time, remains a cleft, or a veſtige of one. This is the *corpus luteum*, common to all warm quadrupeds, in which ſome late anatomiſts have found a ſort of juice before copulation; which, however, experience does not admit, ſeeing there is no corpus luteum at that age. But neither is the veſicle, which is the human ovum, contained in a body like a cup.

578. The extremity of the tube, therefore, ſurrounding and compreſſing the ovarium in a prolific congreſs, is thought to preſs out and ſwallow a mature ovum, from a fiſſure in the outer membrane, from whence it is continued down by the periſtaltic motion of the tube, to the uterus itſelf; which periſtaltic motion begins from the firſt point of contact with the ovum, and urges the ovum downward ſucceſſively to the opening into the fundus uteri, which is very manifeſt in brute animals. The truth of this appears from the conſtant obſervation of a ſcar or fiſſure in the ovarium, which is produced there after conception; from a fetus being certainly found in quadrupeds, both in the ovarium of the female, and in the tube; from the analogy of birds, in which the deſcent of the ovum from the ovarium is very manifeſt. Yet we muſt acknowledge, that a true ovum was never found in quadrupeds, unleſs after a long time. It is probable, that at the time of conception, the true ovum is almoſt fluid, very ſoft and pellucid, and cannot be diſtinguiſhed from the mucus with which the tube is filled; likewiſe, that it is very ſmall, on account of the narrowneſs of the tube. The veſicle itſelf which was in the ovary remains in it fixed, and becomes the covering of the corpus luteum. But the accounts of ova ſaid to have fallen from women during the firſt days are not certain, and are contradicted by the ſmallneſs of the fetus obſerved many days after conception; by the ſhape in which it is firſt obſerved, which

which is always oblong, and in brutes even cylindrical; and likewife by the fmallnefs of the tube.

879. Thefe things are performed, not without pleafure to the future mother, nor without a peculiar fort of fenfation of the internal parts of the tube, threatening to induce a fwoon. Neither is the place of conception in the uterus, whither certain experience fhews that the male femen comes. For the power of the male femen fecundates the ovum in the ovaria themfelves, as we fee in the cafe of fetufes found in the ovaries and tubes; from the analogy of birds, in which by copulation one egg indeed falls into the uterus, but very many are fecundated at once in the ovaria. Nor is the fmall quantity of the male femen, or its fluggifh nature, any objection to this, which by eminent anatomifts has been thought to render it lefs fit for performing fuch a journey. For it is certain that the male femen fills the tubes themfelves at the firft impregnation, both in women and brute animals.

880. The uterus indeed, in animals certainly, and in women probably, is clofed, left the very fmall ovum, together with the hope of the new progeny, fhould perifh. At that time the new mother fuffers many difagreeable affections; which probably arife from the fubputrid and fubalkaline male femen reforbed into the blood. A naufea is occafioned by conception, almoft in the fame manner as by fwallowing a bit of a rotten egg. Flefh is at this time chiefly naufeated; a vomiting alfo occurs; fome puftules break out, and the teeth ach. The moft of thefe complaints I reckon to be owing to the fwelling of the uterus, and the retention of the menfes.

881. Thefe things as yet are either certainly evinced by the teftimony of our fenfes, or can be confirmed or corrected by them. Thofe which follow are more conjectural; and the more difficult on account of the paucity of experiments, and their difagreement with one another. And in the firft place, it is a difficult queftion, From whence proceed the firft ftamina of the new animal?

animal? Whether are they from both parents, and mixed into one animal by a conjunction of seminal matter coming from the whole body; as indeed there is a resemblance of the fetus to both parents in animals, but especially in plants, as confirmed by very many experiments: the same thing also seems confirmed by the faults of parents being conveyed to their children. But no seed has ever certainly been observed in females; and innumerable examples shew, that the species of animals may be propagated without any mixture of seeds. Lastly, the resemblance of the young animal to its father seems only to shew, that in the male seed there is some power, which only can form the soft matter of the embryo in its least state; just in the same manner as that power adds length to the pelvis in certain bodies, dilates the larynx, and causes the horns appear.

882. To the father some have attributed every thing; chiefly after the seminal worms, now so well known, were first observed in the male seed by the help of the microscope, which are observed with truth to agree in figure with the first embryos of all animals. But in these animals there is wanting a proportion betwixt their number, and that of the fetuses; they are also not to be constantly observed through all the different tribes of animals; they have too great a resemblance to those animalcules that are every where spontaneously produced in other juices, which yet are always tenacious of their own genus, and are never found to grow in the most dissimilar kinds of animals that have limbs.

883. Again, other anatomists, not less celebrated or less worthy of credit, have taught that the fetus existed in the mother and maternal ovary; which the male semen excites into a more active life, and likewise forms it variously, so as to shew it just brought into life, and make its presence manifest. Yolks are also manifestly found in the female ovaries, even although they have not been impregnated with any male semen. But a yolk is known to be an appendix to the intestine of

fowls;

fowls; and to have its arteries from the meſenteric artery, and the covering of the yolk to be continued with the nervous membrane of the inteſtine, which is continuous with the ſkin of the animal. Along with the yolk, therefore, the fetus ſeems to be preſent in the mother hen, of whom the yolk is a part, and which gives veſſels to the yolk. Laſtly, that the analogy of nature ſhews that many animals generate eggs without any connection with a male of the ſame ſpecies, but that a male animal never becomes prolific without a female. That the progreſſions are continued from a female quadruped to an oviparous animal, and from that to one which is not oviparous. But the young animal proceeds from a part of the old one from which it is generated. Certainly, therefore, the males muſt give ſome addition to that ſex which produces the fetus from its own body; which addition is neceſſary in ſome tribes of animals, but in others may be wanted. But neither is it poſſible that with any kind of truth we can admit of an inſertion by which the open navel of the male animal when conceived ſhould adhere to the veſſels of the female. For this navel would be by far too ſmall at the time when the yolk is of a conſiderable bigneſs; neither could the very ſmall umbilical arteries be applied to the very large yolk with any hope of a continuance of the circulation.

884. Thus much concerning the materials: but we are again difficulted concerning the formation, by what means the rude and ſhapeleſs maſs of the firſt embryo is faſhioned into the beautiful ſhape of the human body. We readily reject ſuch cauſes as a fortuitous concourſe of atoms, the blind attractions between the particles of the nutritious juices, and the ſtrength of ferments inconſcious of the reaſons why they operate; the ſoul is certainly an architect unequal to the taſk of producing ſuch a beautiful fabric; as for internal models, of which I never could conceive one clear idea in my mind, we ſhall refer them to thoſe hypotheſes which the deſire of explaining

explaining those things of which we are unwillingly ignorant has given rise to.

885. To me, indeed, experience seems to agree with those things which the mind foresees will follow from their own causes. Namely, that this most beautiful frame of animals is so various, and so exquisitely fitted for its proper and distinct functions of every kind, and the offices and manner of life for which the animal is designed; that it is calculated according to laws more perfect than any human geometry; that the ends have been foreseen in the eye, in the ear, and the hand, so that to these ends every thing is most evidently accommodated: it appears, therefore, certain to me, that no cause can be assigned for it below the infinite wisdom of the Creator himself. Again, the more frequently, or the more minutely, we observe the long series of increase through which the shapeless embryo is brought to the perfection necessary for animal life, so much the more certainly does it appear, that those things which are observed in the more perfect fetus have been present in the tender embryo, although the situation, figure and composition seem at first to have been exceedingly different from what they shew themselves to be at last; for an unwearied and laborious patience has discovered the intermediate degrees by which the situation, figure, and symmetry, are insensibly reformed. Even the transparency of the primary fetus alone conceals many things which the colour added a little after does not generate, but renders conspicuous to the eye. And it sufficiently appears that those parts which eminent anatomists have supposed to be generated in after times, and to be added to the primeval ones, have been all cotemporary with the primeval parts, only small, soft, and colourless.

886. It is highly probable, that for a long time the latent embryo neither increases nor is agitated, except by a very gentle motion of the humours, which we may suppose to librate from the heart into the neighbouring arteries, and from these into the heart of the fetus.

But we may alſo ſuppoſe, that the ſtimulus of the male ſemen excites the heart of the fetus to greater contractions, ſo that it inſenſibly evolves the complicated veſſels of the reſt of the body by the impulſe of the humours, and propagates the vital motion through all the canals of the little body of the animal; that it is more quick in ſome parts, and more ſlow in others; and that from thence it happens that ſome parts of the body of the animal ſeem to be produced very early, and others to ſupervene afterwards; and laſtly, that ſome do not ſhew themſelves until a long time after birth, as the veſicles of the ovaries, the veſſels of the male teſticles, the teeth, hairs of the beard, and horns of brute animals. In all animals, heat aſſiſts this evolution; in the more ſimple ones whoſe veſſels are few, and leſs complicated in their various origins, it is the ſole inſtrument of bringing it to perfection.

887. Of the objections which are uſually brought, ſome are not true, ſuch as the ſuppoſitions of an excreſcence of a different ſtructure from the reſt of the body; others ſeem to belong to cauſes depending on ſome accident, ſuch as moſt kinds of monſters; ſome to the increaſe of ſome particular parts, occaſioned by the powers of the male ſeed; ſome to the cellular texture variouſly relaxed, as it ſeems to increaſe in the parts newly produced, or to be occaſioned by indurated juices. Although it is not eaſy to explain every thing mechanically, yet we ought to remember, that if indeed the new animal is truely, and ſhewn by experience to be, preſent in the egg, thoſe difficulties which are moved cannot overturn ſuch things as have been truely demonſtrated, although perhaps ſome things may remain, to which, in ſo great an infancy of human knowledge, we cannot yet give a full anſwer.

888. When the human ovum is brought down into the uterus, we become more ſenſible of its change of ſhape after the interval of a few days. The ovum itſelf ſends out every where ſoft branchy flocculi from the ſuperficies of its membrane hitherto ſmooth, which adhere

adhere to and inosculate with the exhaling and resorbing flocculi of the uterus (843.) This adhesion happens every where in the uterus; but chiefly in that thick part which is interposed between the tubes, and is called the *fundus uteri*. Thus the thin serous humour of the uterus, proceeding from its arterial villi, is received into the slender venous vessels of the ovum, and nourishes it together with the fetus. But before this adhesion, it is either nourished by the matter it already contains, or else by such juices as it absorbs from the surrounding humours, if indeed there is any time when it does not adhere.

889. At this time, in the ovum, there is a great proportion of a limpid watery liquor, which, like the white of an egg, hardens by the heat of fire, or a mixture with alcohol; and now the fetus, for a long time invisible, as I have never observed it before the 17th day, makes its appearance at first a shapeless mass, consisting of mere mucus, and as yet seemingly of a cylindrical shape. When some distinction of parts is next to be seen, it has a very great head, a small slender body, no limbs, fixed by a very broad flat navel to the obtuse end of the ovum.

890. From hence forward the fetus continually increases as well as the ovum, but in an unequal proportion: for while the arterial serum is conveyed by more open passages into the smaller vessels of the ovum, the fetus itself grows the fastest; because now the greatest part of its nourishment seems to pass through the very large umbilical vein. At the same time the ovum itself also grows, but less in proportion; and the waters, which it includes, gradually diminish from their first proportion, in respect of the bulk of the fetus. The fleecy productions of the vessels from the ovum are gradually spread over with a continued membrane, and only those which sprout out from the obtuse end of the ovum take root, or increase so as to form a round circumscribed placenta or cake.

891. Such is the appearance of the ovum, as we

have here defcribed it, commonly in the fecond month; from whence forward it changes only by increafing in bulk. That part of the ovum next the fundus uteri is commonly uppermoft, making about a third of its whole furface, in form of a flat round difh or plate; fucculent, fibrous, full of protuberances, but throughout perfectly vafcular; changing into other tubercles of the fame kind, for the moft part accurately, and often infeparably, connected with the uppermoft part of the uterus, remarkable for its large veffels, of a thin cellular texture, collecting the veffels every where, but chiefly in the circumference of the greateft circle, as well the exhaling arteries anfwering to fuch as come from the uterus into the veins of the placenta, as the arteries of the placenta opening into the large veins of the uterus. There, in the common furface of the uterus and placenta, a communication is made, by which the uterus fends to the fetus, firft that white ferous liquor not unlike milk, and laftly, as it feems, red blood itfelf. This communication of the humours feems to be demonftrated by the fuppreffion of the menfes in women with child, whofe blood muft be turned into another channel; from the lofs of blood which follows from a feparation of the placenta in a mifcarriage; and from the blood of the fetus being exhaufted from an hemorrhage in the mother; from hemorrhages that enfue from the navel-ftring, fo as to kill the mother when the placenta has been left adhering to the uterus; and, laftly, from the paffage of water, quickfilver, tallow, or wax, injected from the uterine arteries of the mother into the veffels of the placenta, as is confirmed by the moft faithful obfervations. But that it is blood which is fent into the fetus, is evinced by the magnitude of the finufes of the uterus and placenta; the diameter of the ferpentine arteries of the uterus; the hemorrhage that follows, even when the placenta is very flightly hurt; but efpecially by the motion of the blood, which, in a fetus deftitute of a heart, could only be given to the humours of the fetus by the blood of the mother.

892. The

892. The remaining part of the ovum, and likewiſe the ſurface of the placenta, are covered by an external villous and fleecy membrane, full of pores and ſmall veſſels, of a reticular fabric, eaſily lacerable, ſo as to reſemble a fine placenta, and is called the *chorion*. But even this is connected to the flocculent ſurface of the uterus, which is very like to itſelf, but ſofter, by veſſels ſmaller than thoſe of the placenta, but manifeſtly inoſculated from the chorion into the veſſels of the uterus.

893. Under the chorion lies a continuous, white, opaque, and firm membrane, not vaſcular, which does not cover the part of the placenta turned towards the uterus, but is concave, and turned to the fetus. It coheres by a cellular texture both to the chorion and amnios. The moſt ſimple name we can give it, is the *middle* membrane.

894. The innermoſt coat of the fetus, which is called *amnios*, is a watery pellucid membrane, very rarely ſpread with any conſpicuous veſſels, which yet I have obſerved in an human ſubject; extremely ſmooth, and in all parts alike; alſo extended under the placenta with the former, the ſurface of which is every way in contact with the waters. If there are more fetuſes than one, either in man or beaſt, each of them has their proper amnios.

895. The nouriſhment of the fetus from the beginning to the end of the conception, is without doubt conveyed to it through the *umbilical vein*. This gathers its roots from the exhaling veſſels of the uterus (854.), and has manifeſt communications by ſome roots with the umbilical artery, from whence it in part riſes, and, meeting together in a large trunk, is twiſted in a circular manner through a number of folds to a ſufficient length, that may allow of a free motion; and in this courſe it is ſurrounded with a cellular ſubſtance full of mucus, diſtinguiſhed by three partitions, and the membrane which is continued to the amnios, but known by the name of the *umbilical rope*; and after forming

forming ſome protuberances, it enters through the navel, in an arch made by a parting of the ſkin and abdominal muſcles, and goes on through a proper ſinus of the liver (692.), into which the ſmaller portion of the blood that it conveys is poured through the ſlender ductus venoſus into the vena cava ſeated in the poſterior foſſa of the liver: but the greater part of its blood goes through the large hepatic branches, which conſtantly ariſe from its ſulcus, and remain even in the adult (695.); but it goes thence to the heart by the continuous branches of the vena cava (697.) The ſinus or left branch of the vena portarum itſelf is a part of the umbilical vein, and its branches bring the blood from the placenta to the cava, while the right branch alone carries the meſenteric and ſplenic blood through the liver.

896. But this is not all the uſe of the placenta: for the fetus ſends great part of its blood again into the ſubſtance thereof, by two large *umbilical arteries*, which are continued on in the direction of the aorta; and after giving ſome ſlender twigs to the femorals, with ſtill ſmaller arteries into the pelvis, they aſcend reflected back with the bladder on each ſide of it, ſurrounded with the cellular plate of the peritonæum, with ſome fibres ſpreading to them from the bladder and urachus, in which manner they proceed on the outſide of the peritonæum into the cord at the navel, in which paſſing alternately in a ſtraight and contorted courſe, they form various twiſtings or windings, ſomewhat ſharper than thoſe of the vein which they play round; in which manner they at laſt arrive at the placenta, whoſe ſubſtance is entirely made up of their branches, in conjunction with thoſe of their correſponding veins, and a ſlippery cellular ſubſtance following both veſſels; ſo that the kernels themſelves that are conſpicuous in the placenta, are convolutions of thoſe veſſels. By theſe branches the blood ſeems to paſs out through the minute arteries of the placenta into the bibulous veins of the maternal uterus, that after undergoing the action

of the lungs by the mother's reſpiration, it may return again in an improved ſtate to the fetus: for what other reaſon can be aſſigned for ſuch large arteries, which carry off above a third part of the blood of the fetus?

897. But it will perhaps be demanded, Whether the fetus is not nouriſhed by the mouth likewiſe? Whether it does not drink of the lymphatic liquor contained in the cavity of the amnios, which is coagulable, unleſs putrefied, and in the middle of which the fetus ſwims, and whoſe origin is not ſufficiently known? Whether this opinion is not in ſome meaſure confirmed by the open mouth of the fetus, and the analogy of chickens, which are under a neceſſity of being nouriſhed from the contents of the egg only: to which add the abſence of a navel-ſtring in ſome fetuſes; the quantity of meconium filling the large, and part of the ſmall, inteſtines; the ſimilitude of the liquor found in the cavity of the ſtomach to that which fills the amnios; the proportionable decreaſe of the liquor amnii, as the fetus enlarges; the glutinous threads which are found continued from the amnios, through the mouth and gula, into the ſtomach of the fetus; the true feces found in the ſtomach of the fetus of quadrupeds; the open mouth of the fetus, which we have certainly obſerved; the gaping of a chicken ſwimming in this liquor, and its attempts as it were to drink it up? Again, what are the fountains or ſprings from whence this lymph of the amnios flows? whether it tranſudes thro' the inviſible veſſels of the amnios, or through certain pores from the ſucculent chorion, which is itſelf ſupplied from the uterus? It muſt be confeſſed, that theſe inquiries labour under obſcurities on all ſides; notwithſtanding which, there ſeems more probability for them than otherwiſe, ſince the liquor is of a nutritious kind, at leaſt in the firſt beginnings of the fetus, and derived from the uterus.

898. All the excremental feces, which are collected in the fetus during the whole time of its reſidence in the womb, amount to no great quantity, as they are the

the remains of ſuch thin nutritious juices, percolated through the ſmalleſt veſſels of the uterus. I frequently obſerve, that the bladder is almoſt empty in the fetus. However, there is generally ſome quantity of urine, collected in a very long conical bladder. But in the cavity of the inteſtines, there is collected together a large quantity of a dark green pulp, which may poſſibly be the remains of the exhaling juices, like the feculent remains, which are ſometimes left in the other cavities of the body that are filled with exhaling juices, and ſuch as I have ſometimes obſerved even in the vaginal coat of the teſticle.

899. It may then be demanded, whether there is any allantois? ſince it is certain, that there paſſes out from the top of the bladder a duct called the *urachus*, which is a tender canal, firſt broad, covered by the longitudinal fibres of the bladder as with a capſule; and afterwards, when thoſe fibres have departed from each other, it is continued thin, but hollow, for a conſiderable way over the umbilical cord, yet ſo that it vaniſhes in the cord itſelf. Whether this, although it be not yet evident in the human ſpecies, is not confirmed by the analogy of brute animals, which have both an urachus and an allantois? But as for any proper receptacle continuous with the hollow urachus, it either has not yet been obſerved with ſufficient certainty, or elſe the experiment has not been often enough repeated, to become general in the human ſpecies; and thoſe eminent anatomiſts who have obſerved a fourth kind of veſſel to be continued along the umbilical rope into its proper veſicle, will not allow that veſſel to be called the urachus, and very lately have referred it to the omphalomeſenteric genus; and in the human fetus, the urine is ſeparated in a very ſmall quantity: but it perhaps may be no improbable conjecture, that ſome portion of the urine is conveyed to a certain extent into the funiculus umbilicalis, and there is transfuſed into the ſpungy cellular fabric that ſurrounds it; and therefore, that, of all animals, man has the longeſt

longeſt umbilical cord, becauſe he alone has no allantois. But then this can take up but a ſmall ſpace, terminating in the funis, and hardly ever ſeems to reach as far as the placenta. Sometimes, even in an adult perſon, this open duct has brought the urine to the navel.

900. In the mean time, the fetus continues to advance in growth; the limbs by degrees ſprout from the trunk, under the form of tubercles; and the other outworks of the human fabricature are by degrees beautifully finiſhed, and added to the reſt; in a manner not here to be at large deſcribed, as indeed it has not been as yet by anatomiſts in general; of which, however, we muſt premiſe ſome compendium.

901. The embryo which we firſt obſerved in the uterus of the mother was a gelatinous matter, having ſcarce any proper ſhape, and of which one part could not be diſtinguiſhed from another. There was, however, in that gluten, a heart, which was the cauſe of life and motion; there were veſſels which generated the humour of the amnios; there were therefore veſſels of the umbilicus and yolk, the little trunks of which, being received from the fetus, are at that time very large, ſeeing they have lately begun to be obſerved. There was both a head and ſpinal column, both parts very large, and larger in proportion to the reſt than ever. There were likewiſe, without doubt, all the reſt of the viſcera, but pellucid and of a mucous nature; for which reaſon, they may be obſerved ſome days ſooner than can be hoped for from nature alone, if you render them opaque.

902. But in the whole fetus, an immenſe quantity of water is mixed together with a very little earth, as the very cellular texture ſurrounds it in a ſtate between fluid and ſolid; ſeeing large drops of water are interpoſed betwixt the remote elements of the ſolid parts.

903. In birds there is added to this the vivifying gluten or white of the egg, which is of the nature of lymph; and the yolk, which is of an oily nature: in man, ſomething of a milky nature, not altogether un-

like the yolk of an egg, and the coagulable lymph. That the blood is perfected from the fat by the proper powers of the fetus, we are perſuaded from the example of birds. From it are inſenſibly prepared all the other humours, but all of them at firſt mild, void of taſte, colour and ſmell, and of a glutinous nature. The proper nature of every one of them approaches to that of ſerum; but ſome of them are not produced till many years after birth, for inſtance the ſemen.

904. The firm parts, even in a grown perſon, make much the ſmalleſt portion even of the harder parts of the human body; in the fetus they differ from the fluids, by a ſomewhat greater degree of coheſion; as yet, however, they are like a gluten, at firſt fluid, and afterwards more conſiſtent. In theſe the fibres which we could not diſtinguiſh in the primeval embryo are by degrees produced; the gluten, as it would ſeem, being ſhaken between the neighbouring veſſels, part of the water expreſſed, and the terreſtrial parts attracting one another. Theſe fibres variouſly comprehend one another, and form a cellular texture, even in diſeaſes, and intercept little ſpaces, in which there is a kind of humour. From this cellular ſubſtance are formed the membranes and veſſels, and almoſt the whole body.

905. The veſſels are the oldeſt parts of the body, and are prepared in the firſt delineation of the embryo. What firſt appears in an egg during the time of incubation, having any diſtinct form, are venous circles: but theſe veins fabricate the arteries, by which they both receive their juice, and the motion of that juice. They are not generated mechanically from an obſtacle, as the arterial blood is found at that time. At firſt the trunks of the veins are conſpicuous, afterwards the branches which convey the humours to the trunks. If they were produced from the arteries reflected, the branches would firſt be ſeen, and the trunks formed in the laſt place. Neither could the arterial blood, driven back by an obſtacle, form thoſe moſt beautiful circles, and bring back the veſſels into the heart. It would rather

ther flow irregularly through the cellular texture. And the primeval heart would ſoon loſe its life, unleſs as much of the humours returned to the heart as was ſufficient to keep up its pulſations.

906. There are, therefore, in the primeval fetus, ſuch as we firſt obſerve it, ſome things more perfect and conſpicuous; others involved, inviſible, and very ſmall. The heart is the moſt perfect; it is the only moveable and irritable part; although it is in many reſpects different from what it is in an adult perſon. The brain is large and fluid; the veſſels formed which appear in the back next to the heart. The viſcera, muſcles, nerves, and limbs, are not yet to be ſeen; the bones themſelves are preſent, of which the firſt appearance is a mucus, as are the veſſels of the reſt of the body. The other portion is that of the abdomen, the umbilical capſule of which is an immenſe hernia.

907. To this embryo is ſuperadded motion, in man almoſt of the heart alone; as alſo in birds, whoſe formation does not take place without heat rather greater than that of the human body: yet, without the heart, heat deſtroys, inſtead of forming the fetus. It is the largeſt in proportion to the reſt in theſe beginnings; afterwards its proportion to the other parts of the body grows gradually leſs and leſs. Its pulſations are alſo at this time the moſt frequent, and in the ſofteſt fetus the moſt powerful for impelling the humours, and diſtending and producing the veſſels.

908. To the force of the heart is oppoſed what is yet of ſervice in forming the fetus, namely, the viſcidity of the vital humours which collect the earthy elements. There is therefore in the embryo both an impelling force, which increaſes the parts longitudinally; and a reſiſting force, which moderates the increaſe, and increaſes the lateral preſſure, and thus the diſtention. By the force of the heart all the arteries, but for eaſineſs of expreſſion we ſhall ſay only one artery, which repreſents all the reſt, with all its ſurrounding cellular texture, is lengthened out; its folds are ſtretched out, and the

fame artery is dilated. And the blood by its lateral preffure makes an effort againft the almoft blind branches of the arteries, fills and evolves them, and fets them off at more obtufe angles: thus are produced fpaces which make very little refiftance, in which the gluten is depofited. In the very fubftance of the artery itfelf, while it is every where dilated, between its imaginable folid threads are prepared little reticulated fpaces like a ftretched-out net, which are equally fit for receiving humours. The largeft of thefe are formed round the heart and in the head, whither the impulfe of the heart drives the humours in a ftraight direction, and in the placenta: the leffer ones are in the inferior part of the body, from which the umbilical arteries fubtract the greateft part of the blood.

909. The fetus increafes very quickly, as is moft evident in the example of a chicken, whofe length the twenty-fecond day is to its length the firft day at leaft as 1,000,000 to 1; and the whole increafe of bulk in the bird during the remainder of its life does not exceed the fifth part of the increafe of the egg the firft day. For the fetus has a larger and more irritable heart, veffels larger in proportion, and likewife more numerous and relaxed, and the folid parts are mucous and diftenfible. The breaft is later of coming to perfection, furrounded with membranes fo foft, that they cannot be feen.

910. The embryo does not only increafe in bulk, but is fo remarkably altered in fhape, that it comes forth into the light totally diffimilar from any thing that could be obferved in it at its firft formation. And firft it is probable, that the articulations of the limbs are produced from the elongated arteries, that they are laterally knit together by a certain gluten, feparately evolved, and at firft that they fprout out very fhort, but afterwards increafe by infenfible degrees, and appear divided into diftinct articulations, as the wings of a bat are formed from an open vafcular net-work. Thus likewife the right ventricle of the heart is expanded by the

the blood coming to it in greater quantity; and, being increaſed by degrees, equals the left.

911. On the other hand, the cellular texture, from its glutinous aqueous nature, by which earthy particles are continually brought to it, becomes inſenſibly harder; by a gentle attraction contracts its parts, which were before ſtraight, into various flexures; and ties the auricles to the heart, from which they were as yet at a diſtance. So the muſcles draw out proceſſes from the bones by their continual pulling, and open ſmall cavities into large cells: the ſame likewiſe incurvate the bones, and variouſly figure them.

912. Preſſure can do a great deal: to it we muſt attribute the deſcent of the teſticles into the ſcrotum, after the irritable force of the abdominal muſcles has taken place: to this alſo we muſt aſcribe the repulſion of the heart into the breaſt, when the integuments of the breaſt are larger: to it we are to aſcribe the length of the breaſt and the ſhortneſs of the abdomen, and the ſmaller ſize of the viſcera of the latter; becauſe the air received into the lungs, dilates the cavity of the thorax. But even the bones are variouſly hollowed out by the preſſure of the muſcles, blood-veſſels, and even of the very ſoft brain itſelf; and by the ſame means fleſh is changed into a tendinous ſubſtance.

913. The power of derivation brings the blood into the pelvis and lower extremities from the cloſed umbilical arteries: the ſame, when the foramen ovale is contracted by the auricles drawn towards the heart, evolves the right ventricle of the heart: when the veſſels of the yolk have taken up the whole length of the egg, and can receive no farther elongation, it dilates the umbilical arteries of the chick, and produces a new membrane with incredible celerity. On the other hand, but by the ſame power, after the blood has got an eaſy paſſage through ſome veſſels of any part, the other parts which do not afford a like eaſy paſſage increaſe the leſs. The head grows leſs after the lower limbs have begun to increaſe in bulk.

914. A

914. A membrane may be formed from a humour of which the thinneſt part is exhaled, as we have an example in the epidermis: from the ſame may be formed a cartilage as happens in the bones, or even a bone itſelf, or ſomething of a ſtony nature, which is very frequent in the teſticles of aquatic animals. The bones at firſt are ſoft, and of a mucous nature; then they become of the conſiſtence of jelly; this afterwards becomes a cartilage; without any change made on the parts, as far as can be obſerved.

915. A cartilage, however, is not afterwards ſecretly changed into a bone. That never happens, unleſs lines and furrows have at firſt run along the cartilage: nay, the red blood has made a paſſage to itſelf through the veſſels of the bones; but theſe veſſels manifeſtly come from the nutritious trunks in the interior parts of the bone, and ſtrike as it were in right lines on the cartilaginous extremity of the body of the bone, which they remove farther and farther from its middle. Round theſe veſſels is formed a cellular texture and laminæ, which ſeem to preſs the veſſels themſelves towards the medullary tube. Laſtly, in the epiphyſis, which both remains much longer cartilaginous, and denies entrance to the blood, the red veſſels penetrate through the cruſt which covers the extremity, as well as the others which come from the exterior veſſels of the limbs. Thus alſo in the epiphyſis is produced a red nucleus of a vaſcular texture, which, being gradually increaſed by veſſels ſent out from its ſurface, changes the reſt of the cartilage into a bony nature.

916. In theſe long bones it ſeems evident, that the increaſe is owing to the arteries elongated by the force of the heart, and gradually extended to the extremities of the bones: but that the hardneſs is owing to groſs particles at laſt depoſited in the cartilage when its veſſels admit the red blood. But even a bony callus never becomes ſound till the newly formed red veſſels have penetrated its ſubſtance.

917. The flat bones originate from ſomething of a mem-

membranaceous nature. Over this the fibres ſpread themſelves, at firſt in a looſe net-work, but afterwards they become more denſe, having the membrane for their baſis; the pores and clefts between theſe fibres being gradually contracted and filled with a bony juice, at laſt perfect the nature of the bones.

918. That a heavy bony juice, conſiſting of groſſer particles, is depoſited between the primeval fibres, is proved by the phenomena of the growing callus, which exſudes in ſmall drops, not from the perioſteum, but from the inmoſt ſubſtance of the bone, and is hardened by degrees. But even a chemical analyſis extracts that gluten from the bones; and in an anchyloſis it appears poured round the joint in a fluid, and manifeſtly fills up the chinks of the bones and intervals of the ſutures. It contains groſs earthy particles, which have been diſcovered by various experiments; and the juice of madder which adheres to it, manifeſtly diſtinguiſhes it by its colour.

919. The perioſteum covers the bones, as a membrane does any of the viſcera; and from it cellular productions follow the interior veſſels of the bones: but, in the perioſteum, there are neither ſtraight fibres, nor an appearance of alveoli or laminæ, nor red veſſels, while the bone grows hard in the egg; nor does the perioſteum at all adhere to the bone, except in the epiphyſis, when it has aſſumed a bony nature in the middle; and it is thinneſt when the bone is in a cartilaginous ſtate, but every where complete. In the flat bones it every where affords a baſis for the bony fibres.

920. Therefore the head is large, every where membranaceous, in a few places cartilaginous on theſe firſt days of geſtation, with a mouth deeply cut, and long jaws. In the fetus come to maturity, there are alſo rudiments of the teeth, which have a great deal of membrane as an appendage: the brain, at firſt fluid, and always ſoft, is itſelf very large, with large nerves: the eyes are big, and the pupil ſhut by a membrane: the breaſt is very

ſhort,

ſhort, but capable of extenſion, on account of a great quantity of cartilage: the abdomen is large, ſurrounded with membranes, with a very large liver: the bile is innocent and mucous: the inteſtines are at laſt irritable, and full of ſoft, green, excrement, when the fetus has now arrived at its ſtate of maturity: the kidneys are divided into lobes, are large, and have very big capſules: the pelvis is very ſmall, ſo that the bladder, ovaries, and tubes, project out from it: the genital ſyſtem is denſe, not yet evolved, nor preparing its juices: all the glands are large, particularly the conglobate ones, and full of a ſerous juice: the ſkin is at firſt pellucid, then gelatinous, and at laſt covered with a ſoft cuticle, and ſebaceous ointment: the fat is firſt gelatinous, and then grumous: the tendons ſoft, ſucculent, and not yet ſhining.

921. There is a great difference betwixt the circulation of the blood in the fetus and in the adult: that this may be underſtood, it is neceſſary to deſcribe the organs by which it is performed. The firſt is the *thymus*, a ſoft looſe gland, conſiſting of very many lobes, collected into two large upper horns, and two inferior ſhorter ones, which are however joined together by a great deal of long and lax cellular texture: this gland is large in the fetus, and occupies a great part of the breaſt: it is ſeated in the cavity of the mediaſtinum, and part of the neck; and is wholly filled in its very inmoſt ſtructure with a white ſerous liquor, which cannot be diſcovered without wounding it. This gland, in an adult, being continually leſſened by the increaſe of the lungs, and by the aorta now become larger, gradually diſappears. What is the uſe of this gland or its liquid, we are altogether ignorant; but even all the other glands, eſpecially the conglobate ones, are larger in the fetus than the adult, as we have juſt now obſerved.

922. The cavity of the breaſt is ſhort in the fetus, and greatly depreſſed by the enormous bulk of the liver; the lungs are ſmall in proportion to the heart, and ſo ſolid as to ſink in water, if they are every way excluded

excluded from taking the atmoſphere into their ſpungy ſubſtance, in making the experiment. Since therefore the like quantity of blood (292, 297.), which paſſes the lungs by reſpiration in adults, cannot be tranſmitted through the unactive lungs of the fetus, who has no reſpiration; there are therefore other ways prepared in the fetus, by which the greater part of the blood can paſs directly into the aorta, from the lower cava and umbilical vein, without entering the lungs. In the primeval fetus there is no right ventricle of the heart; and therefore there is ſuch a large opening of the right auricle into the left, that all the blood which comes by the vena cava immediately paſſes into the aorta, a very ſmall quantity excepted, which goes to the inconſiderable and inconſpicuous lungs. Afterwards in the fetus, now grown bigger, the lungs are indeed larger, and the paſſage from the right part of the auricle into the left is narrower, ſeeing the auricular canal is now taken into the heart, and the auricles themſelves are become much ſhorter. But yet the ſeptum betwixt the right and left auricle, conjoining them together, is perforated with a broad oval foramen; through which the blood coming from the abdomen, and a little directed or repelled by the valvular ſides of the right auricle (88.), flows in a full ſtream into the cavity of the left auricle. But it is by degrees that the membranes of each ſinus depart from each other, upward and backward, above the oval foramen into the pulmonary ſinus, where they are connected on each ſide above, by ſeveral orders of fibres, which below are palmated or like fingers, ſo as to cloſe up at firſt a ſmall part, and afterwards a greater part, of this foramen, ſo as to leave only a ſmall oval portion of it at liberty; which lies free betwixt the round margin of the ſaid oval foramen and the increaſing valve, making in the mature fetus about a fifteenth part of the area or capacity of the mouth of the vena cava.

923. That the blood takes this courſe in the fetus, and that it does not on the contrary flow from the ſinus

of the left to that of the right auricle, is evident, from all manner of experiments and obſervations. For, firſt, the column of blood in the right ſinus, is of all the largeſt; and, as it is the returning one from the whole body, cannot be exceeded by any other: but the left auricle has ſo much leſs blood in proportion than that of the right, inaſmuch as part of it flows throw the duct or canalis arterioſus into the aorta, whence its contents will be much leſs than that of the right auricle: moreover, the valve of the oval foramen, in a mature fetus, is ſo large, and placed ſo much to the left of the muſcular arch or iſtmus (922.), that when it is impelled by the blood from the left ſide, the valve, like a palate or ſhutter, cloſes up the foramen; but being impelled from the right ſide, it readily gives way ſo as eaſily to tranſmit either blood or flatus, but it will retain even flatus itſelf when injected from the right, nor will it ſuffer it to paſs back again to the right ſide.

924. Moreover, there is but a ſmall portion of the ſame blood, which firſt entered the right auricle and ventricle of the heart, that takes its courſe through the lungs: for the pulmonary artery, being in the fetus much larger than the aorta, is directly continued into the ductus arterioſus; which is larger than the light of both the pulmonary branches together, and greatly larger than the opening of the foramen ovale, and enters that part of the aorta which comes firſt in contact with the ſpine, under its left ſubclavian branch: by which means it transfers more than half the blood to the deſcending aorta, which muſt otherwiſe have paſſed through the left auricle and ventricle into the aſcending branches of the aorta; and this is the reaſon why the aorta in the fetus is ſo ſmall at its coming out from the heart. By this mechaniſm an overcharge of blood is turned off from the lungs, by directing a great part of that fluid in a ſtraight courſe to the umbilical arteries, and the powers of both ſides of the heart are united in propelling the blood.

925. Thoſe who have aſſerted that the fetus reſpires in

in the uterus, having made very few experiments, have neglected that most easy one which is made by water, in which the fetus will swim; and likewise from the lungs, which in a fetus are constantly heavy, and sink in water: lastly, they do not attend to the evident shortness of the breast, and smallness of the lungs. Whether or not it can take in air through the vagina of the mother, is very difficult to be determined: and I suspect it to be possible in a certain situation, that a well-grown fetus, which is not too much compressed, may sometimes draw in air, while it sticks by a part of its body between the parts of its mother.

926. As the fetus grows larger, so the uterus increases proportionably; the serpentine arteries of which it is composed being extended by the impelled blood, and stretched into a more direct course; while the veins having their trunks compressed by the great bulk of the uterus, and being unable to return the blood, swell out into immense sinuses; and lastly, from the menstrual blood retained in the uterus, and not yet quite spent on the fetus. Thus its thickness continues the same, because the greater quantity of blood and dilatation of the arteries and veins make up for the extenuation of its solid parts. But more especially the fundus, or upper part of the womb, increases beyond the rest; so that, by dilating the above tubes, these last seem thus to descend from the middle of the uterus, which now by degrees goes out of the pelvis, even as high as the colon and stomach itself, so as to compass all the abdominal visera, more especially the bladder and rectum. The os uteri in the first months of gestation is drawn upwards with the uterus itself, and recedes from the entrance of the vagina: after the third month, however, it again descends, and stretches into the vagina. The same becoming perpetually shorter, projects upon the close extremity of the vagina: it is, however, constantly tender; and, from that cartilaginous hardness which is observed in the virgin womb, is relaxed into a mucous softness. It is never perfectly closed or shut

together, but only ſtopped up and defended from the air by thick mucus from the ſinuſes, and perhaps from the veſicles which are ſeated in the cervix uteri. Moreover, the cervix or neck of the womb itſelf, which has long remained unchanged, during the laſt months of geſtation becomes likewiſe ſhort, and forms a broad flat opening, of no length; which, towards the time of delivery, is always more or leſs relaxed and gaping. As theſe matters advance, the fetus, which in the firſt months had no certain ſituation, being now grown to a conſiderable bulk, is, about the middle of the time of geſtation, folded together into a globe, in ſuch a manner that the head lies betwixt the knees; and being the heavier part, it ſubſides by degrees more and more into the pelvis towards the cervix uteri.

927. The various complaints in the uterus are now increaſed to the higheſt degree, being diſtended by the great quantity of blood retained in it; for nothing is more diſagreeable to a human creature than a violent tenſion, unleſs it is done very gradually. From the head of the fetus ſinking down into the pelvis, the rectum, bladder, and that part of the uterus next the neck, and which is the moſt ſenſible, are preſſed, and become painful: the fetus, having received its full increaſe of bulk, diſtends the uterus every way; and that with the greater uneaſineſs, becauſe, the waters being now taken away, the limbs which are fully formed, and the head, preſs much more vehemently on the uterus. It is thought alſo that the placenta itſelf, now very large, diſtracts the internal and naked ſurface of the uterus. From theſe cauſes ariſe at firſt ſlight endeavours of the uterus to free itſelf; and at laſt, when theſe cauſes are now got to their utmoſt height, ſuch an uneaſy ſenſation is occaſioned by the impacted head of the fetus as ariſes from a collection of fæces in the rectum; by which pain, therefore, the mother is conſtrained to attempt the birth of the child. The time of delivery comes on after the expiration of nine ſolar months, and

is kept pretty exactly in every ſpecies of animals, although by ſome cauſes it may be accelerated or retarded for ſome weeks, according to the nature of theſe cauſes, whoſe power, however, we muſt not extend too far.

928. The teneſmus thus increaſing till it is no longer tolerable, the mother uſes all her efforts by very deep inſpirations, which preſs downwards the uterus and viſcera of the abdomen (756.); and at the ſame time the womb itſelf, by its contractile vital force, conſtringes itſelf ſo powerfully about the fetus, as ſometimes to exclude it, without further efforts from the mother. The difficulties of the birth, however, are evidently overcome principally by the efforts of the mother, while the mouth of the uterus, now very ſoft, ſuffers itſelf to be diſtended by the head of the fetus. Here then the amnios, filled out with the waters, is firſt protruded vertically, before the head of the fetus, ſo as to dilate the os internum uteri; in which, the membranes being by degrees extenuated and dilated, eaſily break, and pour out their waters, which lubricate the paſſages, and relax all the parts of the vagina. The naked head of the fetus now preſents naturally with the face to the os ſacrum, directed that way by its weight: and being urged forward, like a wedge or cone, it further dilates the os uteri; till at length, by the more powerful efforts of the mother, which often looſen the bones of the pubes in young women, the head is thruſt out thro' the diſtractile vagina, with intolerable pain to the mother, and an univerſal tremor of body; and if none of the bones of the pelvis happen to preſs unequally, the infant eaſily advances, and is delivered into the world. This happens difficultly even in quadrupeds; but moſt of all in the human race, whoſe fetus has the largeſt head in proportion to its body.

929. It is natural for women to have but one child at a birth, which law they have in common with all the larger animals, unleſs they are of the carnivorous kind. Frequently, however, they have two, more rarely three, and

and ſcarce ever five. It is not to be doubted, however, that a ſecond fetus may be conceived, while the firſt remains in the uterus; ſeeing women have frequently born children, when a hard and oſſified fetus had been for a long time retained in their uterus.

930. The placenta, or after-burthen, of the fetus, connected with the fundus uteri (888.) is, in the next place, ſeparated from the womb, without much difficulty in a mature birth, partly by the weaker throes of the mother, and partly by the extracting force of the deliverer; by which the fleecy or villous ſurface of the placenta being withdrawn from that of the womb, is immediately followed with a conſiderable flow of blood; and thus is the mother delivered from the ſecundines or after-birth. The umbilical chord of the fetus is next tied with a ligature before it is cut off; for it cannot be left open, without danger of a fatal hemorrhage. Thus the umbilical vein is deprived of all the ſupplies of blood which it uſed to receive, and at the ſame time an inſuperable obſtacle is oppoſed to the exportation that was made by the arteries of the ſame name.

931. The uterus, which hitherto had been diſtended beyond imagination, now contracts itſelf by the elaſtic power of its fibres (843.), ſo ſuddenly and powerfully, as often to catch and embarraſs the hand of the deliverer, and frequently retain the placenta, if it be not ſoon looſened and withdrawn. By this contraction of the womb, the bleeding veſſels are compreſſed, no leſs than by the contraction of their own coats; whence the large quantity of blood that was collected in the uterine ſubſtance abundantly flows out, under the denomination of the *lochia;* at firſt a mere gore, but afterwards, as the openings of the veſſels more contract themſelves, they firſt become yellow, at length become of a whitiſh or wheyiſh complexion; and then the ample wound of the uterus is ſoon healed, and ſhrinks up to a bulk not much exceeding that of the virgin uterus.

944. But after two or three days are elapſed from the birth, when the lochial diſcharge has almoſt ſpent itſelf,

itſelf, the *breaſts* begin to ſwell conſiderably; and their ducts, which in the time of geſtation often diſtil a little thin ſerum from the nipple, become now very turgid with a liquor, which is at firſt thin or like whey, but is ſoon after followed by the thicker chyle itſelf. For *milk* very much reſembles chyle, but human milk leſs than that of other animals. It is white, thickiſh, ſweet, and replete with a very ſweet eſſential ſalt, which grows ſour ſpontaneouſly, but is tempered by the oil and lymph added to it. It has alſo a volatile and ſomewhat odorous vapour, a good deal of fat or oily parts, a larger portion of a white craſſamentum or cheeſy curd, and ſtill more of a diluting water; and again, in the craſſamentum, are contained parts of a more earthy, alkaleſcent, or animal nature. But when the chyle is once changed into ſerum, by faſting a conſiderable time, the milk becomes brackiſh, alkaleſcent, and diſpleaſing to the infant. As the chyle, ſo the milk frequently retains the nature of the aliments and medicines taken into the ſtomach. The cauſe of this increaſed ſecretion in the breaſts, ſeems owing to the revolution, in conſequence of the plentiful uterine ſecretion being ſuppreſſed, by which the fetus was nouriſhed; in the ſame manner as a diarrhæa is ſuppreſſed by increaſing the perſpiration. For it has been obſerved, that true milk will ſometimes make its way through other parts beſides the breaſts, and even eſcape through wounds. And there is otherwiſe between the uterus and breaſts, ſome kind of nervous ſympathy, and a ſimilar fitneſs for generating a white liquor. For the uterus in infancy, and during the time of pregnancy, manifeſtly generates it. But the inoſculations betwixt the mammary and epigaſtric arteries, though true, are ſo ſmall, that they can have but a very little ſhare in this account.

945. The *breaſts* are made up with a very large quantity of ſoft ſurrounding cellular fat, of a white colour; and conglomerate glandules, of a convex figure, aſſembled into bunches ſomewhat round and hard, of a reddiſh blue colour, outwardly ſurrounded and connected

ted together by a firm web of the cellular ſubſtance, ſeparating off into leſſer kernels, which are common both to men and women. To theſe glandules a great number of blood-veſſels are diſtributed from the internal mammaries, from the external veſſels of the thorax, and ſometimes from thoſe of the ſhoulders, all which inoſculate together around the nipple. The trunks of the mammary arteries, but not the *mammales*, inoſculate with the epigaſtric veſſels, but the veins more evidently. The nerves are both large and numerous, like thoſe of the more ſenſible cutaneous parts, being derived from the ſuperior intercoſtals.

946. From the middle of this gland of the breaſt, and likewiſe from the ſurrounding fat, an infinite number of ſmall ducts or roots ariſe, very ſlender, ſoft, white, and dilatable, which come from all ſides to the middle of the nipple, and likewiſe into the circle which ſubtends its baſis, and then run together on the area of that circle, and emerge at the root of the nipple, which they perforate round its margin, in a circular figure, after emerging through the root of the ſaid *papilla* or nipple; for by this denomination we call a cavernous or ſpungy cellular body, into which the blood may paſs out from its veſſels, ſo as to cauſe a kind of erection, as in the penis. Through this papilla open about twenty or more of the excretory ducts from the breaſt, called *lactiferous;* none of which inoſculate or join with the others, but are greatly contracted at their opening in the nipple, to what they were in the breaſt: and theſe, in a looſe or flaccid ſtate of the nipple, are compreſſed, wrinkled, and collapſed together; but when the nipple is erected by any kind of titillation, they become ſtraight and open, with patulent mouths, lurking betwixt the cutaneous wrinkles. This papilla or nipple is ſurrounded by a circle, planted with ſebaceous ſmall glandules, which defend the tender ſkin againſt the repeated attrition and perpetual moiſture.

947. Thus the infant is naturally provided with its firſt food, which is otherwiſe exceedingly ſalutary to

man.

man. This the infant by inſtinct knows how to receive, although it is as yet a ſtranger to all the other offices of human life. Taking the nipple in its mouth, it cauſes it to ſwell by gentle vellications; the lips are preſſed cloſe to the breaſt, that no air may enter betwixt; at the ſame time the inſpiration is deep, and a ſpace formed in the back part of the mouth, in which the air is more dilated or rarefied; and thus, by the preſſure of the external air, joined with that from the lips of the infant, the milk is urged from the breaſt thro' the nipple, in which it would otherwiſe be collected in ſo great a quantity, as ſometimes to diſtil ſpontaneouſly and be very ready to flow out; and thus the infant ſucks, and is nouriſhed. The firſt milk, which is like whey, termed *coloſtra*, looſens the tender bowels of the infant, and purges out the meconium (898.), to the great advantage of the infant. Yet it is alſo obſervable, the lactiferous ducts are ſo open, that when the nipples of the breaſt are diſtended by titillation, and a greater quantity of blood ſent into the breaſts, they have yielded milk, even from virgins, ſometimes from old women, or even from men. Milk is only generated after puberty; before that time a ſerous humour flows from the breaſt; and for the moſt part it is generated only about the middle of the pregnancy. After the menſes have ceaſed, the breaſts, as well as the uterus, being grow effete, ceaſe to perform their office.

948. But great changes now happen to the little new-born infant; and the firſt is *reſpiration*, which it endeavours to exert, even before it is well ſet at liberty from the vagina of the mother, being probably excited, from the pain or anguiſh it feels, to thoſe cries with which it ſalutes the light, and perhaps from the deſire of food which it had hitherto taken in from the liquor of the amnios. At firſt, therefore, a portion of the air is admitted into the lungs, which are as yet ſmall and full of moiſt vapours; but being dilated from the air, change from a ſmall denſe body, ſinking even in ſalt water, into a light ſpungy floating fabric, extended

to a confiderable bulk with air, and of a white colour Now, therefore, the blood paffes more eafily into the enlarged and loofe fabric of the lungs (265.); in confequence of which, a large portion of the blood that went before from the pulmonary artery, through the canalis arteriofus, into the aorta, goes now into and through the lungs themfelves, by the other branches of the faid pulmonary artery. And fo much the more is the arterial duct or canal deferted, inafmuch as there is made a new obftacle to the defcent of the blood into the abdomen; for the umbilical arteries being now very ftraitly tied, the blood of the defcending aorta cannot now find its way but by the fame force with which it dilates all the arteries of the pelvis and lower extremities. Finally, as the lungs now receive more blood, fo the aorta itfelf receives a greater quantity, and with greater force likewife from the heart; whereupon the intermediate canal, betwixt the protuberant part of the aorta and pulmonary artery, clofes up or fhrinks to fuch a degree, that, in adults, it is not only an empty ligament, but likewife of very little length; and otherwife it is fingularly red in the inner part, foft, and very fit for concreting with the ftagnating blood. This courfe of the blood, therefore, is foon abolifhed, commonly in about the compafs of a year.

949. In the like manner alfo, the foramen ovale is, from the fame caufes, gradually clofed up. For when the way is rendered more free and pervious into the lungs, it will likewife be more free into the right fide of the heart; whence the blood, both of the afcending and defcending cava, will flow thither more plentifully as it is invited by the more lax pulmonary artery, into which it will rather move on, than through the paffage through the feptum of the finufes. Again, the umbilical vein, being now almoft deftitute of any fupply with blood from the ligature of the navel (930.), lefs blood will from thence flow into the lower cava, and confequently the preffure againft the oval mouth will be diminifhed, by which means the blood of the upper cava, being turned

turned off by the iſthmus, will be ſcarce able to penetrate the obliquity of the foramen ovale. Thence again, as more blood is derived through the lungs into the left ſinus and auricle, its greater dilatation and extenſion will ſtrain the little horns of the oval valve, ſo as to draw up and preſs the valve, together with the iſthmus, whereby it is extended ſo far, as wholly to ſhut up the opening in the mature infant, while, at the ſame time, the blood, within the left ſinus, props up the ſaid valve, ſo as to ſuſtain the impulſe of the blood on the the other ſide within the right ſinus. Thus, by the acceſſion of a little friction of the uppermoſt margin of the valve againſt the upper part of the iſthmus, the foramen ovale cloſes up by degrees, and the upper margin of the valve forms a concretion to the poſterior face of the iſthmus. But this is performed very ſlowly; inſomuch that frequently, in an advanced age, there will be ſome ſmall aperture or tube ſtill remaining; and where there is none of this tube, yet there are the remains of one, as a kind of ſinus, hollow to the left ſide, that makes a tube opening upward to the right ſide, and blind or cloſed to the left, becauſe the power of the blood in the right ſide is always greater than its reſiſtance on the left, or certainly not leſs, even in the advance of life.

950. The *umbilical vein*, being deprived of blood, ſoon cloſes up. The blood of the vena portarum, having no oppoſition from that which formerly flowed through the umbilical vein, occupies the left ſinus and curve of the umbilical foſſa (695.), and ſends its blood through thoſe branches by which that of the umbilical vein before paſſed. Thence the *ductus venoſus* being neglected, ſhrinks up and cloſes, by the new compreſſure which the deſcending diaphragm makes upon the liver by inſpiration; and by which the left lobe of the liver is preſſed towards the lobule, and perhaps too from the obtuſe angle which it makes with the left ſinus of the vena portarum; for it is certainly firſt cloſed in that part which lies next the vena portarum.

951. The *umbilical arteries* are alſo cloſed up from the ſame cauſes, as other arteries uſually are after a ligature, when ſome of the blood being at the ſame time compacted into a polypus, fills up the blind void part, while the other blood, flowing above, whoſe impulſe was ſuſtained by the reſiſting membranes, ſpreads itſelf through the adjacent leſs reſiſting branches, which are thereby rendered more open or diverging. Nor do I overlook the force of the abdominal muſcles towards this effect, by which thoſe arteries are compreſſed againſt the full abdomen in each reſpiration; and, again, the very acute angle in which the umbilicalis goes off from the iliac artery, now becomes a curve, by deſcending with the ſides of the bladder, and is then directly extended into an acute fold, which the thighs make with the body of the fetus. Thus the capacity of theſe arteries is ſoon ſhut up, leaving only a ſmall tube, that gives paſſage into two or three arteries of the bladder. The *urachus* being likewiſe a very thin tube, extended perpendicularly upward from the bladder, is therefore eaſily cloſed up; ſo that the contents of the bladder make no endeavours to paſs that way, finding a ready outlet by the deſcending urethra.

952. From the like cauſes the bulk of the liver itſelf is leſſened, and by degrees contracts itſelf within the capacity of the ribs; in the mean time the inteſtina craſſa, from the ſlender condition in which they are obſerved in the fetus, dilate to a conſiderable diameter, and the ſtomach itſelf is gradually elongated; the large convexity of the cæcum forms itſelf by the force of the feces preſſing perpendicularly downward to the right ſide of the vermicular appendix; and the lower limbs are likewiſe conſiderably enlarged by the return of the blood, ſent back from the umbilical arteries now tied; and by degrees all the other changes are made, by which a fetus inſenſibly advances to the nature and perfection of an adult perſon.

CHAP.

CHAP. XXXII.

NUTRITION, GROWTH, LIFE, *and* DEATH.

953. EVEN after the child is born, it continues to grow, but always ſlowly, and in leſs proportion the older it is. There are many concurring cauſes by which the growth is continually rendered leſs and leſs. Many veſſels ſeem to be ſtopped up, both becauſe they are compreſſed by the neighbouring torrent of blood flowing through the great arterious tube, and becauſe the blood being now become more viſcid runs into clots. But the harder kind of food that is now made uſe of, throws into the blood more terreſtrial parts, which being carried through the whole body along with the nutritious parts, renders them all harder, as the bones, teeth, cartilages, tendons, ligaments, veſſels, muſcles, membranes, and cellular texture; ſo that an increaſe of hardneſs may be perceived in them, even by touching them with the finger. Wherefore, ſeeing the blood flows from the heart through fewer canals, and ſeeing all parts are grown harder which ſhould be lengthened or diſtended, it neceſſarily follows, that thoſe which ought to increaſe in bulk, will yield leſs and leſs to the impulſe of the heart.

954. But the heart likewiſe, which is the part that is firſt conſolidated among all the ſoft ones, increaſes leſs than any other part of the whole body; and while the much more tender limbs and ſofter viſcera are diſtended, the proportional bulk of the heart to the reſt of the body grows continually leſs and leſs, till at laſt its proportion to the body of the adult becomes eight times leſs than what it was in the new-born infant. At the ſame time, from that very denſity which it has ſo quickly acquired, it becomes leſs irritable, and is contracted leſs frequently within a given time. Thus, while the

reſiſting

refifting forces are augmented, the diftending ones are at the fame time diminifhed.

955. There will therefore, fooner or later, be an end of the increafe of bulk; and that will happen fo much the fooner as the heart has had the more frequent and vivid contractions: but this ceffation of growth will take place when the cartilaginous crufts of all the bones are now become fo thin that they cannot yield to the increafe of the bony part. In women the menfes feem to put a ftop to the growth fooner than in men. In cartilaginous fifhes, there is perpetual growth.

956. There is no ftate in which nature by a perennial progrefs induces a continual decreafe from the firft conception. It is faid however to take place, when there is neither any increafe of bulk, nor yet does any vifible decreafe take place.

957. For we are all perpetually confuming (434). Nor do we only lofe the fluid parts of our bodies, but even thofe which are at laft reckoned to be the moft folid. For even the bones are changed; and the teeth, which are harder than the bones, increafe in bulk when the attrition of the oppofite teeth has ceafed to wear them away, and therefore their elements are changed: even the fibres of ivory in the elephant's teeth, have quitted their places, and furrounded on each fide in curve lines a leaden fhot: the bony juice likewife is changed; feeing in fome cafes the bones grow foft, in others they fwell out in bony tumours: even cicatrices themfelves have a manifeft growth, otherwife they would not be fufficient in an adult perfon to clofe up a wound which he had received when a boy; and a great quantity of the earthy part of our bodies goes off by urine, as is proved by fome difeafes.

958. The caufe of the deftruction of the folid parts lies in their perpetual extenfion and retraction, which happens at every pulfe of the heart: this occurs an hundred thoufand times every day, and by this motion even metals themfelves are worn. Other caufes are from the friction of the fluid againft the folid parts; from the

wear-

wearing away of all the membranes, which terminate with a moveable extremity, either on the surface or in the internal cavities of the body, the firmneſs of which only belongs to the reſt of the canal; in the alternate ſwelling and decreaſe of the muſcles; and in the attraction and preſſure which at firſt form our fleſhy parts. But all parts of our body are the ſooner worn away, that they conſiſt of a great deal of gluten combined with a ſmall quantity of earth; and that gluten when it is extended, if the extenſion has been a little ſuperior to the force of its coheſion, muſt of neceſſity fall away and be carried off from the earthy parts. Thus wrinkles or furrows are generated; ſuch as are viſible in the arteries of old men. The cellular texture, which otherwiſe would be diſſolved into water or gelly, is worn away by the impetus of the blood preſſing againſt the neighbouring blood-veſſels and muſcles, by friction, and by perpetual flexion and extenſion.

959. The decreaſe would be very quick, and indeed there would be no great diſtance between the end of our life and its beginning, unleſs theſe loſſes were repaired. The fluid parts are reſtored by the aliments, and that pretty quickly; as appears from the example of a chicken, in which blood is generated out of its aliment within two days. The fat, however, and red globules of blood, are formed out of the fat, as is ſhewn elſewhere; the lymphatic juice from jelly; the mucus from mucus; and the reſt of the humours from theſe and water. The ſolid parts are repaired almoſt by the ſame methods which we have deſcribed in the hiſtory of the fetus. A gelatinous juice is brought from the aliments, through the arteries, to all parts of the body, and exſudes into all parts of the cellular texture. The furrows, which we might imagine to be made in the inmoſt arterial membrane by the impetus of the blood, are filled up by a viſcid matter brought into them by the lateral preſſure; nor is it poſſible that theſe furrows can be overfilled, becauſe every exuberant particle of nu-

tritious

tritious juice muſt neceſſarily be carried off by the current of the blood. This will not be wanting while there is a ſufficient quantity of aliment; while there is more reſt, and leſs reſiſtance, in the bottom of the furrow than elſewhere, which always muſt be the caſe, becauſe the bottom is farther removed from the motion of the blood by the depth of its cavity. There ſeem to be certain powers in the air, by which the aliment is attached to the ſolid parts, although we are ignorant of the manner in which they act.

960. The decreaſe of the cellular texture ariſing from attraction or preſſure, will be repaired by the viſcid vapour exhaling from the artery, and preſſed towards thoſe places which ſtand in need of reparation by the force of the neighbouring arteries and compreſſing muſcles, its aqueous part being preſſed out and reſorbed. The gluten repairs moſt of the organic parts, tendons, and membranes; being formed into a new cellular texture, as in the fetus.

961. The waſte which takes place in moveable parts adhering by their other extremity to the reſt of the body, can be repaired by protruſion alone, while the lymph fills up the intervals or hollows that are thus produced.

962. At that time when the growth of the body can proceed no further, fatneſs is produced, which is a kind of imitation of real growth. This proceeds from the fat generated by the aliment; which by reaſon of the impetus of the blood being leſſened, and its entering the ſmalleſt veſſels with more difficulty, is carried to the ſides of the veſſels; enters the lateral ones and the inorganic pores of the arteries; exſudes into the cellular texture; and there, the power of conquaſſation of the blood being now diminiſhed, and likewiſe the abſorption by the veins, the fat is conſequently collected.

963. We feel the beginnings of decay even in youth itſelf. Even in that blooming ſeaſon the ſolid elements of the body are augmented, the chinks through which the humours flow are leſſened, ſmall veſſels filled up, and the greater attraction of the cellular texture has added

added a denſity to the whole body. Throughout the whole body that hardneſs occaſioned by age is very conſpicuous, in the bones now wholly brittle, in the ſkin, in the tendons, in the conglobate glands, in the arteries, and likewiſe in the weight of all the parts, and of the brain itſelf. But theſe parts grow ſtiff ſooneſt which are moſt exerciſed by motion; as thoſe in every mechanic, which he chiefly makes uſe of in his buſineſs.

964. Moreover, the arteries alſo continue to become more denſe, more narrow, and even to be quite filled up, as well by the internal preſſure of the blood flowing through the large arterial tube, as from the attraction of the cellular texture of which the greateſt part of the artery is made up. An infinite number of parts of the cellular texture thereof ceaſe to be nouriſhed; to which the ſmalleſt arteries hitherto brought their nouriſhment, but now when ſtopped up can bring none. The extending force being removed, the cellular fleeces draw themſelves together, contract the little ſpaces intercepted between them, degenerate into membranes, or ſubſtances of a hard texture, which intercept and as it were choak up other veſſels. But the gelatinous vapour likewiſe concretes in the ſmall hollows of the cellular texture, and unites into a hard ſolid with its ſides. The muſcles, having expelled the blood they contained, and condenſed their fibres, degenerate into hard denſe tendons deſtitute of all irritable power.

965. At the ſame time the nerves become more and more callous to the impreſſions of the ſenſes, and the muſcles grow leſs ſenſible to the ſolicitations of the vital powers: thus the contractile force of the heart, and the frequency of its pulſations, is diminiſhed, and therefore the whole force which drives the blood into the ſmalleſt veſſels.

966. The quantity of humours is diminiſhed in a denſe body, as is evident in the perſpiration, ſemen, humours of the eye, and of the conglobate glands; the

vapour alſo which bedews the ſolid parts of the body, every where decreaſes. For this reaſon nutrition now languiſhes, becauſe there are more parts of the body which require nouriſhment, and leſs nutritious juice.

967. Nor is the quantity of humours only diminiſhed: they themſelves are likewiſe corrupted. They were mild and viſcid in children: but theſe ſame humours are now acrid, ſalt, fetid, with a great quantity of earth, in old men. This happens through the uſe of ſalt or putrid aliments, the fault of which grows ſtronger by being collected through a great length of time; alſo through the fault of a leſs perſpirable ſkin, a coſtive belly on account of the diminiſhed irritability, and thus the increaſed reſorption of the putrid liquamen. Hence the fetor of the urine, of the breath, and the difficult healing of wounds.

968. But the greateſt fault of the humours is, that they abound with earthy particles, as well thoſe collected inſenſibly from the aliments after the ſecretions have become leſs free, as from thoſe which more are off from the ſolid parts and returned into the blood: of this conſiſts the earth collected in ſome diſeaſes, and which is of the nature of the gouty earth. By this quantity of earth, the portion of that element through the whole body is augmented, becauſe the nutritious liquor brings too much of that along with it; whence the brittleneſs of the bones, and the hardneſs of all the other parts, increaſes: the ſame is likewiſe every where depoſited in the cellular texture, and produces cruſts, which are at firſt callous, then of a bony or ſtony nature, and that chiefly in the coats of the arteries.

969. The hardneſs or rigidity of the whole body, the decreaſe of the muſcular powers, and the weakening of the ſenſes, conſtitute *old age;* which happens to mankind ſometimes ſooner, and ſometimes later: ſooner if they have been ſubjected to violent labour, or given themſelves up to pleaſure, or lived upon unwholeſome diet; but more ſlowly if they have followed a moderate way of life, and uſed temperance in their diet,

diet, or if they have removed from a cold to a warm country.

970. But when thoſe cauſes continue to operate by rendering the matter of the body more denſe, by diminiſhing its irritability, and augmenting the quantity of earth, it is not poſſible but decrepit old age muſt ſucceed. In it the ſenſes are almoſt deſtroyed, the natural power of the muſcles is exceedingly weak, the limbs loſe their ſtrength, the feet eſpecially are not ſufficient for ſupporting and directing the body. Thus the callous inſenſibility of the nerves cannot be incited to perform the office of generation; thus the very inteſtines becoming inactive, refuſe to anſwer to the accuſtomed ſolicitations: thus alſo, by the induration of the cartilages interpoſed betwixt the vertebræ, the body bends foreward; by the falling out of the teeth, the jaws now rendered ſhorter cannot ſupport the lips as uſual; and laſtly, the heart loſes one half of the frequency of its pulſation which it had in the infant ſtate.

971. Thus at laſt natural death neceſſarily follows; but very many people are carried off before their time by diſeaſes. Scarce one in a thouſand exceeds the age of 90; but one or two perhaps may be found in a century that live to the age of 150. Man is long lived when compared with other animals; he is alſo more tender than any of them, has looſer fleſh, and leſs hard bones. Among the long-lived people, it is not eaſy to ſay what was the cauſe of that privilege. England ſeems to excel all other nations in the long-lived people; and generally the temperate countries are remarkable in this reſpect. Among all the different profeſſions, the commonalty has almoſt ſolely afforded theſe rare examples of longevity already mentioned; although from the more numerous claſs, we might expect a greater number of examples. Some prerogatives to long life ſeem to be ſobriety, at leaſt in a moderate degree; not very rich food; a mild behaviour; a mind not endowed with very great vivacity, but cheerful, and little ſubject to care. Among animals, fowls are longer lived

than many others, but fiſhes the moſt of all; the latter have the ſmalleſt heart, and the ſloweſt growth, and their bones are never hardened.

972. Death happens ſometimes, but rarely, from mere old age. This we ſay happens when the powers are gradually loſt, firſt of the muſcles ſubject to the will, then of thoſe that are ſubſervient to the vital functions, and laſtly of the heart itſelf; ſo that old men ceaſe to live through mere weakneſs, rather than through the oppreſſion of any diſeaſe. I have often obſerved the ſame kind of death in brutes. The heart becomes unable to propel the blood to the extremities, the pulſe and heat deſert the feet and hands; yet the blood continues to be ſent forth from the heart into thoſe arteries that are next to it, and to be carried back from thence: thus the flame of life is ſupported for a little while; which we ſoon perceive to be extinguiſhed, when now the heart itſelf being totally deprived of its powers, and not irritable by the blood to any effectual motion, cannot drive the blood through the lungs, that the aorta may receive its due quantity. Thus the utmoſt force of reſpiration is exerted in order to open a paſſage to the blood through the lungs, until even the powers given by nature for performing the action of inſpiration, becoming unequal to their taſk, ceaſe altogether. Thus the left ſide of the heart neither receives blood nor is irritated, and therefore remains at reſt; while yet for a little time the right ventricle, and laſtly the auricle of the ſame ſide, receive the blood brought by the veins from the cold and contracted limbs, and by this means being irritated they continue to beat weakly. But laſtly, when the reſt of the body has become perfectly cold, and the fat itſelf congealed, even this motion ceaſes, and the death becomes complete.

973. I ſhall call that death, when the whole irritable power has left the heart. For the mere reſting of the heart is not without hope of a revival: neither does the putrefaction of any part of the animal body demonſtrate the

the death of the whole animal; nor does its insensibility or coldness do so: but all these things when joined together, and perpetually increasing, with the stiffness which follows the coagulation of the fat by rest and cold, afford the signs of death in any doubtful case.

974. The body of a dead person is committed to putrefaction. Thus the fat, and the water, and gluten, being dissolved, fly off; the earthy part being destitute of its bonds of union, insensibly moulders away, and mixes itself with the dust. The spirit goes to that place which God hath appointed it: which we may know to be indestructible by death, from a very common phenomenon; namely, that very many people, while their bodily powers are wasted by a consumption, give evident proofs of a most serene, vigorous, and joyful mind.

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